BRONZE AGE ECONOMIES OF THE CARPATHIAN BASIN: TRADE, CRAFT PRODUCTION, AND AGRO-PASTORAL INTENSIFICATION

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

.

LIST OF APPENDICES

ABSTRACT

This thesis develops a general anthropological framework through which factors underlying the emergence of (and variability within) complex political formations can be understood, which I apply to Early-Middle Bronze societies of the Carpathian Basin (c. 2700-1500 BC). I use economy as a means to assess the processes underpinning emergent administrative institutions, since whatever their form, they require novel means of finance. A fundamental aspect of political economies is centralization, in which control over the economy is increasingly held in the hands of the elite or a ruling class. I target three major aspects of the economy: (1) regional exchange, (2) craft manufacture, and (3) agro-pastoral systems. For each of these, I establish methods that allow the relative degree of centralization to be assessed over time within individual settlements as well as between contemporary groups. Agro-pastoral systems are given special attention as they have not been well integrated into studies of early complex societies.

I employ this economic framework to examine the uneven development of complex societies in the Carpathian Basin Bronze Age. This is a period in which regional hierarchies develop in some areas while in others they do not, creating a mosaic of contemporary political forms. My methods highlight common economic pathways that the more complex systems share, including increased centralization of long-distance exchange and local manufacture of prestige goods at emergent political centers. However, I also demonstrate that intensification within agro-pastoral sectors is equally important, the specific form of which is highly variable among polities. In particular, emergent centers all show a movement away from small-scale, risk-averse animal economies towards those that place greater emphasis on one or more high-value animal products, such as wool or large-bodied livestock. At Pecica Şanţul Mare (Middle Maros), the focal study group, a unique economy developed, one that specialized in the breeding of horses; animals that generally occur in low numbers at this time. The period of peak horse production coincides with elaborate horse-centered feasting and early evidence for chariotry in

the Carpathian Basin. Horses may have even overshadowed metal production as the primary export commodity for this community.

CHAPTER 1: INTRODUCTION

The emergence of political complexity is a fundamental transformation in human organization. It has long been a central topic within the social sciences and one that is well suited to archaeological study given the discipline's ability to document long-term culture change. While our understanding of the general processes underlying the development of complex political formations has greatly increased over past decades, it has also become increasingly clear that their developmental pathways and specific configurations are highly diverse. It is this variability that is the focus of this dissertation.

This thesis seeks to understand the factors underlying variability in political organization in complex, pre-state societies. There are many ways to approach this topic as complexity involves reorganization of numerous aspects of social structure. I use economy as a means to assess these changes as emergent administrative institutions, whatever their form, require novel means of finance. In particular, I employ the perspective of political economy, as it specifically articulates political structures and economic organization, including production, consumption, and exchange systems (Stein 2001). A fundamental aspect of political economies in complex societies is centralization, in which control over the economy is increasingly held in the hands of the elite or a ruling class. This includes centralized decision making concerning the production and allocation of resources as well as the development of formal mobilization systems which structure the upward flow of goods and labor via tribute, taxation, or similar institutions.

Political economies are often characterized as either "wealth" or "staple" finance based (D'Altroy and Earle 1985), differing in the degree to which elite control over prestige or subsistence goods is dominant. While this classification scheme is a useful starting point, political finance systems are more complicated than this suggests, with considerable variability in the degree and form of centralized control among diverse economic sectors.

To better understand the factors influencing the variable development of political economies, I use a multi-faceted, multi-scalar, and contextualized approach. This entails examining trajectories of different economic spheres individually in order to identify which sectors are affected by centralization, to what degree, and in what form. It is also important to recognize the timing and rate of changes, as economic reorganization may or may not take place within different spheres simultaneously. Rather, political economies tend to be accretional and it is essential to establish the relative stages of their development, how changes in different economic sectors are interrelated, and how their restructuring is integrated within larger sociopolitical institutions. Economic reorganization should be assessed at multiple scales, both temporally and spatially. This allows shorter-term developments to be identified and situated within longer-term processes. Similarly, changes at the settlement (or intra-settlement) level must be viewed within a regional framework as components of a broader suite of transformations. Lastly, it is necessary to contextualize economic systems. Economic organization is influenced by a variety of internal and external factors, including the physical environment, sociocultural structures, external connections, and historical contingencies. As a result, these variables also must be evaluated to assess their effects on economic formations.

In this thesis, I target three major aspects of the economy: (1) regional exchange, (2) craft manufacture, and (3) agro-pastoral systems. Within each of these sectors, I incorporate principal components of production, distribution, and consumption. A series of test expectations are created for each of these sectors that allow centralized and non-centralized features to be distinguished, which can be applied broadly within archaeological studies. These tests highlight features that are indicative of intensified and/or specialized production and asymmetric control over labor, raw materials, foodstuffs, and finished goods. Particular attention is paid to the animal economy, as the effects of centralization on pastoral systems have been strongly under-theorized in archaeology, especially in pre-state societies.

While the models developed here can be applied widely, I use the Carpathian Basin Bronze Age as a case study for several reasons. During the Bronze Age (c. 3000-500 cal. BC), political complexity developed in many parts of Europe, including the study area. The Carpathian Basin is of particular interest as recent research has suggested that there is considerable variability in organization, not only between cultures but also within them (Duffy 2010; Earle and Kristiansen 2010b; O'Shea 1996; O'Shea, et al. 2012), which challenges previous assumptions of uniform and well-developed complexity in this region. In addition, there is a wealth of archaeological and environmental data that can be used to assess the specific test criteria developed in this thesis.

I first conduct an in-depth study of economic development within an aspiring political center, Pecica Şanţul Mare. This is a major fortified tell settlement of the Middle Maros culture, situated along the eponymous Maros River in Romania. On-going excavations by a collaborative project between the University of Michigan and the Arad County Museum have produced a range of high-quality data that allows detailed examination of economic systems at fine spatial and temporal scales. Importantly, these data also enable comparison of organization between two distinct site sectors, the central on-tell occupation and the peripheral habitation beyond the fortification ditches, which are hypothesized to reflect elite versus commoner populations, respectively.

The second research component assesses larger scale patterns of economic development. The political economy at Pecica is compared to those within six contemporary sites in the Carpathian Basin study region. These represent settlements within contrasting political systems, from autonomous village societies (Lower Maros culture) to three-tiered regional hierarchies along the Danube (Nagyrév/Vatya culture). Attention is paid to how differences in their economic organization are related not only to their specific political formations, but also to their environmental and cultural settings. Given the scope of this regional study, focus is placed on more generalized, long-term changes within exchange, craft production, and subsistence economies.

This dissertation makes several important contributions. This thesis helps to clarify the development of Bronze Age cultures in the Carpathian Basin, many aspects of which remain poorly understood. I am the first to systematically evaluate Maros culture animal economies and to provide a holistic examination of husbandry practices across the greater region. I also provide the first detailed assessment of intra-site socioeconomic variability, based on systematic excavations in both peripheral and central settlement occupations at Pecica. To date, any such differences have been assumed rather than demonstrated. In addition, this thesis is one of the few studies to articulate organization within multiple economic sectors in an explicit attempt to understand variation in political economies within the Carpathian Basin.

More broadly, a major goal of this thesis is to develop better models with which to identify economic centralization, using a multi-faceted, multi-scalar, and contextualized approach. Special attention is paid to the pastoral sector, which has received relatively little consideration in studies of political complexity. I demonstrate the central role that animal husbandry plays in emergent political economies and highlight different ways that elite influence over livestock production and distribution systems may be used to accentuate economic disparities and promote political asymmetries. Lastly, I draw attention to specific factors, both internal and external, that contribute to variable development of political and economic organization.

THESIS STRUCTURE

This dissertation is divided into 15 chapters. Chapter 2 presents the theoretical approaches informing this study. I begin with a brief review of anthropological and archaeological frameworks that have been used to study the development of political complexity. I then discuss the concept of political economy and how it can be an effective tool for understanding the emergence of regional polities. I highlight three economic spheres that have received much attention archaeologically and are utilized in this thesis: regional exchange, craft production, and agro-pastoral systems.

In Chapter 3, I outline the research design for this thesis. I introduce the goals of the dissertation and the frameworks through which these research questions will be addressed. In short, I seek to understand the variable development of complex societies using economic centralization as a primary lens. I provide a brief background of the study region, the Bronze Age Carpathian Basin, and the focal study site, Pecica Şanţul Mare. The principal variables used to assess the degree and form of centralization within the three target economic sectors are presented. General hypotheses are developed for intra-site and inter-site patterning in the study region. These are elaborated in Chapter 7 where specific test expectations and methods are developed.

Chapter 4 describes the physical setting for the Carpathian Basin case study, highlighting factors that may have influenced economic organization, such as the distribution of raw materials, variation in agro-pastoral productivity, and location of water-borne trade routes. The general climatic regime for the Carpathian Basin is presented, along with significant changes occurring during the Bronze Age (Sub-Boreal period). Basic geology of the region is discussed, along with mineral/metal sources, hydrology, and soil types and distribution. I also give an overview of major plant and animal communities, focusing on economically important taxa and habitats.

Chapter 5 provides the archaeological background for this dissertation. First, a broad-scale overview of the European Bronze Age is presented, including basic space-time systematics and a history of major research. I outline theories for the development of "Bronze Age Societies," incorporating both traditional understandings and modern approaches and interpretations. Particular attention is paid to research on the development of Bronze Age political economies and their limitations. Second, the culture history of the study area is summarized. I begin with a general discussion of the Carpathian Basin region, highlighting major social, political, and economic developments from the Neolithic through the early Iron Age. I follow with a more detailed presentation of groups used in my study, the Middle and Lower Maros, Ottomány/Gyulavarsánd, and Nagyrév/Vatya cultures.

In Chapter 6, I describe the sites and selection criteria used in this thesis. Sites were chosen based on the comparability of their occupation periods, recovery strategies, and analytical methodologies, while also representing contrasting culture groups, environments, political organization (when known), and settlement types. These variables, along with their major features, site size and layout, history of excavations, and faunal assemblages, are detailed for each of the seven study sites. Pecica Şanţul Mare, the focus of this analysis, is presented in greater depth.

In Chapter 7, I introduce a series of testable hypotheses for the emergence of centralized political economies, drawing on both the strengths and weaknesses of the theories presented in Chapter 2. I focus on the aforementioned three economic spheres that represent economic organization at multiple scales: long-distance prestige goods exchange, local craft production, and agro-pastoral systems. Again, the latter forms the core of the model, in which I developnew integrative methods to evaluate changes in animal economies. As part of this model, I consider centralized control over herd management decisions, specialized production systems that favor valuable export commodities, and indirect distribution systems associated with elite provisioning and mobilization systems. For each of these three economic sectors, generalized models are presented in which Iestablishcriteria that can be used to assess degree of centralization broadly. A series of specific expectations are then created for the study region, drawing on background information presented in Chapters 4 through 6. These tests consider intra-site and inter-site patterning in non-centralized and centralized economic formations.

Chapter 8 describes the specific analyses used to evaluate the hypotheses in Chapter 7. Quantitative and qualitative methods are summarized for various material classes, including faunal and botanical remains, ceramics, worked bone and antler, chipped and ground stone, metal items and metallurgical debris, and other finished prestige goods.

In Chapter 9, I provide a comprehensive analysis of the faunal remains at Pecica Şanţul Mare. A primary goal is to identify changes in animal production systems resulting from expanding centralized control over agro-pastoral systems as part of an emerging political economy. These changes include the development of increasingly intensive, specialized, and higher-risk husbandry practices, geared towards surplus production of high-value species and animal products. The presence of elite provisioning and feasting is also examined. In order to address these issues, I evaluate taphonomy, taxon representation, livestock mortality profiles, and body part representation for the major occupation phases. Intra-site variability is also examined. I compare animal production and consumption between inhabitants of the central tell versus the peripheral occupation in order to assess the presence and degree of socioeconomic differentiation over time.

Chapter 10 evaluates the organization of agriculture at Pecica, with a focus on temporal changes that reflect different intensification practices, including intensification proper, extensification, expansion, diversification, and specialization. In addition to production strategies, crop processing, distribution, and storage systems are also assessed.

Chapter 11 examines the effects of centralization on craft production and regional exchange systems at Pecica over time. Organization and intensity of production are evaluated for a wide range of crafts, from basic utilitarian items to prestige goods, in order to identify the degree to which there is elite control over different craft classes and potential production bottlenecks that may be exploited. The importance of raw material availability, skill/labor requirements, and end use are evaluated, with particular attention paid to crafts that are likely to enter regional exchange networks. Similarly, the level of elite control over different types import goods is assessed. Centralized regulation over the acquisition and distribution of raw materials, both for utilitarian and prestige goods, as well as finished luxury items is documented.

In Chapter 12, a synthesis of Pecica's political economy is presented, drawing on the results from analyses presented in Chapters 9 through 11. These are used to test the specific expectations for economic organization in more or less centralized systems that were described in Chapter 7. Focus is placed on identifying which aspects of the economy become centralized, to what degree, at what time and rate, and in what relationship to each other. Together, this provides a comprehensive view of changes occurring within Pecica's economy over time and how these are integrated with larger sociopolitical developments.

Chapters 13 and 14 take a regional perspective, comparing Pecica's political economy (from Chapter 12) to that of six contemporary sites in the Carpathian Basin. Chapter 13 focuses on the agro-pastoral sector while Chapter 14 highlights the organization of craft production and regional exchange systems. These two chapters include a comparison of developmental trajectories between Pecica and its nearest neighbor settlement to understand their relationship to one other, in particular, whether there are political and/or economic asymmetries indicative of a regional hierarchy. Middle Maros groups are then contrasted against two settlements of the related, but organizationally distinct, Lower Maros region, which by autonomous villages . At a larger scale, comparisons are also made against settlements within two other organizational types: simple hierarchies (Ottomány/ Gyulavarsánd, Körös River) and complex regional polities (Nagyrév/Vatya, Danube River). The degree to which economic centralization is present and in which sectors, is used to better understand the nature of variable political organization in the region. A principal goal is to demonstrate divergent developmental pathways that result in these contrasting endpoints in political systems.

Lastly, in Chapter 15, I synthesize the results from this thesis. I present a discussion of how the emergence of Pecica's political economy is embedded within larger systemic changes occurring within Bronze Age societies, highlighting both common trends as well as unique pathways. Factors underlying organizational variability in the Carpathian region can be used to understand the development of political complexity more generally. I underscore the importance of changes within agro-pastoral systems as part of this process and the need to integrate local, regional, and extra-regional economic organization to create a more holistic understanding of the emergence of complex political systems.

CHAPTER 2: THEORETICAL FRAMEWORK

Few concepts have received as much attention and been at the heart of so many contentious debates in archaeology as the origins of socio-political complexity. Yet the topic remains one of the most important as its development marks a fundamental transformation in human culture, one that underlies the basic structure of most modern societies. In this chapter, I introduce some of the major themes that have shaped the study of emergent complexity. While there are myriad approaches, I focus on economic models since novel means of finance are necessary to sustain more complex social institutions. In particular, I employ theories of political economy as they explicitly examine the relationships between political structures and economic organization. I target the concept of centralization specifically, as it is the primary feature distinguishing more complex political formations and their economies. Three economic sectors are considered in detail: regional exchange, craft production, and agricultural systems. Intensification of agro-pastoral systems is given special attention as it has not received sufficient consideration in pre-state societies. Within these economic spheres, I examine the ways in which each can be appropriated into more centralized economic systems and the variable pathways this restructuring may take. Together, these theories are used as the foundation on which my dissertation's primary research questions and hypotheses are built.

COMPLEX SOCIETIES

One of the most basic, yet rancorous, debates concerning complex societies is how the concept should be defined. While few scholars have difficulty distinguishing groups at the far ends of the spectrum of social complexity, namely small-scale egalitarian societies (bands) and bureaucratic states, it is the great range of variability in between these two bookends that has proven problematic. There have been myriad ways that these societies have been classified. Some argue that there is too much variability among them to be meaningfully subdivided, and that broad terms such as "middle-range" (Feinman and Neitzel 1984; Kelly 2000; Rousseau 2006; Upham 1983) or "transegalitarian" (Bogucki 1999; Clark and Blake 1994; Hayden 1995) should be applied to all. While useful as a means to avoid the reductionist traps of traditional evolutionary classificatory systems (Fried 1960, 1967; Morgan 1877; Sahlins and Service 1960; Service 1962), these generalized terms also overlook important, and I would argue, fundamental differences in organization.

I define complex societies as regional polities with hereditary inequality, institutionalized leadership positions, and centralized political formations. This overlaps with many current definitions of "chiefdoms" that have developed out of Service's original 1962 classification system. This rather broad definition would include states, but these features develop in pre-state societies as well, those that lack strongly bureaucratic political systems and class (non-kin) based social divisions. Importantly, this definition also makes a critical distinction between other middle-range groups that lack regionally-integrated, centralized political formations, those that are traditionally referred to as tribes.

The development of hereditary inequality is a pre-condition for the emergence of centralized polities. While no groups are entirely egalitarian, the shift from achieved to ascribed status has important ramifications for sustained and increasingly asymmetric socio-economic differentiation that characterizes more complex social formations. Vertical transmission of wealth and status within lineages may lead to institutionalization of these distinctions, with permanent elite and commoner kin groups emerging. This ranking is often coupled with the establishment of an ideology of separate, often mythological, descent of elite lineages. In addition, leadership positions may also become inherently tied to the dominant lineage, leading to hereditary rulers. Status, wealth, and power become increasingly concentrated within the hands of a few.

Institutionalized social inequality and hereditary leadership positions may develop within individual communities. However, there is a fundamental change when these leadership positions expand to multiple communities. The vertical integration of communities at a regional scale requires novel organization as decision making becomes increasingly centralized within a single, nested administrative system, including the management of economic, military, and religious realms.

It is important to stress the variability in the ways that these centralized institutions develop and are organized. The narrowly defined evolutionary and neo-evolutionary classification systems of previous generations were flawed in that they assumed that all the features used to define culture types vary in tandem and groups could be neatly pigeon-holed into their typologies. It has become clear that this is not the case, that different cultural components do not in fact develop in lock-step, that there is a high level of organizational variably present in groups falling within a particular class, and that social forms emerge along unique evolutionary trajectories (Feinman and Neitzel 1984; O'Shea and Barker 1996; Peebles and Kus 1977; Plog and Upham 1983; Whallon 1982). As a result, I maintain a fairly broad definition, highlighting the concept of centralization at a regional scale, but allowing for considerable variation in the way that this centralization is manifested, with the expectation that different features become centralized to different degrees and at different times. This mosaic development is fundamental to the organizational variability that we see in complex pre-state societies, or what has been termed “the complexity of complexity” (Stahl 2004:146).

Another central debate concerning complex societies is how they emerge. While early studies of social organization were largely focused on creating typological systems, in the 1960s, the new school of processualist archaeologists in North America, led by Lewis Binford (1962; 1965), along with “social archaeologists” in Europe, such as Colin Renfew (1968, 1974), explicitly addressed general processes underlying culture change. These archaeologists drew heavily upon neo-evolutionary and cultural ecological theories developing within cultural anthropology (Sahlins 1963, 1972b; Sahlins and Service 1960; White 1959). Early attempts were largely focused on “prime-mover” explanations and a wide range of causal factors were proffered. Popular explanations for the development of complexity (both chiefdoms and states) included population pressure/agricultural intensification (Boserup 1965; Wittfogel 1957), population circumscription/warfare (Carneiro 1970, 1981), and coordination of regional exchange (Childe 1951; Polanyi, et al. 1957; Renfrew 1969; Sanders 1968). Explanatory models became more sophisticated over time, with prime-mover theories being replaced by increasingly nuanced multi-causal explanations, often situated within systems theory (Flannery 1965; Flannery 1968, 1971, 1973).

Underlying most of these early explanatory models is the assumption that the emergence of institutionalized, centralized leadership was an adaptation to a particular set of pressures, particularly those caused directly or indirectly by some environmental-demographic imbalance. Elites were seen as coordinators, with chiefs managing the group’s economy for the benefit of all (Earle 1991b). This is especially seen in arguments in which population pressure fosters agricultural intensification (Wittfogel 1957) or where leaders coordinate resource production and exchange in environmentally variable landscapes (Service 1962). Central to these explanations is the primary role of redistributive economic systems.

In the following decades, several limitations of this framework became apparent, the critique of which has strongly shaped current approaches to the study of complexity. First is the movement away from neo-evolutionary, adaptationist explanations and towards models in which centralized political systems emerge via self-interested actors rather than in service to the good of the community (Earle 1989, 1991b, 1997). In particular, the central role of redistribution has been questioned, which is discussed in more detail in the following section. Much of this critique has stemmed from the influence of structural Marxist thought, which became increasingly influential during the 1980s and since.

At the same time, some archaeologists, especially those influenced by the postmodern movement, argued that efforts to establish generalized processes of culture change should be abandoned, returning to a particularistic framework that dominated culture-historical anthropology prior to the neo-evolutionary movement (Hodder 1982; Shanks and Tilley 1987; Yoffee 1993). However, others were (and continue to be) unwilling abandon the study of generalized processes entirely. Instead, most archaeologists shifted the focus of study within complex societies. This was in part related to increased attention paid to variability within individual cultural components, allowing organizational changes to be assessed in far more detail and their inter-relationships to be better understood (Feinman and Neitzel 1984; O'Shea 1981). However, there also has been more emphasis placed on the specific question of how power comes to be institutionalized within the hands of a few. A range of factors has been introduced in the literature, from control over agricultural facilities to esoteric knowledge, generally developed in reference to a particular regional case study. Over time more explicit attempts were made to synthesize these diverse arguments, highlighting common developmental pathways within these competing strategies.

Among the most influential of these new syntheses has been the work of Earle and his various collaborators (Earle 1989, 1991a, 1997; Kristiansen and Larsson 2005). Drawing upon previous work on social power by Mann (1986), Earle and his colleagues (1991a) proposed a range of different political strategies, which can be generally divided into economic, military, and ideological means to consolidate power and compel compliance (Earle 1991b:5). Economic power derives from being able to buy compliance, military power involves coercion, and ideological power derives from routines of compliance (Earle 1997:6-8). Importantly, there are diverse strategies that fall within each of these categories, ranging from inflicting debt via feasting or gift giving, improving subsistence production, seizing control over internal and external wealth production, appropriating symbols of legitimacy, and naked force (Earle 1991b:5). These strategies are utilized to varying degrees and in different combinations, depending on particular physical, cultural, and historical conditions. Regardless of the particular methods employed, they all serve to create conditions under which the cost to refuse elite demands outweighs the costs of compliance for followers.

It is clear that organizational changes underlying the emergence of political complexity are multifaceted and require restructuring within a number of interrelated social components. And while these different components are connected to one another, their reorganization follows unique pathways. Further, the stability of these polities varies and they cycle between more or less complex forms (Anderson 1996a, b; Parkinson 2002). Together, these factors tend to create mosaics of complexity within regions. It is this variability that is the focus of this dissertation. While there are many ways to approach this variability, I target the economy since novel ruling institutions must be financed and therefore economic changes are central to their development. To understand the relationship between political structures and economic organization, I employ the framework of political economy here as it explicitly links them together.

POLITICAL ECONOMY AND COMPLEXITY

Political economy in its most broad sense can be defined as “the relations between political structures and systems and the economic realms of production, consumption, and exchange” (Stein 2001:359). This generalized definition has the benefit of being applicable to a wide range of sociopolitical formations, from the simple to the highly complex. However, most scholars would restrict its usage to more complexly organized societies. In doing so, other features must be included to enhance its utility as a conceptual framework. For example, when dealing with complex societies, it must be acknowledged that there is a decision-making apparatus that exists above the domestic household level which manages (to a greater or lesser degree) sources of wealth and power (Rice 2009:70). In addition, while political economies are highly flexible and may take a variety of forms, they are all characterized by the ability to mobilize and distribute resources to support ruling institutions (Earle 2011:241) via centralization.

Political economy has a long history in the social sciences and over time there has been considerable change in the way it has been defined and applied. While the roots of political economy perhaps can be traced back to the 18th century physiocrat school of economics[1] (Cobb 1993; Roseberry 1988), the foundations of its anthropological study lie primarily within the works of Karl Marx. Marx (1964) viewed political economy in terms of the structural relationships between the means of controlling wealth and creating inequality, stressing exchange and labor relationships (Hirth 1996). Much influential work derived from his ideas has focused on modern or historic capitalist states where it can be applied more directly, with Frank's dependency theory (1967, 1969) and Wallerstein's (1974) world systems theory being more well-known examples, which are discussed below.

During the 1950s and 1960s Marx's ideas, particularly materialism, functionalism, and the focus on production, were adapted to the study of pre-capitalist and/or pre-state societies using frameworks of cultural ecology (Steward 1955), cultural evolution (Fried 1960, 1967; Sahlins 1963, 1972a, b; Service 1962; White 1959), and substantivist economics (Polanyi 1944, 1957; Polanyi, et al. 1957). These anthropological frameworks were briefly addressed in the previous section, but Polanyi's work on economic systems deserves further attention. Polanyi (1944, 1957) divided economic organization into three principal modes of exchange, reciprocity, redistribution, and market systems, which vary in their degree of expression in different social forms. Reciprocity is characterized symmetrical exchanges between social units, and includes barter (immediate exchange) and gift giving (delayed exchange). The latter may create debt relations and can be used to foster social asymmetries. Redistribution is the vertical movement of goods or services to centralized leadership, which are then transferred back down (redistributed) to members of the society. Market systems are associated with states and entail the exchange of goods through a free-price system following laws of supply and demand.

Redistribution was seen as a defining feature within complex pre-state societies and central to the classification systems of Service (1962), Fried (1960, 1967), and others based on their work. In redistributive economies, leaders intervene in production and distribution systems, adding a level of decision making above the household. Viewed through an adaptationist

[1] Physiocrats believed that landholding and agrarian wealth formed the basis of political power.

framework, redistribution developed in order to increase efficiency or reduce risk of shortfalls, particularly in areas where there is diversity in the abundance and distribution of resources. For example, elites may coordinate the distribution of agricultural goods across environmental zones, schedule land and labor use in farming, or sponsor central markets to facilitate exchange of necessary goods. Central stores may also be reallocated during times of resource shortfall as a means for risk buffering. This elite management was seen as beneficial to the larger population.

However, redistribution as the modal economic structure within chiefdoms proved problematic, despite some limited success in archaeological studies (Steponaitis 1978, 1981). In Earle's (1978) examination of Hawaiian chiefdoms, he argued that they lacked redistributive functions. Rather, the upward flow of resources (goods and labor tribute) is better viewed as "mobilization," as they do not flow back downwards in equal degree or kind. Instead, these resources are co-opted by elites to serve their own agendas, being used primarily to reinforce socioeconomic inequalities and finance elite institutions of political power. This fundamental shift from elites as managers to elites as exploiters in a structural Marxist vein laid the foundation for much recent thinking on political economy and the development of complexity.

The concept of redistribution deserves further discussion. While redistribution *sensu* Service may not be the dominant mode in more complex societies, it does play a significant, if secondary, role in shaping resource flows (Hirth 1996) and should not be abandoned entirely, especially for early stages of complexity, as it lays the foundations for economic structures that elites may appropriate. Redistribution is important in tribal "Big Man" societies, and redistributive practices are maintained in more complex polities as well, although they become increasingly asymmetric. In tribal societies, a few households over-produce and use these surpluses for community-oriented purposes, including feasting (Blitz 1993) and risk mitigation in periods of resource shortfall (Halstead and O'Shea 1989). Reallocation of resources bestows prestige upon the benefactor, and this can be used to encourage additional production among other community members, especially when rationalized in terms of specific end usage (Hirth 1996). Over time, this can form the basis for more formalized systems of redistribution (or mobilization) that emerge in more complex societies (Sahlins 1963). In addition, certain forms of redistribution, especially feasting, are widely held to be important political strategies to gain and extend power (Earle 1991b).

Notably, the role of redistribution within complex societies has been revisited in recent years. While it is widely acknowledged that there are limitations to redistribution in complex societies, there has been considerable development and reinterpretation of the principle; "the idea of redistribution did not begin with Polanyi in 1957 or end with Earle in 1977" (Galaty, et al. 2011:175). Halstead (2011:229) in particular argues that redistribution as defined as "centrally administered movements of goods and services without equivalence of value" has maintained its usefulness as a heuristic device. It is emphasized that redistributive systems are highly variable, that they should be viewed as only one part of a larger economy. Further, redistribution is used as much to signal asymmetrical social relationships as to finance elite needs for goods and labor. Importantly, while redistribution may not function in the adaptationist usage by Service (1962), Halstead notes that it is also naïve to think that "what goes up, stays up" entirely. Rather, "things come in, things go out" (Schon 2011), even if in different degrees and kind, unequally amongst the population, and to the primary benefit of the elite.

Returning to the discussion of political economy more generally, the concept gained increasing popularity after the late 1970s, and by the 1990s, there were a number of overview articles published on the topic (Cobb 1993; Hirth 1996; Roseberry 1988; Stein 1998). These will not be extensively reviewed here, but a few key theoretical developments will be outlined that bear directly on the approach taken in this dissertation. Since the 1970s, there has been a strong shift away from viewing culture change as systemic responses or adaptations to external forces, whether ecological or cultural, but instead to internal pressures. There also has been less emphasis on explanatory models and more focus on social dynamics and internal functioning (Stein 1998). The study of political economy has similarly changed, but following two rather distinct paths, one expanding on and modifying the processualist framework outlined above and the other taking a more strict Marxist approach (Cobb 1993).

One of the most influential developments is the reorientation of frameworks from adaptationist to political models of economic change within complex societies (Brumfiel and Earle 1987). In political models, the primary beneficiaries of centralized intervention in economic systems are the elites themselves, rather than the general populace. These elite-imposed changes are used to "create and maintain social inequality, strengthen political coalitions, and fund new institutions of control, often in the face of substantial opposition from those whose well-being is reduced by such actions" (Brumfiel and Earle 1987:3). This restructuring can take a variety of forms, but they often rest on the control and manipulation of wealth (broadly construed), whether agricultural products, specialized crafts, labor, or foreign commerce. Elite concentrated wealth can be converted into power through monopolizing (and potentially withholding) key resources, distributing wealth to establish or reinforce alliances, supporting specialists (administrative, craft, military, religious) working directly for the elite, and differentially acquiring and manipulating symbols of power. Wealth is also how elites define social statuses and their associated rights and obligations.

Systems of political economy are often divided into what D'Altroy and Earle (1985:188) describe as "wealth finance" and "staple finance" systems. Wealth finance[2] involves the manufacture and/or procurement of prestige goods or other valuables that are used as a means of payment. These are less bulky than staples and are thus easier to transport over long distances. However, they also often have restricted intrinsic use value, and as they rely on regional and extra-regional exchange networks, are more volatile than staple finance systems (Blanton, et al. 1996). Staple finance, in contrast, involves obligatory payments (tribute, taxation) of subsistence goods, primarily grains, or as corvée labor on centrally administered lands. Staple products have the advantage of being used directly to support non-agricultural groups but are more difficult to transport over distances. The authors note that these systems should not be used as discrete categories in which to place societies. Rather, they form a continuum with wealth and staple finance systems operating in conjunction but to different degrees.

This division of wealth versus staple finance system overlaps in part with several other classificatory systems. These include Blanton et al.'s (1996) "network/exclusionary" versus "corporate" strategies in their influential dual-processual model.[3] Network strategies focus on wealth finance via prestige goods exchange, and are more commonly in regional networks of small, autonomous polities. Corporate strategies are more common to larger scale polities and tend to rely on agricultural intensification (especially at a large scale) and symbolic or ritual power. The latter is often viewed as "authoritative resources" in contrast to material "allocative resources," following Giddens' terminology (Giddens 1981; Rice 2009). This division into network and corporate strategies strongly parallels Renfrew's corporate versus individualizing

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[2] Note that this draws heavily from the earlier Prestige Goods Economy model (Frankenstein and Rowlands, 1978; Friedman and Rowlands).
[3] See Blanton, et al. (1996) Table 2 for a more comprehensive list of similar systems.

chiefdoms (Renfrew 1974) and Kristiansen's centralized versus decentralized stratified societies (Kristiansen 1991, 1998; Kristiansen and Larsson 2005),

While political models for emergent complexity have become widespread within archaeology (Allen 1996; Earle 1997; Fargher, et al. 2011; Makki 2011; Maldonado 2008; Marston 2012; Patterson 2005; Pollard 1987), they are not without criticism. Much of the critique has been Marxist, arguing that by focusing on top-down approaches processualist theories ignore conflict and contradiction inherent in all societies, including that generated by including self-interested actors (Erickson 2006; Gilman 1981, 1987; Halperin and Foias 2010; Matthews, et al. 2002; Price and Feinman 1995) and competing factions (Brumfiel 1994; Crumley 1995). There also has been increased attention paid to the role of material culture in constructing social relations and asymmetries (Chapman 2008; Cobb 1993; Hodder 1991).

There has been a growing attempt to rectify these viewpoints to create a more holistic view of culture change, addressing issues of global versus local influences, the relationship between structure and agency, and incorporating historical contingencies within larger scale processes (Earle and Kristiansen 2010a; Kristiansen 1998). These have met with varying degrees of success and the long-term influence of these more eclectic approaches, especially those attempting to integrate post-processualist frameworks, will be seen in future work. Nonetheless, while not novel, the renewed attention to variability within larger developmental trajectories and the use of multi-scalar analyses, incorporating internal and external factors, are constructive.

Studies of emergent complexity and its economic foundations have examined a range of specific variables. However, three economic sectors have received particular attention and are the foci of this dissertation: regional exchange, craft production, and agricultural intensification. The following section examines these subjects in more detail. The goal here is not to provide a comprehensive overview for each topic, as the literature within each is vast and synthetic reviews can be found elsewhere. Rather, I highlight important theoretical frameworks and draw attention to how these sectors may be restructured during political economy development through centralization. Special attention is paid to agricultural systems and issues surrounding intensification, as these are central to this thesis. Additional considerations, particularly concerning middle-range theories, can be found in Chapter 7.

TRADE, CRAFT PRODUCTION, AND AGRICULTURAL INTENSIFICATION

Regional Exchange

Of the various aspects of the economy that have been studied by archaeologists concerned with emergent complexity, control over regional exchange networks has received the most attention (Hirth 1996; Preucel 2010), which in part is related to its visibility in the material record. However, its popularity has waxed and waned over time as theoretical paradigms have shifted. In the first half of the 20th century, regional interaction was more focused on diffusion and migration rather than trade itself. However, with the development of processual archaeology in the late 1960s, regional exchange became a central focus within studies of culture change. A number of influential works were produced at this time, many of which developed quantitative models that could be used to assess changes in the spatial organization and intensity of trade over time (Adams 1974; Blanton et al. 1981; Braun and Plog 1982; Flannery 1968; Rathje 1971; Renfrew 1969; Sabloff and Lamberg-Karlovsky 1975; Webb 1974; Wright 1972). Elite control over exchange was typically viewed through the adaptationist framework that was pervasive at this time, stressing the importance of long-distance ties to counter periodic resource shortfall or to promote the movement of basic goods between ecologically diverse regions (Cobb 1993).

In the 1980s and 1990s, there was a strong movement away from adaptationist approaches. A variety of new frameworks were introduced, which have had varying degrees of influence on current research. With the rise of post-modernism, many archaeologists espousing this paradigm largely abandoned the study of exchange. As Chapman (2008:335) puts it, "[t]he gauntlet of total rejection of previous trade and exchange studies was thrown down by Ian Hodder (1984:26)." He, along with Shanks and Tilley and others, criticized the extreme formalism of past models on various grounds, from issues of equifinality to a complete dismissal of scientific and mathematical models. In ensuing decades, little attention had been paid to trade by those in post-processualist schools, concentrating more on ideology and various interpretive studies. However, it should be noted that with the recent introduction of the concept of materiality and a new focus on role that material culture plays in shaping social interaction, exchange studies have again become salient among post-processualists (Bauer and Agbe-Davies 2010; Chapman 2008).

At the same time that some camps were rejecting trade studies entirely, others were developing new frameworks for understanding regional exchange and its relationship to social organization. Some archaeologists created models drawing on Wallerstein's (1974) world systems theory. These stressed the need to view economic systems at a very large scale and underscored the influence of asymmetric power and economic relationships between more complex core areas and their dependent peripheries on culture change (Algaze 1993; Kristiansen 1998; Shennan 1993; Sherratt 1993). World systems and similar theories have been challenged on a number of grounds, including their inapplicability to prehistoric economies as well as their assumption of unidirectional influence (Stein 2002). As an alternative framework, Renfrew and Cherry (1986) introduced the concept of peer-polity interaction, which instead highlighted more symmetrical relationships between polities and parallel political developments between neighboring societies, also arguing for the importance of other modes of interaction like competition and emulation. Kristiansen (Kristiansen and Larsson 2005) has recently argued that these two models are not mutually exclusive, and can be better viewed as operating simultaneously at different scales (extra-regional versus regional).

However, political models of exchange have had more lasting effects on trade studies and the emergence of complexity. These are generally viewed within wealth finance (D'Altroy and Earle 1985), network (Blanton, et al. 1996) or prestige goods economies (Frankenstein and Rowlands 1978), as discussed above. These stress the role of elite control over the production and distribution of economically and ideologically important items in creating relationships of dependency between elites and commoners (Brumfiel and Earle 1987).

There is a variety of ways that centralized elite control over exchange can be transformed into political power, both locally and regionally (Brumfiel and Earle 1987; Cobb 1993; D'Altroy and Earle 1985; Earle 1991a, b, 1997; Hirth 1996; Stein 1998). Valuable foreign goods can be used directly as payment to support various specialists, including administrators, religious leaders, military personnel, and craft producers. Importantly, control over these individuals and their services bolster alternative (and parallel) means of political power through ideological, corporal, and other economic means. They can be used to attract local supporters and foster vertical integration through payments or gifts to subordinate elites. At a larger scale, prestige goods exchange between regional elites can establish alliance networks and mutual assistance between polities. The symbolic importance of these items must also be taken into consideration.

Prestige goods are a primary means to define social statuses and their associated rights and obligations. Foreign items often become symbols of authority by referencing non-local or divine sources of legitimacy that are not available to others.

There are a number of mechanisms through which elites can gain disproportionate or absolute control over exchange networks. Depending on the scale of the polity, valuable raw materials and finished goods may be mobilized by elites through formalized tribute or taxation systems within their sphere of influence (Brumfiel 1980; D'Altroy and Earle 1985; Maldonado 2008; Pollard 1987). There may also be state-sponsored market systems (Brumfiel 1980; Sanders 1968). Smaller scale, pre-state societies are less likely to be able to obtain a large range of prestige goods and materials through direct mobilization. Instead, the procurement of exotics is more likely to occur through regional elite gift exchange networks (Voutsaki 2001), elite sponsored trade missions (Rathje 1971, 1972), or by elites directly procuring foreign items, where the journey itself also bestows prestige and specialized knowledge (Kristiansen and Larsson 2005). Control over the means of exchange is also an important method, including the necessary vehicles (Arnold 1995), trade routes (Hirth 1978) (Sáenz 1991), or other transportation bottlenecks.

Centralized control over regional exchange is often difficult to sustain over long periods (Earle 1997). Trade occurs outside of centralized systems as well and it may be challenging for elites to control independent exchange. Regional exchange networks are also unstable, as shifting political alliances alter trade relations and new sources of goods may disrupt existing systems and alter the relative value of imported items. As a result, to be a reliable source of economic power, control over exchange systems must be coupled with control over production spheres, especially local prestige goods manufacture, and can be viewed as two sides of the same coin (Hirth 1996).

Craft Production

Craft production in complex societies is generally approached through specialization. There is a wide array of definitions for specialization in the literature, but it can be generally characterized as production that is restricted to a particular subset of the population, the products of which are meant to be exchanged with non-producing individuals (Cobb 1993). Like regional trade, craft specialization has received much attention in studies of complex societies since early efforts by Childe (1936, 1952, 1957). As exchange and craft production are strongly related, craft production has typically been approached through the same frameworks that have shaped discussions of exchange and will not be reviewed here in similar detail. In the 1960s, craft specialization within complex societies was often viewed as a means for risk mitigation across variable landscapes via regional exchange networks that were centrally administered (Sanders and Price 1968; Service 1962). In the late 1970s and 1980s, focus was shifted towards understanding the role of craft production within political systems and elite strategies for obtaining power (Blanton and Feinman 1984; Brumfiel and Earle 1987; Frankenstein and Rowlands 1978; Friedman and Rowlands 1978), which has led to a plethora of work on the subject in ensuing decades. Importantly, these studies include the introduction of new methods that operationalize the study of specialization in the material record as well as several comprehensive overviews (Clark and Parry 1990; Costin 1991, 2001; Peregrine 1991). More recent work has drawn increased attention to the symbolic meanings and ritual use of crafts, the creation of artisan identities, and the practice of production (Hruby and Flad 2007; Inomata 2001, 2007; Schortman and Urban 2004; Spielmann 2008).

Specialized craft production differs greatly in scale and organization between different levels of political complexity and is found in both non-centralized and centralized systems (Spielmann 2008). Here I focus on the latter. In emergent political economies, increasingly centralized control over the local production of economically significant and symbolically charged goods is a means to create relations of dependency between elites and commoners (Arnold 1995; Brumfiel and Earle 1987; Clark and Parry 1990; Earle 1997). In the same manner as foreign valuables, locally produced prestige items can be exchanged as direct payment for goods and services, to create alliance networks, and displayed as symbols of power and authority. It should be noted that in states a wider range of goods tends to be manufactured by government-sponsored specialists, including simple domestic items, and that full-time specialists are frequently independent and produce for market exchange (Rice 1991).

The importance of craft specialization is not simply a matter of presence or absence, since it is found to some degree in all societies. Rather, importance lies in the social structures that shape the organization of production and create the ability to produce and distribute surplus goods (Cobb 1993).In centralized economies, a critical variable is degree of elite sponsorship or patronage of particular crafts (or attached specialization), which can be evaluated through the context, concentration, scale, and intensity of production (Costin 1991, 2001). Centralized control requires the ability to exploit a bottleneck within the production sequence, including raw material procurement, ownership of necessary facilities, restriction of specialized knowledge or skills, or the ability to compensate artisans for labor-intensive crafts that draw them away from basic subsistence activities, especially for full-time specialists. It should also be kept in mind that elites themselves may be the specialist producers in an embedded production system (Ames 1995). In both of these systems, the goods produced are controlled by the elites, which can then be exchanged, gifted, or displayed to achieve various political ends.

Agricultural Intensification

Intensification of food production is a third economic sector that has been viewed as fundamental to the development of socio-political complexity. It is generally perceived as a means to support an increasing non-farming population, developing along with more complex formations, but it has also been seen as a direct causal factor in their creation. In recent decades, there has been considerable change in the way that intensification is related to the emergence of complexity. There have also been great leaps in how intensification has been studied through increasingly explicit examination of the various, and often simultaneous, pathways intensified production can take. This section examines theoretical approaches concerning the adoption of intensive agricultural strategies (in a general sense) and their relationship to sociopolitical organization. It must be stressed here that generalized considerations of intensification have been almost exclusively restricted to discussions of crop production within state-level societies. There has been far less discussion of agricultural intensification in pre-state societies and animal economies are woefully under-theorized at all scales. I attempt to rectify these shortcomings in this dissertation.

Following Thurston and Fisher (2007b), theories addressing the role of agricultural intensification and the emergence of sociopolitical complexity fall along two continua: prime-mover versus social theories and top-down versus bottom-up approaches. These continua can be equally applied to theories for the development of political complexity more generally.

Prime-mover theories focus on external causes that "push" populations to intensify. These target some imbalance between population size and productive capacity, either through environmental change or increasing population growth. The most influential of these is

Boserup's *The Conditions of Agricultural Growth* (1965). In direct opposition to Malthusian theories, she argued that population determines agricultural methods (and the resulting food supply) rather than the other way around. She defined agricultural intensification as an increase in production costs (increased labor at a lower efficiency), with a specific focus on the length of fallow periods in shifting agricultural systems. While her definition of intensification is still commonly used today, several central assumptions of her theory have been challenged. These arguments include: 1) there are other responses to population pressure than intensification, 2) intensification can occur without any decrease in efficiency, 3) intensification may be spurred by factors outside of population pressure, 4) intensification does not occur along a simple unilinear path, and 5) the "Law of Least Effort,"[4] which underscores her thesis, is fundamentally flawed (Grigg 1979; Kirch 1994; Morrison 1994, 1996).

In recent decades, prime-mover theories have been largely abandoned in favor of social theories that stress internal factors that "pull" populations into intensifying production (Morrison 1994; Thurston and Fisher 2007b). These social theories include models of political economy in which a predictable surplus must be generated and mobilized for tribute or taxes to finance systems of administration, specialist production, and exchange (Arnold 1995; Blanton 1995; Brumfiel and Earle 1987; D'Altroy and Earle 1985; Feinman 1995; Gilman 1991; Hayden 1995; Wright 1984). Note that social causes of intensification are not limited to chiefdoms or states, but can be observed in less complex kin-based societies as well. These causes include a number of practices that fall under Brookfield's (1972) "social production," which is production beyond the requirements of subsistence and the "normal surplus," which is surplus stored for seed and to mitigate waste, variable harvests, and other shortfalls (see also Halstead 1989, Halstead and O'Shea 1989).[5] Social production is surplus generated for a variety of reasons, including meeting various social obligations, rituals, feasting, and exchange for goods or labor. Enterprising or aggrandizing individuals may implement intensified production at the household level, producing surpluses that can be transformed by into status and used to create social inequalities via feasting, gifting, and similar practices. As a result, different degrees and forms of intensification are expected to be found among households within single settlements. While

[4] The "Law of Least Effort" states that the "most-labor efficient solution will be chosen to meet given level of demand" (Morrison 1994:130).
[5] This also excludes Brookfield's "trade production" which includes cash crops grown with the intent to exchange for subsistence goods.

social production is ubiquitous, tribute and tax obligations associated with more complex political formations add an additional level of production that must also be met, which is likely to spur more widespread adoption of intensive farming methods to meet these new demands.

The second issue of top-down versus bottom-up frameworks has also become increasingly relevant, especially with the growing popularity of agent-based approaches. These two approaches differ in who is believed to be primarily responsible for organizing and financing more intensive agricultural systems, elites or commoner farmers. Top-down models have been the traditional viewpoint, with rulers and their centralized administration needed to coordinate and fund these systems, especially those involving major landscape modifications (Kolata 1996; Matheny and Gurr 1983; Sanders 1968; Stanish 1994; Steward 1949, 1955; Wittfogel 1957). Some authors have seen control over such systems as the impetus for state formation. Perhaps most notable is Wittfogel' s (1957) "hydraulic hypothesis" which argues that control over irrigation systems allowed leaders to seize absolute power and create despotic states. Others, especially those in the functionalist and cultural ecology schools, tended to see elite involvement as less coercive, rather appropriating an adaptive "managerial" role.

These top-down approaches have come into question along a number of lines. In regards to the emergence of complex polities (especially states), centralized control over facilities or technologies associated with more intensive production is not necessary or sufficient for their formation (Adams 1981, Blanton et al. 1993, Flannery 1972). In addition, a growing number of ethnographic studies have shown that fairly intensive and elaborate systems of landscape modifications can be constructed and maintained by kin and other village-level organizations (Doolittle 1984; Erickson 2006; Scarborough 1991).

I follow Morrison's (1996, 2006, 2007) view that reality is much more complex. Agricultural production is embedded within larger social structures. Decision making occurs at a variety of scales and takes into account a number of competing concerns. Top-down versus bottom-up organization is a false dichotomy as they are acting simultaneously, albeit to different degrees and in different forms given the specific case. Direct top-down intervention in agricultural decision making is generally not the dominant mode. It is most often seen in the cultivation of elite or state-owned lands (or management of state herds), often through corvée labor. There can also be elite directives for the production of specific items, but a system must exist to fill the basic subsistence needs of farmers if these cannot be met independently. There may in fact be centralized investment in some forms of landscape modification or technologies to intensify production, but again, this is not necessary.

Even in the absence of direct top-down management of agricultural systems, indirect pressures can cause significant changes, and I would argue that this characterizes most situations in which intensification develops in emerging complex polities. Increasing elite demands for surplus production (for tribute, taxation, rents, levees, etc.) can influence strategies employed by farmers, including intensifying production. But farmers are not always “pushed” into more intensive systems. They may also be “pulled” into them by seizing new opportunities that elite consumption preferences may offer, tailoring production with the goal to exchange (or in market systems sell) their goods to elites directly. In short, bottom-up reactions are made to top down stimuli, and farmers often have considerable latitude on how they choose to meet these new obligations or take advantage of new opportunities.

Purely bottom-up intensification has been briefly touched on above in the discussion of social production. I will reiterate here that household production always seeks to produce a surplus beyond immediate subsistence needs, whether for various risk mitigation measures (normal surplus) or for social uses (social production) (Brookfield 1972; Halstead 1989; O'Shea and Barker 1996). Intensified production for social use (e.g., feasting, ritual, exchange, debt creation) is found among aggrandizers in societies of all types and is not specific to more complex formations. This type of intensification is not the focus of this thesis. Rather, it is changes in the degree and form of intensified production that is either a direct or indirect response to new stimuli introduced by more centralized political systems. Importantly, these practices are additive to other types of social production.

Intensification has been the subject of a number of synthetic works in the past two decades (Lele and Stone 1990; Marcus and Stanish 2006; Morrison 1994, 1996; Thurston and Fisher 2007c). These are briefly reviewed here and are examined in greater detail in later chapters. It must be underscored that there are multiple pathways to intensification and different practices may be used simultaneously. In addition, we need to move beyond viewing agricultural intensification as simply a means to increase subsistence production to meet growing population demands or to support non-producers. Rather, there is a range of factors that influence both the adoption of intensification generally as well as its specific form. This includes the role of export production and regional exchange, which deserves further attention.

Intensification Proper

Intensification is often used in archaeological literature as a catch-all phrase, meaning increased food production in a general sense. However, "intensification proper" (Kaiser and Voytek 1983) has a more specific definition, which refers to an increase in output per unit of land, achieved through increased energy input with diminishing returns (Brookfield 1972). Intensification methods are varied, but generally utilize additional investment in labor, resources, or facilities. It should also be pointed out that increased yields per area can be generated without increased labor through technological improvements or biological changes in crop species, which Kirch (1994) terms *innovation*, which is in contrast to intensification proper.

The most visible means of intensification proper is through *landesque capital* improvements (Blaikie and Brookfield 1987; Brookfield 1972) that increase the productivity of land through the construction of facilities or other land modifications. These include terracing, land reclamation, and various water management systems such as irrigation channels, drainage systems, check dams, and reservoirs (Brookfield 1984; Erickson 2006; Gilman 1981, 1987; Kirch 1994, 2006; Kusimba and Kusimba 2007; Marcus 2006; Miller 2006; Morrison 1994, 2006, 2007; Scarborough 1991; Stanish 1994; Williams 2006; Wittfogel 1957). These require not only a large initial cost, but also periodic maintenance to greater or lesser degrees. Kirch (1994) points out that if there are little to no maintenance costs involved, over the long term these facilities may in fact reduce labor demands.

Additional labor (or other resources) per unit area is a more common intensification method. The reduction of fallow periods has received the most attention, being central to classical works like that of Boserup (1965). Fallow period reduction means that more fields are in production at any given time, increasing overall crop yields. Crop cycles can also be increased within a single growing season through double cropping. Both of these may contribute to decreased yields per field over time because the soil is given less time to regenerate. Manuring and other fertilization methods are also common ways to increase yields per unit area and to counter soil degradation through increased cropping frequency. This requires additional labor in the procurement of fertilizing agents, which for manure requires integration with animal husbandry systems. There is also additional labor in fertilizer transport and application, both in terms of the actual work involved as well as investment in necessary technologies (e.g., bulk transport vehicles for more distant fields). However, the benefits of manuring in many cases may outweigh the costs as crop yields can be increased significantly, especially when there are only short fallow periods or none at all. Lastly, intensification can be achieved through more energy expenditure in crop maintenance practices, including seed bed preparation, tilling, weeding, and watering.

Extensification

There is less agreement on the definition of extensification. It is often subsumed within or overlaps with the classification of other intensification methods, especially expansion, diversification, and disintensification.[6] Extensification involves the use of more efficient or less labor intensive farming practices, allowing a greater amount of land to be worked with the same energy input (Bogaard 2004). While resulting in a lower output per unit area, the greater amount of land able to be worked overall worked creates a net increase in crop production. This must be distinguished from simple *expansion*, which brings new land into production without a corresponding change in farming strategies.

In extensification, the labor advantages are often the result of new technologies, such as novel planting, maintenance, or harvesting tools/techniques. Plows, carts, and other technologies utilizing animal labor are important but special cases that are considered in more detail below. In other forms of extensification, there is a shift in labor allocation and land use rather than the use of more efficient technologies. For example, additional fields may be brought into production with a corresponding decrease in labor expended per field. More extensive practices can be added to existing intensive systems through diversification. For example, there is often a division between household gardens, in-fields, and out-fields, where intensive practices are used on the former two (manuring, weeding, etc.) but little additional investment is given to the latter (Jones, et al. 1999). Extensive practices may also be employed when less productive lands are incorporated into field systems.

The issue of increasingly efficient technologies is not necessarily straightforward. Some technologies require large initial investments and maintenance costs, which must be balanced against advantages in long-term labor reduction and resulting yield increases. The use of carts and plows, which are among the most widespread extensification technologies, are prime

[6] Disintensification, a shift away from the use of intensive methods (Thurston and Fisher 2007a:256), is often used as a proxy for extensification, but their underlying motivations differ. Extensification is an explicit attempt to increase food yields while disintensification is concerned with labor reduction at the expense of output.

examples. Carts and related wheeled vehicles allow more distant land to be cultivated efficiently as they reduce travel time for farmers moving to and from their fields as well as facilitating the transport of bulk items like heavy agricultural tools, manure, and harvested crops. Animal-drawn plows greatly reduce labor costs during field preparation and maintenance, allowing a much larger area of land to be cultivated using equivalent labor and time. The advantages (and limitations) of extensive plow agriculture have been considered in detail by Halstead (1995), the main points of which are reiterated here. The discussion of animal traction equally applies to their use for carts or plows.

The labor advantages of plow agriculture are great. In the Mediterranean region, Halstead (1995:13) estimates that the rate of hand cultivation to be 0.02-0.05 ha/day compared to 0.1-0.3 ha/day with a team of oxen, with up to 15 times the amount of land able to be tilled using plows with the same labor allocation. However, there are important investment and maintenance costs that must be taken into account. First, carts and plows require initial capital for their construction in terms of both labor and resources, and given the complexity of carts in particular, are often made by specialists. An average farming household may not have the skill or resources to either make technologies themselves or obtain them from a specialist producer.

Second, the cost of animal labor should not be underestimated. Traction animals, primarily large bovids (e.g., cattle, water buffalo, yaks) and equids (e.g., horses, donkeys, mules), are expensive to obtain and maintain, although their costs vary substantially by ecological conditions and form of animal husbandry systems. In regions where animal husbandry is focused on smaller livestock, typically where pasturage is poor or limited in extent, obtaining traction animals may be expensive, especially those that are already trained. Large livestock also require more and often higher quality graze than smaller livestock, and during periods of intense agriculture work, foddering. The cost of animal feed also varies by region and by agricultural systems. In areas with abundant fertile graze, the additional costs may not be great. But in areas with limited pasturage, additional food must be supplied. This may be done through cultivating fodder crops as part of the agricultural cycle or through different crop processing methods. For example, traction animals can be fed crop by-products. This may require more labor-intensive harvesting techniques. It also affects processing, with more laborious threshing needed. Maintenance costs of traction animals may be offset by utilizing other resources, including milk, manure, and labor for other activities like threshing and general transport.

In sum, compared to manual cultivation, extensive plow agriculture reduces human labor costs and allows a much larger scale of agriculture to be implemented. Although there are often reduced yields per unit area since less labor is generally invested in field maintenance, the great increase in the amount of land able to be cultivated with the same labor allows the production of larger food surpluses. For households that can afford the initial investment and maintenance costs, the benefits are substantial. Halstead (1995) and Bogucki (1993) both argue that plow agriculture can exacerbate socioeconomic stratification. It tends to foster increased economic asymmetries between wealthier farmers who can afford these technologies and those that cannot by amplifying differences in productive capabilities. Halstead's ethno-historical study showed that in the Mediterranean, households using hand cultivation could rarely produce beyond that needed to achieve a normal surplus and meet tax obligations, being strongly affected in years with crop failure. In contrast, plow agriculturalists can readily meet subsistence demands and also produce sufficient surplus for market. He also suggests that the areal expansion of cultivation in extensive agricultural systems may create land shortages, making possible uneven access to arable land among households.

Expansion

Expansion is simply a matter of bringing new land into production without a corresponding change in agricultural strategies. It does not produce a difference in the output per unit land or labor, with the increased output directly in proportion to the amount of additional land (and corresponding labor costs). As a result, expansion is not an intensification method *per se*, and consequently is often not considered (or dismissed) in the intensification literature. However, I include it here as an alternative to intensification proper under certain conditions, such that instead of putting additional labor into a given unit area (with diminishing returns), that extra labor can be used to work more fields, given sufficient land and labor availability. Because of inherent land and labor limitations within households and communities, expansion is finite and is associated primarily with initial measures to increase overall crop yields. When these limits are reached, different practices must be implemented.

Expansion reaches a point when there is no longer new land with the same return rates available. At some point the cost of travel time to distant fields will outweigh benefits of their cultivation. Alternatively, expansion may be pressed towards increasingly marginal areas that will result in a decrease in output per unit area or labor, depending on the specific conditions. Given specific cost-benefit considerations, adopting more intensive, extensive, or diversified farming methods will be viable alternative solutions. It must be underscored here that simple expansion is only a short-term solution with finite applicability. Increasing pressures to boost crop yields will eventually require a shift in agricultural strategies, their specific form dependent on land and labor availability, ecological parameters, farming technologies, and the range of crop species in the husbandry system.

Diversification

Like extensification, diversification has been approached in different ways and the term is sometimes used for production systems which are better classified under alternative methods. Following Morrison (1994:144), diversification is an increase in the number of components within a production system. Using this generalized definition, diversification has little analytical utility for understanding economic change since it can be equally applied to practices that are the result of opposing processes. For example, diversification alternatively can be an indicator of risk-buffering practices in small-scale, independent-household farming systems or of highly centralized systems influenced by market demands. It is critical to examine the specific configuration of diversified farming practices to distinguish risk- mitigating strategies from those related to centralized economic systems. Risk-buffering strategies are discussed in subsequent chapters. Here I focus on diversification as it relates to political economies.

In centralized systems, diversification reflects a large-scale amalgam of contrasting agricultural strategies at smaller scales. There are two primary production goals that encourage the adoption of diversified strategies as a means for intensification (broadly defined). First, diversification may result from an expansion of field systems into different and often lower yield areas in an attempt to increase overall food production. These new areas require restructured farming strategies, which take different forms given the specific ecological and technological parameters. If there is sufficient labor, more intensive strategies may be employed to work these lower yield areas. If additional labor is not available, then more extensive methods may be applied. However, changes may be as simple as growing a specific range of crops that are suited to that environment. The key here is that there are multiple cropping strategies being used simultaneously in order to maximize overall food production in diverse landscapes.

Diversification can also be related to exchange production. A wider range of crops may be added or become more important components of farming systems, especially those that are high-value, high-demand species. These are often resource intensive, non-staple crops with low overall utility. As they are typically not major food sources, they are only minor components in smaller-scale farming systems or completely absent. It is important to note that diversification associated with targeted export production requires the existence of social systems that create sufficient demand for these items (e.g., elites) and exchange systems that allow for their efficient trade and distribution.

A number of studies have focused on diversification in state-level societies with market economies (Morrison 1996, 2006, 2007; Thurston and Fisher 2007a, b). These are beyond the scope of this dissertation, but it should be mentioned here that market systems allow farmers increased latitude in decision making concerning agricultural strategies, and farmers themselves may opt to diversify in response to market demand (see also specialization). However, diversification may also be a top-down imperative in centralized systems, whether in state or pre-state societies. The exchange of high-value crops is likely to be controlled by elites in regulated exchange networks at both the local and regional level. As a result, their production is more likely to be encouraged (or demanded) by elites as well, especially if it takes away resources from subsistence farming.[7] In pre-state societies, targeted diversification for exchange is strongly related to centralized economies, with top-down pressure to produce high-value/low-utility crops that are mobilized by elites for either local consumption or for regional exchange.

Specialization

Specialization, in many ways, is the elaboration of organizational relationships established with targeted diversification systems. Specialization is simply the reduction of diversity, and in farming systems, is directly related to exchange (Morrison 1994:143). The shift to the production of a small number of (or single) high-value crops is risky and removes self-

[7] As Thurston and Fisher (2007b:10) note: “Extreme efforts may be put into producing small quantities of highly valued but limited-use resources such as religious or prestige-related items. People who are pressed to produce more for elite consumption may be worked to death for meager increases in production.”

sufficiency. Specialized agriculture requires economic structures that allow farmers to obtain necessary subsistence goods that they are no longer producing themselves. This includes market and provisioning systems, both of which are directly associated with centralized economies and more complex political systems.

Specialization is strongly related to states and market economies. As with diversification, markets allow farmers to specialize independently. State-administered farms may also be highly specialized, focusing on the production of a single or small number of preferred crops. In pre-market systems, specialized production is unlikely to develop without elite sponsorship given the corresponding loss of household autonomy. Elite sponsored specialization may take the form of compensating (provisioning) farmers in exchange for their production of a limited range of desired crops or through corvée labor on elite-owned lands. In the former case, provisioning fosters dependency relationships between the coordinating authority and producers (Zeder 1991), which may lead to further socioeconomic differentiation and asymmetric power relations.

CONCLUSION

The study of complex societies has changed greatly over time. Over past decades, it has become apparent that to understand the emergence of complexity and the variable pathways that development may take, it is necessary to examine a range of cultural components independently and at multiple scales, with attention paid to the role of both internal and external factors. Changes in the economy are fundamental to this process as political institutions require financing. Political economy is a particularly useful framework, as it explicitly relates political structures with the economic systems that underlie their maintenance. Political economies, while variable in their organization, can all be characterized by increased centralization, in which control over the production, distribution, and consumption of resources is increasingly held in the hands of a few. A range of economic sectors may be manipulated by elites, but it is most commonly seen in regional exchange networks, local craft production, and agriculture, which are the focus of this dissertation.

Drawing on the frameworks presented above, the following chapter outlines the research questions and approaches of this thesis in examining the variable development of political complexity in the Carpathian Basin Bronze Age. Chapters 4 through 6 provide background information, both physically and culturally, that are used to create the specific hypotheses in

Chapter 7. Details on analytical methodologies can be found in Chapter 8. The final chapters present the analyses used to evaluate my hypotheses at both the local (Chapters 9 through 12) and regional scale (Chapters 13 and 14).

CHAPTER 3: RESEARCH DESIGN

The purpose of this dissertation is to better understand the emergence of centralized, regional polities and the factors underlying their structural variability. There are numerous ways to approach this topic. Here I focus on the economy, as it is necessary to restructure production and distribution systems to finance increasingly complex political formations. The development of political economies can be characterized by increased economic centralization. Centralization may take a variety of forms within a range of diverse economic spheres. In this thesis, my objective is not to simply identify centralized versus non-centralized economies. Rather, my primary goal is to develop ways to more systematically evaluate 1) the different pathways that this economic restructuring may take, 2) what factors influence the development of specific economic systems, and 3) how these economic changes are related to other aspects of social and political organization.

To achieve this goal, I incorporate several fundamental premises. First, it is necessary to decouple different components of the economy. Just as organizational features of societies are not expected to vary in lock-step (Feinman and Neitzel 1984; O'Shea and Barker 1996), economic restructuring is not expected to occur within each sector at the same time or to the same degree. The nature of this variability is a major factor that both shapes and is shaped by larger sociopolitical organization. I target three aspects of the economy: exchange networks, craft production, and agro-pastoral systems. Together, these will allow principal production and distribution systems to be assessed.

Second, it is necessary to take a multi-scalar approach, both temporally and spatially. The development of political complexity is not instantaneous. To understand the underlying processes involved, one must observe long-term sequences in order to follow the full course of development. But it is also necessary to examine changes at a finer scale because restructuring is not expected to occur at uniform rates or times. It is important to determine the order of changes and the rate at which these changes occurred to better assess their inter-relationships.

The study of regional polity development, by definition, requires a large-scale approach. Organizational changes must be understood through the dynamic relationships between emerging political centers and surrounding settlements. But restructuring also occurs within individual settlements, and it is important to trace concurrent changes in internal organization, especially within aspiring political centers.

Lastly, it is essential to contextualize patterns of change. Societies do not exist in a vacuum. The development of specific organizational forms is influenced by a range of factors, both internal and external. Social organization is shaped, to differing degrees, by both the cultural and physical environments in which they are situated. Societies develop diverse relationships with groups surrounding them, with varying degrees and forms of interaction. These relationships affect a range of organizational features, from the structure of trade networks to the rates of information exchange (material culture styles, technological innovations, ideological systems, etc.). Similarly, the natural environment affects organization. This includes the distribution of natural resources, from fertile soils to metal ores, as well as features that structure inter-group interaction. For example, rivers may act as trade conduits while mountain ranges may act as cultural barriers. The structure of both cultural and physical environments must be understood in order to identify how these may have influenced the development of particular organizational systems.

In this dissertation, I use the Carpathian Basin Bronze Age as a case study to examine the variable development of political economies. The settlement of Pecica Şanţul Mare of the Maros culture is used to test expectations for economic centralization within an emerging political center at a fine spatial and temporal scale. This detailed intra-site analysis is coupled with a broader, regional study to assess variability in economic development more broadly and how this variation is influenced by particular physical and sociocultural factors. Groups with contrasting political formations are targeted to better understand the relationship between economic organization and political structures. The selected study sites include groups ranging from autonomous villages societies to three-tiered regional hierarchies.

This chapter is divided into two sections. The first introduces the archaeological case studies, providing basic background for Bronze Age groups of the Carpathian Basin and the focal study site, Pecica Şanţul Mare. I then outline how the research is structured. This includes a brief overview of how centralization is approached in this study and presents the criteria that will be used for assessing regional exchange, craft production, and agro-pastoral systems. More detailed consideration of these economic variables, both theoretically and methodologically, is presented in Chapter 7, as well as general expectations for intra-site and inter-site patterning in centralized and non-centralized economies. There, specific test expectations also are created for the case study, drawing on the background information provided in Chapters 4 through 6.

CASE STUDIES

The European Bronze Age is a period in which political complexity emerged in many parts of the continent. Outside of the Aegean, this region has not received as much attention as areas where the world's classic civilizations developed. However, it is precisely because of this that temperate Europe provides an interesting case study, because in most regions strongly bureaucratic and regionally integrated states did not develop within or directly out of these Bronze Age societies. Rather, middle-range societies persisted over millennia, cycling through varying levels of complexity. As a result, the Bronze Age can be viewed as a dynamic mosaic of pre-state societies, each following their own independent trajectories while sharing a suite of features that unify this period across the continent.

Within Europe, the Carpathian Basin is a unique region. It is bounded by a ring of mountains that acted as a social barrier through much of prehistory, with groups within the Basin interacting more intensely with each other than those outside (Figure 3.1). As a result, the region shares many cultural features, and to a greater or lesser extent, has followed its own developmental course, even while maintaining significant external connections. However, it has become increasingly apparent that there is great variability present within the Basin, despite the commonalities. While differences in material culture, settlement types, and mortuary ritual have long been recognized as regionally distinctive (and used to define archaeological cultures), it was assumed that their social and political systems were largely similar. A generalized picture of Bronze Age complexity was projected onto all of these groups with little explicit examination of organizational features.

Figure 3.1: Map of the Carpathian Basin, modern political boundaries, and mountain systems

The assumption of uniform organization has been questioned in recent decades and a number of archaeological projects have been designed to examine sociopolitical and economic systems specifically (Duffy 2010; Earle and Kristiansen 2010; O'Shea 1995, 1996, 1997; Poroszlai and Vicze 2000, 2005). These have demonstrated that there is considerable diversity in organization within the Carpathian Basin, ranging from autonomous village societies in the Lower Maros region to complex chiefdoms of the Vatya complex along the Middle Danube (Figure 3.2). Further, this variability is not just found between (traditionally defined) archaeological cultures, but also within them. New research has provided preliminary evidence for divergent organization within the Maros culture area, between groups inhabiting the Lower and Middle reaches of the river (O'Shea, et al. 2012). In this case, it appears that the Middle Maros region may have been organized into a regional, hierarchical polity. In contrast, their neighbors to the west, while sharing a similar material culture, maintained village autonomy. For this reason, the Maros culture is a focus of this study. I seek to understand how and why groups in the Middle Maros area developed more complex political formations while their Lower Maros neighbors did not. The answers to these questions will shed light on processes responsible for regional variation at a larger scale.

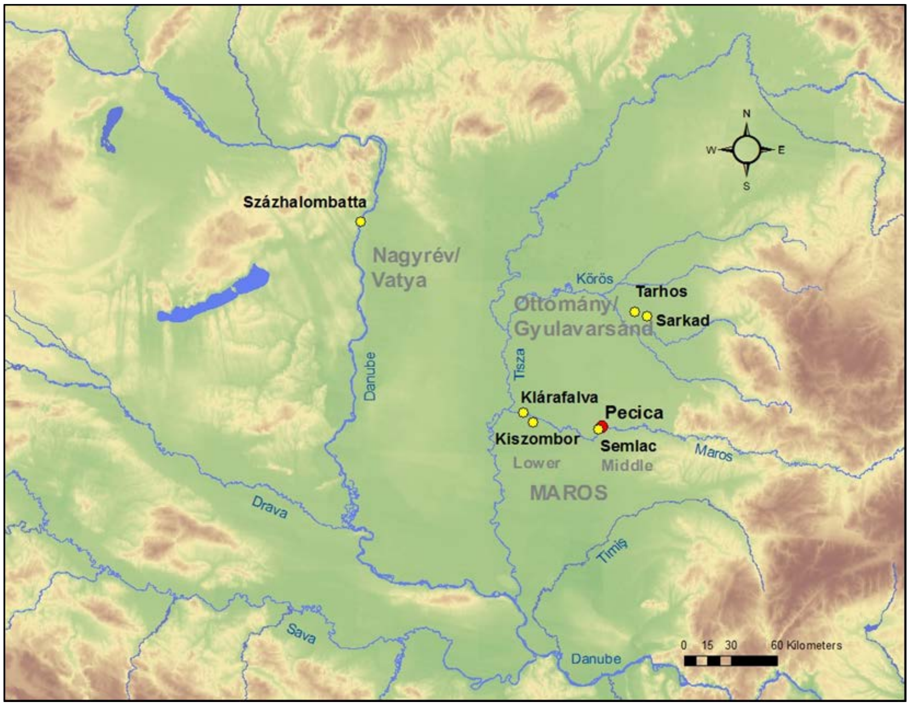

Figure 3.2: Map of the Carpathian Basin with location of Pecica Șanțul Mare, the Maros culture, and other principal groups/sites used in the regional study

The Carpathian Basin is an ideal study area not only for its diversity in archaeological formations, but also because it has a long history of research. Bronze Age groups within this region have been the focus of synthetic studies since early works of Childe (1929), and its major settlements were key to developing the relative chronologies that linked the Near East and Aegean to groups as far as northwest Europe. There has been more than a century of excavations at Bronze Age sites, including an increasing number using modern, systematic recovery and recording systems. In Hungary, there is also a national program to systematically survey the entire country (Magyarország Régészeti Topográfiája), significant portions of which have been completed to date. As a result, there is a wealth of data to work with, from individual sites to regional settlement patterns, which allow examination of organizational changes at multiple scales.

As discussed above, this thesis examines the development of complex polities through changes in economic systems, using a multi-scalar, multi-faceted, and contextualized approach. This includes a detailed case study of a single settlement, Pecica Șanțul Mare, and a larger comparative study of its relationship with other groups in the Maros culture area and to contrasting, contemporaneous systems in neighboring regions. I begin here with a brief introduction of the principal study site and how it will be used to examine the economic restructuring within a single center. I then outline the regional study, presenting the different cultures and sites and how they will be used to examine larger-scale patterns of political development.

Intra-Site Trajectories: Pecica Şanţul Mare

Pecica Şanţul Mare is one of the most important Bronze Age settlements within the Middle Maros region, the focus of archaeological research for more than a century. Currently, the site is part of an ongoing research program between the University of Michigan (John O'Shea and the author) and the Arad County Museum, Romania. Pecica is a major fortified tell overlooking the Maros River in Arad County, Romania. The Maros culture component is extensive, with on-tell deposits measuring more than six meters in depth. To date, systematic excavations have been conducted for the latter part of the Maros occupation, spanning roughly 2000-1600 cal. BC (Middle Bronze Age). The depth of unexcavated deposits, exposed partially in test trenches and cores, suggests that the site was also occupied throughout much, if not all, of the Early Bronze Age as well. All three of the Maros culture's divisions are represented, including the Early (2700-2200 BC), Classic (2200-1700 BC), and Late (1700-1500 BC) Maros Periods. A series of test excavations off of the central tell has confirmed that the settlement was divided into (at least) two major occupation areas—the fortified center (tell) and an expansive peripheral occupation. More detail about Pecica, including history of excavations, basic stratigraphy, major features, and its environmental setting, can be found in Chapter 6 of this dissertation as well as in a number of published site reports (Crişan 1978; Dömötör 1901a, b; Nicodemus 2012; O'Shea 2007, 2011; O'Shea, et al. 2012; O'Shea, et al. 2006; O'Shea, et al. 2005; Popescu 1944; Roska 1912).

New excavations at Pecica Şanţul Mare have produced a high-quality dataset that can be used to test hypotheses concerning increasing centralization within various parts of the economy. This includes high-resolution temporal divisions that can be used to examine shorter-term changes (Phases 1-6+, each spanning roughly 50-100 years, and their internal subdivisions). In addition, the more than 400 years of Maros occupation systematically excavated thus far provides the opportunity to examine long-term developmental trajectories as well (Early, Florescent, and Late Periods). This thesis combines finer-scale data with larger temporal patterns to examine the order and tempo of economic changes and their relationship to other aspects of sociopolitical organization.

A second critical aspect of this intra-site study is the examination of spatial variation. There are very few (if any) Bronze Age settlements in the region that have systematic excavations from contrasting settlement areas. As a result, our understanding of settlement organization is based almost entirely on characteristics of central occupations, primarily at major tells. These limited excavation areas do not adequately capture variation in settlement structure or between groups living in different parts of the site. Strong socioeconomic differentiation is assumed to be present at these large sites, but there has yet to be any systematic evaluation of this.

In order to address these shortcomings, I conducted off-tell excavations at Pecica in order to provide the necessary spatial data to assess assumptions of socioeconomic differentiation. In 2010, I excavated two peripheral areas, one between the first and second fortification ditch, the other between the second and third, which provides a contrast to the on-tell occupation. These proved to have fairly extensive Maros culture deposits, which allow the examination of off-tell developmental sequences and how they relate to concurrent changes within the central settlement.

Table 3.1 presents a summary of expectations for the degree of centralization within Pecica Şanţul Mare through time. These are based on the preliminary evidence for changes in the scale, intensity, and nature of occupation over time from previous and on-going excavations. The Early Period has not yet been systematically excavated within a large areal exposure. As a result, little is known about this period but there is some suggestion that occupation was not as intense as in the Florescent Period and there is no evidence for a peripheral occupation at this time. The Florescent Period is an era of very dense occupation on the tell, with construction of public and ritual architecture, high levels of metallurgical production, and presumably population increase as settlement expands well beyond the fortification ditches. It is possible that this reflects settlement consolidation as the nearby site of Semlac Şanţul Mic is abandoned at this time. The Late Period sees a sharp decline in occupation intensity by all measures (artifact, feature, and house density), and off-tell occupation, at least beyond the second ditch, is lost. Given these preliminary observations, it is expected that economic centralization will be most pronounced in the Florescent Period, the apparent peak occupation phase, and that there should be striking differences in economic organization that trace a rise and fall in centralization over time. It is also expected that there will be strong organizational differences between the on-tell and off-tell areas that are associated with economic differentiation.

Table 3.1: Expectations for degree of economic centralization within Pecica Şanţul Mare

Site	Site Type	Period	Occupation Intensity*	Off- Tell Occupation	Other	Expectation
Pecica Şanţul Mare	large fortified tell, possible political center	Early Period	lower?	not present		less centralized?
		Florescent Period	high	present	public/ritual architecture	more centralized, strong spatial differentiation
		Late Period	low	not present		less centralized

*as measured by denisty of artifacts, features, and houses

Regional Trajectories: The Maros, Körös, and Danube Valleys

The Pecica Şanţul Mare settlement study provides an in-depth view of economic changes within an emerging regional center. This study not only tests whether there is evidence for the development of a centralized political economy, but also the particular sequence and form these changes took, if present. However, to better understand variability in Bronze Age organizational systems at a larger scale, it is necessary to take a regional approach. In this thesis, the development and structure of Pecica's political economy are compared against six other sites in the Carpathian Basin.[8]

First, differences in the trajectories of Pecica and its neighbor site Semlac Şanţul Mic are assessed to better understand the relationship of settlements within Pecica's immediate sphere of influence. This analysis draws on column tests by the current Pecica project within a trench previously excavated by F. Gogâltan in 1994. Second, the organization of Middle Maros and Lower Maros settlements is compared, with particular attention paid to the nature of economic differences and how these relate to their contrasting environmental and cultural contexts. This highlights the specific ways in which emerging elites at Pecica and the Middle Maros region could foster economic restructuring in order to finance increasingly centralized political institutions.

[8] The six comparative sites were chosen from a sample of roughly 150 sites/occupation phases with published faunal data. See Chapter 6 for site selection criteria.

The comparative Lower-Middle Maros study draws on a wealth of information available for Lower Maros groups. The Lower Maros region is a marshy area at the confluence of the Tisza and Maros Rivers. Excavations have been conducted on a range of site types, including both settlements and cemeteries. These excavations include two major settlements, Klárafalva Hajdova and Kiszombor Új Élet, which were systematically excavated in the 1980s by a collaborative project between the University of Michigan and the Móra Ferenc Múzeum, Szeged, Hungary. These sites are targeted for this study. The Móra Ferenc Múzeum also conducted surveys of the surrounding Csongrád County, the data from which have been recently supplemented by new data from the Magyarország Régészeti Topográfiája project.

Lastly, Pecica and the Middle Maros culture are compared against two external groups, the Ottomány/Gyulavarsánd culture in the Körös River valley and the Nagryév/Vatya culture along the Middle Danube (Figure 3.2). The former is thought to be organized into a series of simple hierarchies with weak centralized political functions (Duffy 2010). In contrast, Nagryév/Vatya groups along the Benta Valley are thought to be an "intermediate-scale" chiefdom (Earle and Kolb 2010:70). Here there is a clear, multi-tiered settlement hierarchy with tells having centralized functions (Artursson 2010:101). Economic organization is assessed for these groups and compared against Pecica to pinpoint how political economies are structured regionally. Attention is paid to how economic differences are related to other aspects of sociopolitical organization as well as regionally specific environmental and cultural contexts. In the Körös region, two sites are examined: Sarkad-Peckes, a large fortified tell, and Tarhos-Gyepesi Átkelő, a small, unfortified hamlet (Duffy 2010). In the Middle Danube region, this site of Százhalombatta-Földvár is evaluated, which is an apical site for a polity centered on the Benta Valley (Earle and Kristiansen 2010; Poroszlai and Vicze 2000, 2005). More detail about these specific settlements as well as the criteria for their selection can be found in Chapter 6. An overview of these regional archaeological cultures is presented in Chapter 5.

Not all of the economic sectors examined at Pecica can be assessed to the same degree at the comparative sites. Because there are no systematic peripheral excavations at the other settlements, detailed examination of intra-site organization is not possible. In addition, differences in recovery and data collection strategies prevent the comparison of some material classes. These are outlined in Table 6.4. In short, the animal economy, which forms the core of this thesis, can be evaluated in considerable depth for all sites except for Semlac. Similarly, crop production can be assessed (to various degrees of specificity) for all but Sarkad. Regional exchange and craft production can only be evaluated in detail for a subset of the settlements, those with 1) extensive areal excavations, 2) systematic recovery methods, 3) full artifact inventories, 4) precise artifact mapping data, and 5) volumetrics. While some general features of exchange and craft production can be discussed for all of the sites, systematic evaluation of the test variables is primarily restricted to Pecica, Klárafalva, Kiszombor, and Tarhos. These provide a comparison of economic development between a potential political center (Pecica), a subsidiary hamlet (Tarhos), and two autonomous villages (Klárafalva and Kiszombor). Based on known political organization for the culture groups and each settlement's position within regional systems, expectations for the degree of economic centralization are proposed (Table 3.2).

Table 3.2: Expectations for degree of economic centralization between study settlements in the region

Site	Region	Political Organization	Site Type	Political Position	Expectation
Pecica Şanţul Mare	Middle Maros	possible complex hierarchy	large fortified tell	possible center	highly centralized
Semlac Şanţul Mic	Middle Maros	possible complex hierarchy	small fortified tell	possible subsidiary settlement*	weak centralization
Klárafalva-Hajdova	Lower Maros	autonomous village	small fortified tell	independent	non-centralized
Kiszombor-Új Élet	Lower Maros	autonomous village	fortified open site	independent	non-centralized
Sarkad-Peckes	Körös Region	simple hierarchy (weak centralization	large fortified tell	center	moderate centralization
Tarhos-Gyepesi Átkelő	Körös Region	simple hierarchy (weak centralization	unfortified open site	subsidiary settlement**	non-centralized
Százhalombatta-Földvár	Middle Danube	complex hierarchy	large fortified tell	center	highly centralized

*possible 2nd tier settlement?

**not subsidary to Sarkad

ECONOMIC VARIABLES

The focus of this thesis is the development of economic centralization associated with more formalized and expansive political economies. Centralization affects multiple economic sectors and can take a variety of forms. For production systems, the effects of increased centralization are primarily seen through changes in the intensity, diversity, and spatial organization of production. These are expected to reflect increased pressure placed on producers to meet demands of elite resource mobilization as well as direct elite intervention in or sponsorship of the production of certain goods. Distribution systems are also affected by increased centralization as elites exercise greater control over the importation, distribution, and consumption of resources. I evaluate three major economic sectors: regional exchange, craft production, and agro-pastoral systems. These are independently examined using a number of variables that correspond to different degrees of centralization. Importantly, while these economic sectors are inter-related, they do not necessary co-vary in parallel and the specific suite of differences will be used to highlight major contrasts in the development and organization of political economies.

For each of the three economic sectors examined in this thesis, I highlight approaches that are used in this study and their sociopolitical significance. In Chapter 7, detailed criteria are developed using middle-range theory, which are then used to create specific test expectations and analytical methods tailored to the Carpathian Basin Bronze Age and study sites. These expectations draw on contextual information provided in Chapter 4 (physical setting), Chapter 5 (archaeological setting), and Chapter 6 (site descriptions).

Exchange Networks

As reviewed in the previous chapter, long-distance exchange, especially of prestige goods, is a primary vehicle for the development of political economies within complex polities. Elite control over exchange networks and their products is a fundamental means to accentuate economic and social asymmetries that can be converted directly or indirectly into political power (Brumfiel 1980; Brumfiel and Earle 1987; D'Altroy and Earle 1985; Earle 2002; Earle and Kristiansen 2010; Friedman and Rowlands 1978; Haselgrove 1982; Hirth 1996; Randsborg 1982; Renfrew 1969, 1982; Sahlins 1972; Shennan 1993; Sherratt 1993). Elites can gain control over trade networks and prestige goods through a variety of mechanisms, from regulating the means of transportation to sponsoring central markets. Because this thesis is focused on early stages of political economy development, those forms found in pre-state societies, expectations for centralization exclude organizational systems that are associated with states and market economies.

An increase in elite control over import goods and their local distribution should cause specific changes in their abundance, diversity, and spatial distribution within settlements and between them. The strength and form of this patterning will differ depending on the type of items being imported. For example, raw materials imported for the production of utilitarian objects are not expected to be as tightly controlled, if at all, as materials for crafting prestige items. Foreign finished prestige goods will be the most strongly regulated by local elites given their importance in establishing socioeconomic distinctions, maintaining alliance systems, and symbolizing political power. Four variables are examined to evaluate the degree of centralization within exchange networks: concentration, abundance, diversity, and geographic/cultural origin.

The *concentration* of imported goods refers to their spatial distribution and contextual association within settlements. In centralized economies, imported goods, especially prestige items tend to be concentrated in elite contexts. There will also be a greater *abundance* of imported goods overall, although unevenly distributed, which can be assessed through basic density measures. They will be more frequent in elite households and the central settlement within a regional polity. Further, the entire polity will have greater access to imported goods than in non-centralized village systems. Similarly, the expansion of regional exchange networks can be seen through an increase in the *diversity* of types, both for raw materials and finished items, as well as of their geographic and cultural *origins*. These diversity measures follow the same scalar considerations as abundance.

Craft Production

Craft production is a second major component of political economies. Elite control over local production of high-value items may become an important means of finance within economic systems. As with foreign prestige goods, locally crafted items can be converted into other forms of social and economic capital. Valuable objects can be distributed locally as payment for goods or services rendered, to create debt relations, and to attract supporters. They are also used to engage in regional elite exchange systems, establishing larger-scale alliance networks, reinforcing elite monopoly over foreign exchange and strengthening asymmetrical power relations between local leaders and their constituents. Importantly, not all types of crafts are equally likely to fall under centralized control. Goods that have high value, are readily transferable, and whose production is easily restricted are preferentially targeted.

Centralization of craft manufacture is strongly associated with specialization and intensified production, which has received considerable attention in archaeological literature

(Ames 1995; Brumfiel and Earle 1987; Clark and Parry 1990; Costin 1991, 2001; Helms 1993; Hruby and Flad 2007; Patterson 2005; Schortman and Urban 2004; Sinopoli 1988). The organization of craft production can be evaluated along a number of separate but inter-related axes. A subset of Costin's (1991, 2001) variables, with some modification, are used in this thesis to assess the degree of centralization within various crafts. These variables focus on the context and intensity of production as well as the range of items produced and degree of standardization. Again, these changes will affect prestige crafts to a greater degree, as they are more likely to be coordinated by elites, and the organization of their production will differ most visibly from those of non-centralized systems. Utilitarian crafts on the other hand will not differ to any significant degree in pre-state/market societies as their manufacture and distribution lie predominantly within the domestic economy.

The c*oncentration* of production refers to both the spatial distribution (degree of nucleation) and contextual association of manufacture (specific households, workshops, elite areas, etc.). Together, these are used to identify elite-sponsored or elite-controlled workshops. As craft production is increasingly used as a means of wealth finance by elites, there should be increased pressure to expand the output of production and the range of items being manufactured. Here I refer to increased output of production as *intensity*, which can be assessed by the density of manufacture debris, tools, and production facilities. The *diversity* of crafts being produced will increase in more centralized systems. Diversity is assessed in a similar manner as intensity. The number of craft types being locally produced per unit volume can be calculated, which is comparable both within and between settlements. *Standardization* is often used as measure for degree of specialization as an increase in standardization is generally argued to reflect a decrease in the number of individuals involved in a craft's production. Increased standardization, as assessed by basic statistical measures of variability, is used as a proxy measure for the degree of specialization within particular crafts when compared between spatial and temporal contexts.

Agro-Pastoral Sector

In the past two decades there has been a movement to re-examine not only the theoretical underpinnings of agricultural intensification (Chapter 2), but also to more explicitly define what intensification is and the different forms that intensification may take. There is also greater concern with developing new frameworks to better understand how these different forms relate to larger sociopolitical and economic structures (Allen and Ballard 2001; Brookfield 2001; Lele and Stone 1990; Marcus and Stanish 2006; Morrison 1994, 1996; Thurston and Fisher 2007). Importantly, it has been recognized that increased food production can be achieved through multiple and simultaneous routes. While the role of exchange production within the agro-pastoral sector has received greater attention, it still requires further study.

In increasingly centralized political systems, farming is often significantly affected by elite demands, either directly or indirectly. Elite mobilization of subsistence products (via tribute, taxes, rent, levees, etc.) is an important economic development in more complex polities, being used not only to provision elites directly, but also to support various specialists, political supporters, and administrative institutions, to host feasts, or to be exchanged (Brumfiel and Earle 1987; Earle 1991, 1997). Elite demands for surplus production create additional pressure on farmers to increase yields, which are met by employing various means of intensification. Elites may also encourage the production of a specific range of plants or animals (and their products), either for elite consumption (including staple provisioning and luxury foods) or for exchange (locally or regionally). The degree of direct elite intervention varies, and farmers may have considerable latitude in how they choose to meet these new demands. However, direct top-down control over production strategies increases with the level of centralization and complexity of political and economic systems.

Five forms of agro-pastoral intensification are evaluated in this thesis, including intensification proper, extensification, expansion, diversification, and specialization, which were discussed in Chapter 2. Much of the research on intensification pertains to crop production. While the general principles can be applied to livestock management, intensification of animal economies requires further theoretical and methodological development, especially for pre-state, pre-market societies. In the following section, basic features of the five intensification strategies are described. Archaeological variables associated with each are presented in detail in Chapter 7.

Intensification proper is an increase in output per unit of land, generally with diminishing returns per unit labor input (Boserup 1965; Brookfield 1972). This is done through additional labor or resource investment, including the construction of land-enhancement facilities. For animal husbandry systems, this may also entail maximizing resource output per animal. *Extensification*, in contrast, increases overall yields by increasing the area under production.

This is achieved through more efficient or less labor-intensive practices, allowing a greater amount of land to be worked with the same energy input (Bogaard 2004). For livestock, it is generally associated with the adoption of larger-scale but less labor-intensive long-distance herding. *Expansion* brings new land into production without a corresponding change in agro-pastoral strategies. There are land and labor limits for expansion. When these are met, alternative strategies must be employed. *Diversification* is an increase in the number of components within a production system while *specialization* is the reduction of diversity (Morrison 1994:143-144). Diversification must be qualified by its specific form, as it may be related to contrasting strategies. In centralized systems, diversification is used to increase overall output in variable landscapes or to produce a specific range of products for exchange. Specialization is also strongly related to export production. Specialized animal production is typically associated with secondary products. However, more attention needs to be paid to specialized husbandry systems for export of live animals.

In addition to production strategies, mobilization affects the organization of food processing, distribution, storage, and consumption. This manifests as spatial differences in the frequency of processing debris, size and number of food stores, and types and quality of foodstuffs between producer/commoner and consumer/elite residential areas.

CHAPTER 4: THE PHYSICAL SETTING

INTRODUCTION TO THE CARPATHIAN REGION

The dissertation research area is situated within the Carpathian Region of east-central Europe (Figure 4.1). It has two principal components: the ring of mountain chains and high plateaus forming its external geographic boundary and the Carpathian Basin within. The mountains encircling the Basin include the Carpathians, Alps, and Dinaridies. All of the Bronze Age societies examined in this study lay within the Carpathian Basin, a 300,000 km^2 low-lying area centered on modern Hungary and extend primarily into neighboring Romania, Serbia, and Slovakia. The Carpathian Basin consists of two major geographical regions: Transdanubia, the low hilly area west of the Danube, and the Pannonian (or Great Hungarian) Plain, a very flat region to the east (Figure 4.2). Several major rivers run through the region, including the Danube, Tisza (Tisa/Тиса),[9] Maros (Mureş), and Körös (Criş), which served as major trade and transportation conduits (O'Shea 2011). Most Bronze Age societies are centered on these primary waterways. The Maros culture lies approximately at the center of the Pannonian Plain, near the confluence of the Tisza and Maros Rivers. The Ottomány/Gyulavarsánd groups occupy the Körös River Valley to the north, while the Nagyrév/Vatya culture area largely follows the Danube in Transdanubia, also spreading into parts of the Danube-Tisza interfluve of the Plain.

The physical characteristics of the Carpathian Region helped to shape the socioeconomic organization of Bronze Age cultures, including their settlement patterns, exchange networks, and agro-pastoral systems. This chapter provides an overview of the major climatological, geological, and ecological features of the region, with a focus on the Pannonian Plain, where the majority of the study settlements are situated. Special attention is paid to the Maros river valley, which houses Pecica Şanţul Mare and other Maros culture sites. Site-specific parameters are presented in Chapter 6.

[9] Place names follow local spelling when there is no common English equivalent. When a geographic feature falls within multiple countries, the Hungarian spelling is preferred as all but two of the study sites fall within its territory.

Figure 4.1: The greater Carpathian region with modern political boundaries

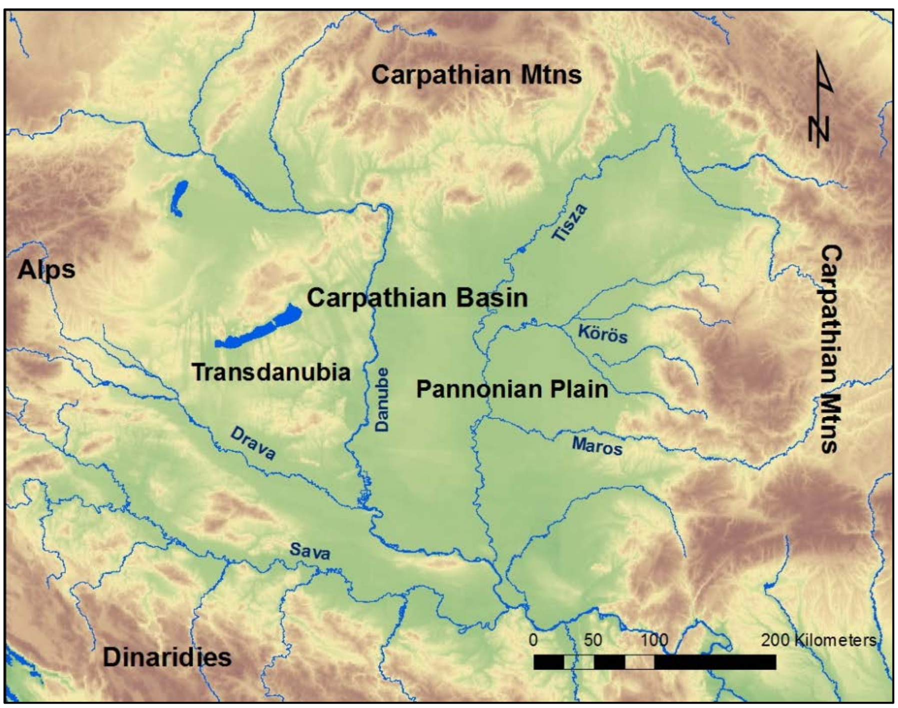

Figure 4.2: The Carpathian Basin with major rivers, mountain systems, and geographic divisions

CLIMATE

Current Regime

Since the end of the last glacial period, patterns of climate, vegetation, and soils are largely similar to today (Sümegi, et al. 2002), including the Sub-Boreal period in which the Bronze Age falls. As a result, modern climatic conditions can be used as a rough guide to general characteristics of the past, particularly for highlighting important regional differences. Deviations from current conditions are detailed in the Sub-Boreal section.

The unique climate within the Carpathian Basin is shaped by relative position to the Atlantic Ocean and Mediterranean Sea and its encapsulation by mountain ranges (Kosse 1979). According to the Köppen System for climate classification (Kottek, et al. 2006),[10] nearly all of the Carpathian Basin is described as a warm temperate climate that is fully humid and has warm summers ("Cfb"). The southeastern most part of the Plain in Serbia differs only in that the summers are hotter, on average being greater than 22° C ("Cfa"). The mountainous regions are typically a fully humid snow climate with warm summers ("Dfb"). In the highest elevations, the summers are cooler and winters cold, falling below -38° C ("Dfc"). The Basin is more temperate than regions to the east as the Carpathians act as a barrier to more extreme temperatures from Siberia (Kosse 1979). Due largely to elevation differences, Transdanubia averages 1-2° C cooler than the Pannonian Plain (Ambrózy and Béll 1989).

The Carpathian Basin has no distinct rainy season, but rain is more frequent in May through July, contributing to the second of the two annual floods (see below). There is a smaller precipitation peak in the autumn. The Alps block much of the moisture from the west and rain is less frequent and regular than in Western Europe (Kosse 1979). Transdanubia is moderately dry to humid, with annual precipitation ranging from 550 to more than 900 mm. The highest levels occur to the west and in the highlands (Ambrózy and Béll 1989) due to orographic effects. Most of the Plain is classified as dry to moderately dry, with insufficient rainfall for crops in the growing season (Kosse 1979). Annual precipitation ranges from 450-600 mm. All of the Plain has an annual climatic water deficit,[11] with the central region, just north of the Tisza-Danube

[10] There are several competing climate classification maps based on the Köppen System, differing mainly in whether Central Europe's main climate zone, including the study area, should be considered temperate or cold (Kottek et al. 2006, Peel et al. 2007). Kottek et al. (2006) is used here as it corresponds more closely to most prior works in the region. Refer to this text for greater detail on the coding system and its attributes.

[11] A climatic water deficit occurs when potential evapotranspiration exceeds actual evapotranspiration and the difference between these two figures provides an estimate of drought stress on soils and plants.

interfluve, having the largest deficit, more than 350 mm (Ambrózy and Béll 1989). Consequently, droughts are fairly regular on the Plain, occurring roughly every three to five years, although years with excess rainfall are just as common. The average growing period is between 160-210 days (Kosse 1979).

Sub-Boreal Period

Understanding Holocene environmental variability is a challenging undertaking.[12] Past climates vary strongly by region, resulting from a complex interplay between atmospheric-oceanic interactions, atmospheric-vegetation feedbacks, trace gases, solar irradiance, and volcanism. Further, there are no universally accepted chronological stages outside of marine climate records (Cronin 2010:215-218). Following European traditions, the Bronze Age falls within the Sub-Boreal climate phase, which spans the period from c. 3800-700 cal. BC. The Sub-Boreal was much more unstable than the preceding Atlantic and subsequent Sub-Atlantic periods, with more frequent cold/wet periods, generally occurring every 200-500 years (Lozek 1997). These fluctuations are superimposed on a general cooling trend spanning the end of the Atlantic (warm) through Sub-Atlantic (cold). However, compared to today, the European Sub-Boreal is slightly warmer (1-2° C) and more humid on average (Lozek 1997). In the Carpathian Region, the Sub-Boreal is marked by maximum post-glacial wetland and forest development (Gyulai 1993; Onac 2002; Sümegi, et al. 2003).

Detailed climate reconstructions within the study area, particularly Romania, are not as well developed as in other parts of Europe (Mackay, et al. 2003). However, there has been a wave of recent research using pollen cores (Sümegi and Bodor 2000; Sümegi, et al. 2002; Tantau, et al. 2005) and speleothems (Onac 2002; Siklósy, Demény, Vennemann, Hegner, et al. 2007; Siklósy, Demény, Vennemann, Kramers, et al. 2007) that have substantially refined previous works (Járai-Komlódi 1987; Kordos 1987; Somogyi 1987). It is clear that climatic changes in the Carpathian Region do not necessarily correlate with well documented events elsewhere, either in timing, extent, or even direction, given the unique geographic location and physical/ecological attributes of the area. Therefore it is important to place emphasis on the

[12] A task that is especially complicated by the fact that most publications for the region do not state whether they are using calibrated dates or not, let alone which calibration curve they are using. This can lead to dramatic differences in phasing when periods last only 100-500 years. Where possible, original radiocarbon dates before present were calibrated by the author using CalPal (quickcal2007 ver.1.5).

available local records. As work continues to add more lines of evidence and study sites, it is expected that Holocene climate reconstructions for the region will be further improved and, for some periods, may produce significant changes from the following discussion.

Although there is some variability in climate reconstructions based on methodology and locality, a general picture of Bronze Age climate can be outlined for the Carpathian Region (Table 4.1). The Sub-Boreal begins with a cooling phase, around 3800 cal. BC, with temperatures falling dramatically from the Atlantic thermal optimum. The final Copper Age lies within a particularly warm and dry period within the Sub-Boreal, from roughly 3000-2700 cal. BC (Kordos 1987; Sümegi and Bodor 2000). The transition to the Bronze Age roughly coincides with a regional temperature minimum and humidity maximum, peaking at 2500-2300 cal. BC (Gyulai 1993; Kordos 1987), although this trend is not as strong in the highland areas (Onac 2002). After c. 2300, there are a series of short and less extreme climate fluctuations: 2300-2100 (warm/dry), 2100-1900 (cool/wet), 1900-1650 (warm/dry).[13] This latter warm period is sharply punctuated between 1700-1600 cal. BC by a strong but brief deterioration, linked to volcanic eruptions at Santorini (Siklósy, Demény, Vennemann, Hegner, et al. 2007; Siklósy, Demény, Vennemann, Kramers, et al. 2007).[14] Geomorphologic studies at Pecica and its immediate area have shown possible increased aridity and loess formation during the final Bronze Age occupation at the site (c. 1700 to post-1600 cal. BC) (Sherwood, et al. 2013). At the end of the Middle Bronze Age, around 1300 cal. BC, a final cooling trend occurs, which, unlike most events in the Sub-Boreal, corresponds to a very dry period. This cold, dry phase spans the Late Bronze Age, ending in a well-documented cold/wet maximum seen throughout Europe between 800-600 BC (Gábris 1998; Gyulai 1993; van Geel, et al. 1996). This marks the beginning of the current Sub-Atlantic Period.

[13] The severity of these fluctuations varies regionally, especially between highland and lowland areas.
[14] Note that a very similar climate record has been documented in the western Alpine region. There, the major cool/wet events at c. 2500 and 1600 cal. BC have been linked to settlement abandonment as lake levels rose (Shennan 2003).

Table 4.1: Summary of relative climatic conditions from the Late Copper Age through Late Bronze Age in the Carpathian Region

<table>
<tr><th>Dates cal. BC</th><th>Climate Conditions</th><th>Notes</th><th>Culture Phase</th><th>Maros Chronology</th></tr>
<tr><td>700</td><td rowspan="2">very cold, wet</td><td rowspan="24">temp min
Thera eruption
temp min
humidity max</td><td rowspan="7">Late Bronze Age</td><td rowspan="8"></td></tr>
<tr><td>800</td></tr>
<tr><td>900</td><td rowspan="5">cold, very dry</td></tr>
<tr><td>1000</td></tr>
<tr><td>1100</td></tr>
<tr><td>1200</td></tr>
<tr><td>1300</td></tr>
<tr><td>1400</td><td rowspan="2">cool, wet</td><td rowspan="7">Middle Bronze Age</td></tr>
<tr><td>1500</td><td rowspan="3">Late Maros</td></tr>
<tr><td>1600</td><td>cold, wet</td></tr>
<tr><td>1700</td><td rowspan="2">warm, dry</td></tr>
<tr><td>1800</td><td rowspan="3">Classic Maros</td></tr>
<tr><td>1900</td><td rowspan="2">cool, wet</td></tr>
<tr><td>2000</td></tr>
<tr><td>2100</td><td rowspan="2">warm, dry</td><td rowspan="6">Early Bronze Age</td><td rowspan="6">Early Maros</td></tr>
<tr><td>2200</td></tr>
<tr><td>2300</td><td rowspan="4">very cold, wet</td></tr>
<tr><td>2400</td></tr>
<tr><td>2500</td></tr>
<tr><td>2600</td></tr>
<tr><td>2700</td><td rowspan="4">very warm, dry</td><td rowspan="4">Late Copper Age</td><td rowspan="4"></td></tr>
<tr><td>2800</td></tr>
<tr><td>2900</td></tr>
<tr><td>3000</td></tr>
</table>

During the Early and Middle Bronze Age, these climactic fluctuations caused a number of important hydrological and ecological changes. Increased precipitation resulted in a higher water table, river down-cutting, and heavy flooding (Gábris 1998; Somogyi 1987), particularly after 2000 cal. BC, and bogs and marshes increased in extent. Heavy meadow-clays accumulated in backswamp areas (Sherratt 1984) and large areas of rich steppic chernozem soils were replaced by acidic brown forest soils (Gyulai 1993). The steppe-forest[15] on the margins of the Plain developed more closed forests, and in the interior regions, the forests changed composition. Overall, there was a loss of thermophilous species and mountain trees expanded

[15] Steppe-forest is a transitional ecozone between temperate grasslands and broadleaf or mixed forests.

into the lowlands, invading the typical open oak woodlands of the steppe-forest[16] (Járai-Komlódi 1987; Tantau, et al. 2005). Animal populations also changed with the environment; as forests expanded, so too did woodland species, particularly red deer (Bökönyi 1988; Choyke 1984).

Three major vegetation trends can be identified in regional pollen records (Sümegi, et al. 2003; Tantau, et al. 2005; Willis, et al. 1998). In the initial cooling phase from c. 3800-2500 cal. BC, hornbeam (*Carpinus spp.*) first appears and there is a dramatic spread of beech (*Fagus spp.*) at the expense of birch (*Betula spp.*), indicative of closing forests, while hazel (*Corylus spp.*), a warm climate species, slowly declines. From c. 2500-1500 cal. BC, hazels and oaks (*Quercus spp.*), the latter of which are the dominant lowland species, are replaced by beech-hornbeam forests in large areas. This reflects the continuing cooling trend, although there are minor oak expansions during warm peaks around 2200 and 1800 BC. In this period, there is a resurgence of birch, a pioneer species, which has been related to large scale forest clearance for expanding farm/pastureland and as fuel for Bronze Age metal production (Willis, et al. 1998). The final strong cold period from c. 1500-700 cal. BC sees another retraction of birch forests as the cold-adapted beech-hornbeam complex becomes regionally dominant. Note that while there was a great expansion of forests and wetlands in the Sub-Boreal, open steppe-forests remained in dryer, central portions of the Pannonian Plain.

Sub-Boreal climatic changes affected several aspects of Bronze Age socioeconomic organization. The overall precipitation increase favored settlement on higher areas away from floodplains to protect against heightened risk of inundation (see Chapters 5 and 6). The spread of forested areas created prime habitat for many important game species and increased the availability of wood as a fuel source, an often limited resource on the Plain. Agro-pastoral systems would have been altered to cope with the changing water regimes, soils, and vegetation. While arable land may have been reduced in many wet lowland areas, the increased humidity would have opened up other regions that were previously too dry for permanent settlement, particularly in the interfluves. Crop and animal husbandry would have placed more emphasis on water- and cold-tolerant species and changed scheduling and seasonal use of habitat types. There is preliminary evidence that pigs become preferred over ovicaprids in animal husbandry systems as a response to expanding forests and wetlands, particularly in Transdanubia, which is more wooded than the Plain (Bökönyi 1988; Choyke 1984).

[16] More detail on plant associations is presented in the ecology section.

GEOLOGY

This section presents a physical overview of the Carpathian Region, including its geologic history, hydrology, mineral resource distribution, and soil types. An understanding of these features is important as they helped to shape long-distance trade networks, settlement patterns, agro-pastoral systems, and even cultural boundaries. Maps are provided for the major regional subdivisions with places and features discussed in the text and tables marked (Figures 4.3 to 4.9).

Geologic History of the Carpathian Region

The Carpathian Region can be divided into a number of distinct geo-physical units. These include: 1) Carpathian Mountains, 2) Eastern Alps, 3) Dinaridies, 4) Transdanubia, and 5) the Pannonian Plain (Figure 4.2). The geologic history and major features of each of these regions is reviewed, along with the major river systems that tie them together. Focus is placed on the Pannonian Plain, Transdanubia, and the Carpathians, the regions in and adjacent to the study sites. This provides the framework for a more detailed discussion of natural resource distribution used in later chapters and contextualizes the locations of the various Bronze Age sites and cultures examined in this study.

Mountain Systems

There are three major fold and thrust mountain systems that encircle the Carpathian Region (Figure 4.2). The Carpathian Mountains are the largest group, forming a roughly 1450 km arc that comprises the northern, eastern, and southwestern border of the Basin (Bojňanksý and Fargašová 2007). To the west lie the Alps and to the southwest are the Dinaridies (or Dinaric Alps). The mountains are important both culturally and economically. They not only create a sharp geographic boundary, but also formed a strong social boundary through most of prehistory. In addition, they provide a wealth of natural resources, some of which helped to support the development of Bronze Age economies in the region. Focus is placed here on the Carpathian Mountains as they lie in greater proximity to the study area and most of the major river systems flowing into the eastern Pannonian Plain, along with their natural resources, derive from them.

The Carpathians are a geologically complex system that covers an area of approximately 209,256 km^2. Unlike the Alps to the west, the Carpathians rarely exceed 2500 m in elevation and lack large glaciers and snow-fields (Bojňanksý and Fargašová 2007). The Carpathians are traditionally divided into eight major geographic units (from northwest to southeast): the Inner and Outer Western Carpathians (IWC/OWC), Inner and Outer Eastern Carpathians (IEC/OEC), Transylvanian Plateau, Western Romanian Carpathians (WRC), and the Serbian Carpathians (Figure 4.3).[17]

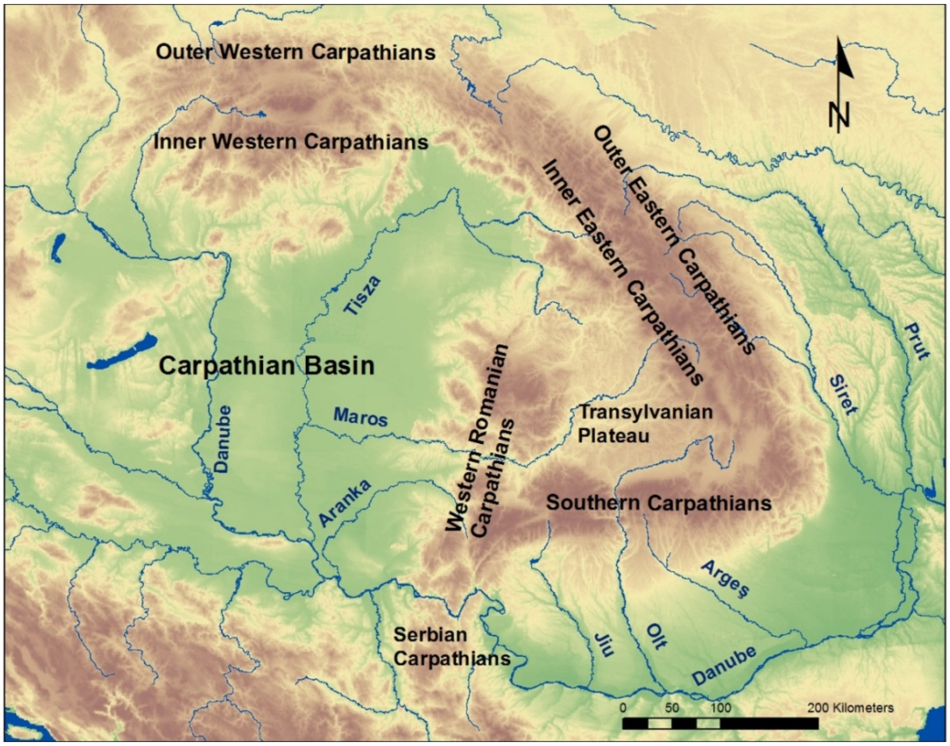

Figure 4.3: Major geographic divisions of the Carpathian Mountains

The Eastern Alps are higher and more glaciated than the Carpathians. The Eastern Alps are separated into three major geographic units: the Northern Limestone Alps, Central Eastern Alps, and Southern Limestone Alps (Figure 4.4). The Dinaridies run 645 km northwest-southeast, flanking the Adriatic Sea (Figure 4.5). The Dinaridies are a series of parallel ridges of

[17] In Romania, a different nomenclature is employed. In this system, the Eastern Carpathians are divided into three units from north to south, rather than Inner and Outer ranges: the Carpathians of Maramureş and Bucovina, Carpathians of Moldavia and Transylvania, and the Curvature Carpathians.

largely sedimentary rocks, divided into two major geologic zones: the external Adriatic Carbonate Platform (sea floor limestone) and the internal Nappe Belt.[18] To the east lies an ophiolite[19] belt called the Vardar Zone and the Serbo-Macedonian Massif follows the Velika Morava valley (Monthel, et al. 2001; Palinkaš, et al. 2008).

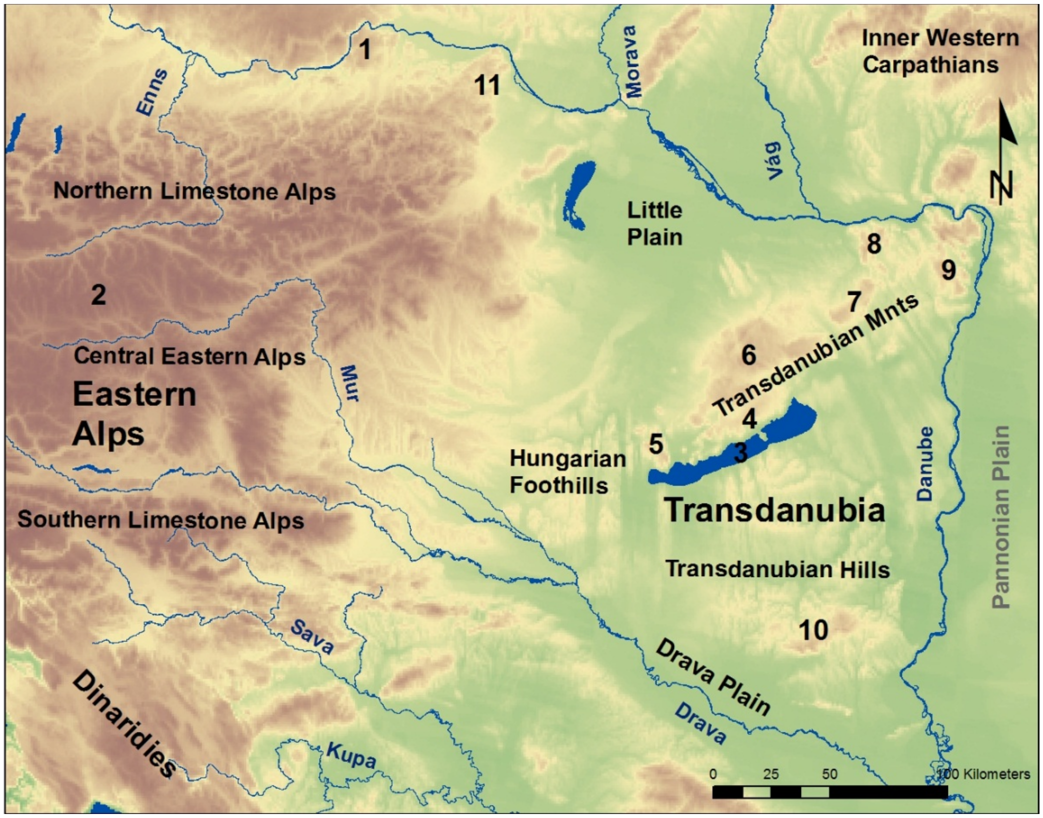

Figure 4.4: Eastern Alps and Transdanubia with features mentioned in the text. 1: Porta Hungarica/Devín Gate, 2: Tauern Mountains, 3: Lake Balaton, 4: Balaton Highlands, 5: Keszthely Mountains, 6: Bakony Mountains, 7: Velence Mountains, 8: Gerecse Mountains, 9: Buda Hills, 10: Mecsek Mountains, 11: Wien-Antonshöhe

The Carpathians, Alps, and Dinaridies were formed during the massive Alpine Orogeny that spans the Atlas Mountains to the Himalayas. This system began to form in the late Mesozoic and Tertiary as the African, Indian, and Cimmerian plates collided with the Eurasian continent (Moores and Fairbridge 1997). The core of the Alps and Dinaridies was created in the Oligocene and Miocene with the northward progression of African plate, forming large nappes

[18] Nappes are sheet-like rock formations that have been thrust many kilometers over an adjacent crustal plate, creating recumbent folds.
[19] Ophiolite is a section of oceanic crust and underlying mantle that has been uplifted over continental crust.

and thrust faults from sedimentary rocks of the Tethys Ocean[20] and the underlying crystalline basement. The Carpathians developed as the Alcapa, Tisza, and Dacia plates pushed over subducting oceanic crust.

Figure 4.5: The Dinaridies with features mentioned in the text. 1: Sana-Una Nappe, 2: Mid-Bosnian Schist Mountains, 3: Dinaridic Ophiolite Nappe, 4: Drina-Ivanjica Nappe, 6: Podrinje-Valjevo Mountains, 7: Rudnik Mountain Area, 8: Lece District, 9: Kopaonik District

The mountain systems of the greater Carpathian Region are all comprised of inner and external belts with different geologic origins. The outer ring of the Carpathian Mountains is the Flysch Belt, which is comprised of deep marine sediments from the Tethys Ocean. The division between the Outer and Inner Carpathians is the strike-slip fault zone of the Pieniny Klippen Belt.[21] The internal mountains are a complex system of up-thrust Precambrian and Paleozoic basement rocks (igneous and metamorphic) overlain by carbonate sedimentary deposits

[20] The Tethys Ocean was a large water body that formed between the Laurasian and Gondwana plates in the Triassic to the Cenozoic.
[21] This belt is marked by exposed limestone cliffs in many areas, particularly in the north.

(Földvary 1988). This internal range is also marked by a ring of volcanics that formed in the Middle Miocene over the sea floor subduction zone (Pácskay, et al. 2006). During the Pliocene, there was strong regional uplift of the mountains along with magma upwelling, volcanism, and of the Paratheys Sea in the central internal basin (Földvary 1988; Sommerwerk, et al. 2009).

The Carpathian Basin

The Carpathian Basin was part of the Paratethys Sea, a northern arm of the Tethys Ocean that formed between the Laurasia and Gondwanda land masses during the break up of Pangaea beginning in the Triassic period. As the mountains surrounding the Basin began to form in the Oligocene, the Paratethys was isolated from the Tethys. In the Middle Miocene the basin began to subside. At the same time, the major rivers of the region formed and began infilling the Paratethys, transporting massive quantities of sediment from the surrounding mountains. By the Pliocene, the Paratethys was a series of smaller water bodies, including the brackish Pannonian Sea which lay within Carpathian Basin. Infilling was accelerated during Pleistocene glacial periods, when megafans formed in the piedmont regions. The Danube River, in particular, formed a large internal delta within the Basin as the Pannonian Sea disappeared entirely (Földvary 1988; Sommerwerk, et al. 2009).

The modern Carpathian Basin is divided into two major units: Transdanubia, the hilly area west of the Danube, and the Pannonian (or Great Hungarian) Plain, the low-lying region to the east. Transdanubia differs markedly from the Pannonian Plain, both topographically and ecologically. This hilly region is largely covered by forests, receives more precipitation, and is slightly cooler than to lowlands to the east. Transdanubia is comprised of several major landscape units varying by topography and ecology (Borhidi and Pécsi 1989) (Figure 4.4). The Transdanubian Mountains comprise the most prominent geographic feature. These run northwest from Lake Balaton and have the highest elevations in the interior Basin, up to 450-500 masl. To the south is the lower Transdanubian Hills region, which includes Lake Balaton and the Mecsek Mountains. The Western Hungarian borderlands encompass the Alpine foothills and the Little Plain lies to the northwest. Lowlands are also found to the south along the Drava and Sava River basins bordering the Dinaridies, extending into the Serbian portion of the Pannonian Plain (Vojvodina) (Figure 4.5).

The Pannonian Plain is about 100,000 km² in area, bounded by the arc of the Carpathian Mountains and the Danube River (Figure 4.6). It is a low area, with elevations ranging from roughly 75 to 200 masl. It is bisected by the Tisza River which divides the Plain into two major components: the Danube-Tisza interfluve to the west and low Plain to the east. The interfluve is a dry, sandy region of the Pleistocene Danube fan and was only lightly occupied prehistorically. The eastern Plain is a mosaic of ecological zones, characterized by highly variable water-regimes, soil types, and vegetation classes (Kosse 1979; Sherratt 1983; Várallyay and Zilahy 1989). Much of the region falls within flood-prone basins of the Körös and Maros rivers. Drier areas are found on the Pleistocene megafans, including the Maros Fan, between the Körös and Maros rivers, and the Tisza Fan in the Nyírség. Importantly, given the surficial geology of the Plain, there are few available mineral resources other than in the river gravels.

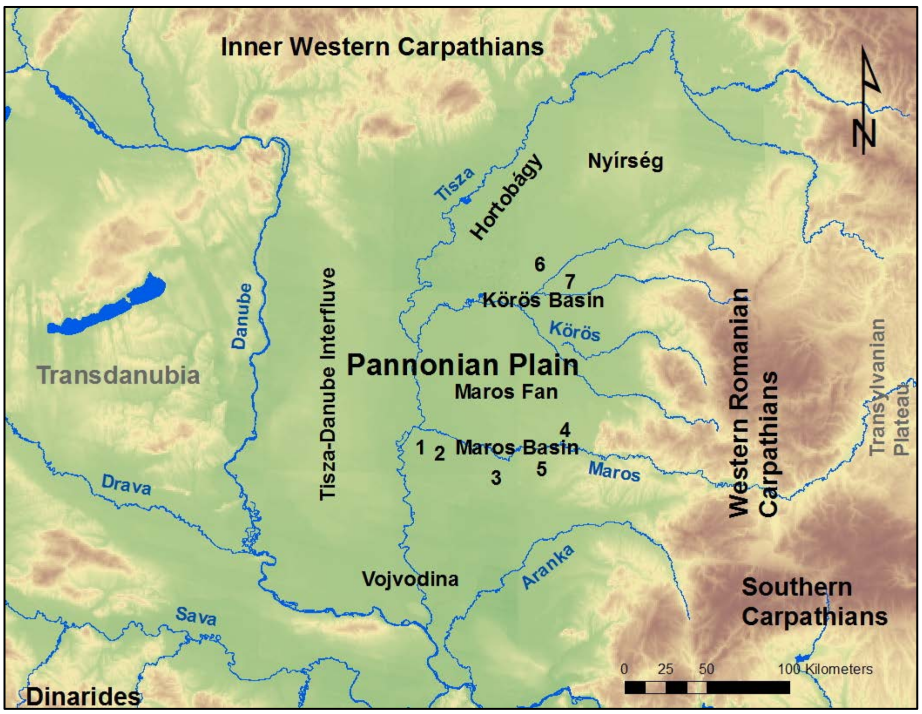

Figure 4.6: The Pannonian Plain with features mentioned in the text. 1: Tisza-Maros Angle, 2: Lower Maros region, 3: Middle Maros region, 4: Arad Plain, 5: Vingă Plain, 6: Nagy Sárrét (marsh), 7: Kis Sárrét (marsh)

Hydrology

Several major European rivers traverse the Carpathian Region, serving as critical routes for the movement of goods, people, and ideas across the landscape. Conversely, they also acted as physical barriers and often cultural boundaries during much of prehistory (O'Shea 2011). The rivers themselves, along with their adjacent floodplains, often were highly productive areas for natural resources, but also sources of destructive floods. Settlement patterns and economic systems in the Bronze Age demonstrate a negotiation of these factors.

Today's river systems in the Basin often bear little resemblance to those of even the recent past. The highly meandering and flood-prone rivers, particularly those on the Pannonian Plain, were largely canalized by the Austro-Hungarian Empire in the latter half of the 19th century to reduce the impact of these often catastrophic inundations. However, old rivers, lakes, and other wetlands have left a mark on the landscape. By combining various data sources, from historic maps to satellite imagery, it is possible to reconstruct the prehistoric waterways and their surrounding habitats (Gyucha, et al. 2011).

As discussed previously, the major rivers in the Carpathian Region first appeared in the Middle Miocene, draining the emerging coastal mountains into the Paratethys Sea and eventually filling in the Basin. By the Pleistocene, nearly all of the rivers had roughly attained their current positions (Gábris 1998; Sommerwerk, et al. 2009).[22] Recent work suggests that there has been little migration of the main river channels throughout the Holocene (Gyucha, et al. 2011).

Major River Systems

The Danube is the principal river in the study area, connecting the Carpathian Region with cultures spanning southern Germany to the Black Sea and beyond. It is the second longest river in Europe, travelling some 2850 km and draining an area of about 801,093 km^2 (Sommerwerk, et al. 2009). It enters the Carpathian Basin via the Porta Hungarica (Devín Gate) at the border of Austria and Slovakia (Figure 4.4). The Middle Danube stretch is marked from this point until it exits via the Iron Gate gorge on the Serbian-Romanian border (Figure 4.6). In the Basin, its major tributaries include the Drava, Sava, Velika Morava, and Tisza. In the Carpathian Basin, its floodplains are relatively narrow (~1 km) in the north but broaden below in central Hungary, averaging 4-8 km wide until entering the Iron Gates. In Transdanubia, the river basin is bounded by a relatively steep escarpment along its western flanks, along which many large fortified Bronze Age tells were situated. To the east and south, the floodplain is less

[22] There are a few notable exceptions. The Olt shifted from being a tributary to the Maros to the Danube directly in the Middle Pleistocene and, at the Pleistocene-Holocene boundary, the Tisza changed its course as a result of tectonic uplift in the northeastern Plain.

constrained as it meets the Pannonian Plain. The riparian zone along the Danube supports some of the highest freshwater biodiversity in Europe. It boasts the largest number of fish species, particularly in the Hungarian stretch, and serves as the most important bird migration corridor (Sommerwerk, et al. 2009).

The Tisza is the longest tributary to the Danube, flowing from the Ukrainian Outer Eastern Carpathians through the Pannonian Plain into the Danube in central Vojvodina, Serbia. It spans 965 km in length (about 1420 km prior to canalization) and drains an area of 156,087 km^2 (Sommerwerk, et al. 2009). The Körös and Maros Rivers are major tributaries to the Middle Tisza, flowing westward from the Romanian Carpathians (WRC/IEC, respectively). In the Pannonian Plain, the Tisza is a typical lowland meandering river. Its peak flow is in March and April and decreases rapidly at the end of winter snowmelt. The Tisza's floodplains are generally broad on both banks, averaging 5-8 km, similar in width to the Danube's section on the Plain. However, there is much less topographical relief compared to the Danube, which causes more extensive flooding. The Tisza has had more than 100 major floods in the past 30 years (Sommerwerk, et al. 2009). While the greater floodplain is quite large, like other rivers on the Plain it is generally constrained by a natural levee system that parallels the river bed to a width of 1-2 km. These levees are a critical source of rich, well drained soils that have attracted prehistoric settlement since the earliest Neolithic. The Tisza has very high biodiversity, more than most western European rivers, due to its extensive wetland habitats.

The Körös River runs 195 km largely east-west, running from the Apuseni Mountains (WRC) in Romania across the Pannonian Plain to the Tisza, and drains a 27,000 km^2 region of Hungary and Romania (Dóka 1997). It has three main branches, each originating from different parallel mountain valleys of the Apuseni's major ranges (Figure 4.7). The Fekete-Körös (Crișul Negru) and Fehér-Körös (Crişul Alb), both southern branches, merge near the Hungarian-Romanian border, forming the main trunk of the Körös. The Sebes-Körös (Crişul Repede) then converges with the main trunk from the north in east-central Hungary. On the Plain, the Körös river basin is bounded by the extensive wetlands of the Nagy- and Kis-Sárret to the north and the dry Maros Fan to the south (Figure 4.6). The river has a very low gradient upon entering the Plain, with elevation differences of only a few meters, which accentuates flooding during wet periods. Much of the area is poorly drained, and prior to prior to Austro-Hungarian river regulation, up to 1900 km^2 held standing water, forming heavy meadow clays. The Körös Basin also has significant salt-affected and peaty areas due to high water tables. In the past, habitation was largely limited to the better-drained levees along tributaries to the major channels, except for special-purpose sites on the primary rivers (Gyucha, et al. 2011).

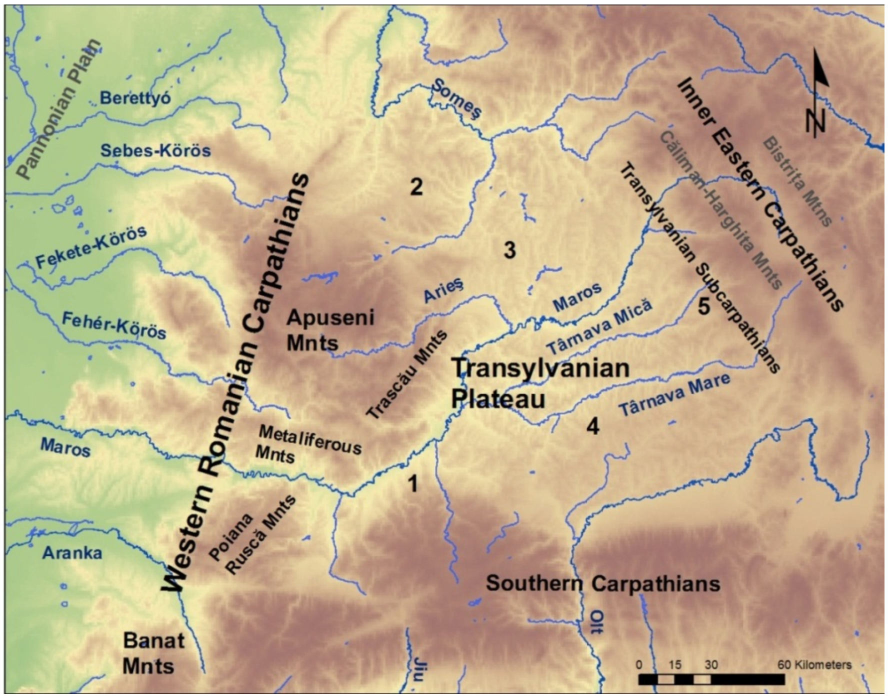

Figure 4.7: The Western Romanian Carpathians and the Transylvanian Plateau with features mentioned in the text. 1: Cerna Valley, 2) Someşan Plateau, 3) Transylvanian High Plain, 4) Târnavelor Plateau, 5) Praid salt mines

Lastly, the Maros (Mureş) River, which lends its name to the eponymous Maros Culture, lies to the south of and roughly parallels the Körös. It is 761 km long, originating in the Bistriţa Mountains (IEC), and drains about 30,000 km^2 (Kiss and Sipos 2007). It traverses the Transylvanian Plateau and enters the Pannonian Plain between the Metalliferous and Poiana Ruscă Mountains (WRC), joining the Tisza near the modern city of Szeged. In the Plain, the river has two distinct segments (Figure 4.6). Upon exiting the mountains, the Maros cuts through thick Pleistocene loess deposits of the Arad and Vingă Plains. In this area, termed here the Middle Maros, the floodplain averages 3-6 km wide and is bounded by relatively high bluff lines. After the large bend near the Hungarian-Romanian border, the river enters a low area similar to the Körös Basin, with little relief and extensive wetlands. This Lower Maros segment is particularly flood prone, especially near the Tisza-Maros confluence, and much of the area was permanently or seasonally flooded prior to river regulation.

Flooding Regime

Water is a critical factor in this region, with both droughts and flooding being serious risks to agriculture. During the Sub-Boreal wet periods, flooding would have been a particular challenge, although one that was relatively predictable in timing, if not extent. There are two annual floods within the Carpathian Basin, one in early spring due to snowmelt, and the other, which is more severe, in early summer (typically late May), during the regional precipitation maximum (Kiss and Sipos 2007). Prior to 19th century river regulation, the Tisza and Danube systems inundated about 2 million hectares each year, more than half of the area within the Carpathian Basin as a whole, and over two-thirds of the Plain (Kosse 1979). The Tisza and its tributaries tend to flood more severely than the Danube, with a difference of 3-4 meters in water level. Tisza floods occur when it is unable to discharge into the Danube due to corresponding high water peaks, which causes the water to back up and flood upstream. The very low river gradients, minimal relief, lack of natural water reservoirs, and fine sediments of the Plain serve to enhance the areal extent of inundations in this region (Gyucha, et al. 2011; Sommerwerk, et al. 2009). The most extensive flooding occurs in the greater Körös Basin and in the lower reaches of the Tisza and Maros (Balásházy and Somogyi 1989). Floods along the Maros are shorter in duration than along other rivers in the region, averaging only six days (Kiss and Sipos 2007). In most of the Pannonian Plain, the highest elevations are found along the natural levees, which tend to be flood free in most years. However, prior to regulation, the low-lying areas bounding the levees were seasonally flooded and internal basins often carried water year round.

Mineral Resources

The highlands of the greater Carpathian region are rich in a range of natural resources due to the complex geology of the area that includes a host of sedimentary, metamorphic, and igneous formations (see above). These resources include gold, copper, and other metallic ores, siliceous rocks for chipped stone technology, various metamorphic and igneous materials used in ground stone manufacture, amber, and salt. The distribution of these resources is fairly well documented in some areas, particularly in Hungary and countries to the north and west.

Unfortunately, less is known about their distribution in Romania and the Balkans, particularly for knappable stone. The following discussion is a basic overview of the types and locations of major inorganic resources, providing a baseline for outlining trade networks. Figure 4.8 illustrates the major mineral-producing regions, while Figures 4.4-4.7 and 4.9 provide more detailed reference maps for specific locations mentioned in the text. Summary tables for resource locations are presented for metals, amber, and salt (Table 4.2) and stone (Appendix Tables 4.1A and 4.2A).

Figure 4.8: Location of major mineral-producing areas within the Carpathian Region. Salt and amber (red A on map) distribution is illustrated for Romania only.

Metals

The importance of metal in the Bronze Age cannot be overstated. In this period, metals were transformed from primarily a means of status display to a commodity essential to the developing political economies of the period (O'Shea 2011). The most important metals in the Bronze Age were copper, gold, and especially tin, the latter of which is most limited in geographic distribution and abundance. While other metals, such as arsenic and antimony, were sometimes used in bronze alloys, they will not be considered in this limited summary of metal distribution.

Copper

Copper ores are found in three geologic settings: mafic igneous rocks, oxidized zones of copper sulfide deposits, and clastic sediments associated with mafic igneous rocks and glacial till (Rapp 2009:154). These rock types are frequent within the mountains encircling the Carpathian Region (Földvary 1988). Given their large distribution, only the general zones of copper ore will be discussed (Table 4.2). Copper occurs throughout the entire inner arc of the Carpathians, from Slovakia to western Serbia, located primarily in volcanic zones. In the Inner Western Carpathians, copper deposits are principally concentrated in the Slovakian Ore Mountains, but also occur in areas of the adjacent Low Tatras and Slovak Highlands (Figure 4.9). There are also trace amounts in the Matras (Brezsnyánszky and Haas 1989). To the east, copper is distributed along a nearly continuous zone from the Interior Eastern to Southern Carpathians in Romania. The Western Romanian Carpathians (WRC) contain large deposits, including both the Banat and especially the Apuseni Mountains (Figure 4.7) (Boroffka 2006). The locations of these WRC sources, which are closest to the Maros culture area, are too numerous to list here, but are treated in some detail in Papalas (2008). In the Serbian Carpathians, the largest deposits are found in the Timoc district, an area that currently is one of the greatest copper producers in Europe (Monthel, et al. 2001) (Figure 4.5).

In the Eastern Alps, significant copper ores are concentrated in the Northern Limestone Alps, especially in central Austria (Figure 4.4). There is also copper in the Erzgebirge (or Ore) Mountains and surrounding chains along the Czech-German border, although these fall outside the study area. However, this area is important as it houses major tin deposits as well (see below). To the south, copper ores exist in pockets along the length of the Dinaridies in the Nappe Belt, from Slovenia to Serbia and Montenegro, with particularly rich deposits in the Mid-Bosnian Schist (or Ore) Mountains of the Durmitor Nappe (Figure 4.5) (Palinkaš, et al. 2008). There are also sources throughout the Vardar Zone, with the closest to the Pannonian Plain found in the Podrinje-Valjevo Mountains, and in the Serbo-Macedonian Massif (Monthel, et al. 2001).

Table 4.2: Location of major mineral resources in the Carpathian Region

Resource	Range	Region	Important Locales
Copper	Inner Western Carpathians	Slovakian Ore Mountains	
		Slovakian Highlands	Zvolenská Basin
		Low Tatras	Starohorské Hills
		Matras	
	Inner Eastern Carpathians		
	Western Romanian Carpathians	Apuseni Mountains	
		Banat Mountains	
	Southern Carpathians		
	Serbian Carpathians	Timoc District	
	Dinaridies	Sava Nappe	
		Pannonian Nappe	Sana-Una Nappe
			Drina-Ivanjica Nappe
		Durmitor Nappe	Mid-Bosnian Schist Mountains
		Dinaridic Ophiolite Nappe	
		Vardar Zone	Podrinje-Valjevo Mountains
		Serbo-Macedonian Massif	
	Northern Limestone Alps		
Gold	Inner Western Carpathians	Tatras	
		Fatras	
		Slovakian Ore Mountains	
		Slovakian Highlands	Kremnica
		Tokaj-Zemplén Mountains	
		Slanské Mountains	
	Inner Eastern Carpathians	Vihorlat-Gutin Area	Oaş-Ţibliş Mountains
		Bistriţa Mountains	
		Caliman-Harghita Mountains	
	Southern Carpathians	Parâng Range	
		Făgăraş Range	
		Getic Subcarpathians	
	Western Romanian Carpathians	Apuseni Mountains	Metalliferous Mountains
		Banat Mountains	
	Serbian Carpathians	Timoc District	
	Dinaridies	Durmitor Nappe	Mid-Bosnian Schist Mountains
		Vardar Zone	Kopaonik District
		Serbo-Macedonian Massif	Lece Mountain District
	Central Eastern Alps		Tauern Mountains
Tin	Dinaridies	Vardar Zone	Podrinje-Valjevo Mountains
		Durmitor Nappe	Mid-Bosnian Schist Mountains
	Inner Eastern Carpathians	Maramureş Mountains	Băile Borşa (?)
Amber*	Western Romanian Carpathians	Apuseni Mountains	Metalliferous Mountains
	Transylvanian Plateau	Târnavelor Plateau (southern)	
	Outer Eastern Carpathians	Bucovina Ridges	Vama
		Moldavian Subcarpathians	
		Buzău Mountains	Colţi
	Southern Carpathians	Getic Subcarpathians	
Salt*	Transylvanian Plateau	Transylvanian Subcarpathians	Praid
		Târnavelor Plateau	
		Someşean Plateau	
		Transylvanian High Plain	
	Innner Eastern Carpathians	Maramureş Depression	
	Outer Eastern Carpathians	Sucevei Plateau	
		Moldavian Subcarpathians	
		Muntenian Subcarpathians	
	Southern Carpathians	Getic Subcarpathians	

*Amber and salt sources are only listed for the Romanian Carpathians

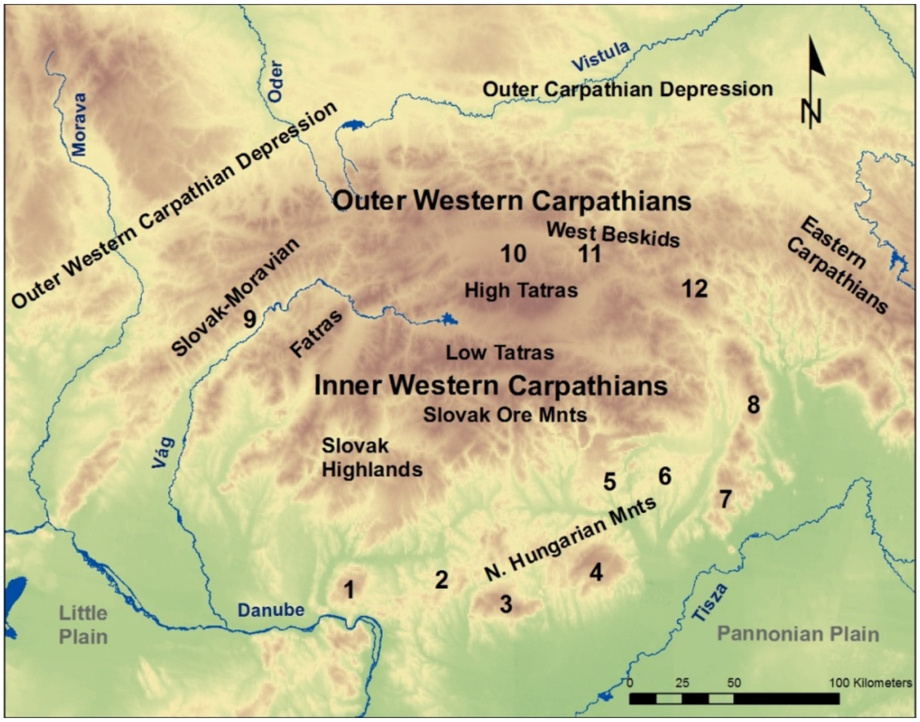

Figure 4.9: Inner and Outer Western Carpathians with features mentioned in the text. 1: Börzsöny Mountains, 2: Cserhát Mountains, 3: Matras, 4: Bükk Mountains, 5: Rudabánya and Szendrő Mountains, 6: Cserehát Mountains, 7: Tokaj-Zemplén Mountains, 8: Slanské Mountains, 9: Vlára Pass, 10: Ovara Beskids/Podhale Basin, 11: Pieniny Mountains, 12: Čergov Mountains

Gold

Like copper, gold is found in many regions of the Carpathians (Table 4.2), typically associated with other metallic ores in areas with high-silica (felsic) igneous rocks and quartz veins (Rapp 2009). In the Inner Western Carpathians, there are extensive gold deposits in the Fatra-Tatra system and adjacent regions of the Slovakian Ore Mountains and Highlands. This includes the Kremnica site, which was the location of the Hungarian National Mint from 1328-1918. There is also gold to the east in the volcanic formations of Tokaj-Zemplén and Slanské Mountains (Brezsnyánszky and Haas 1989; Földvary 1988) (Figure 4.9).

Gold exists in large deposits in the Western Romanian Carpathians, particularly the Apuseni Mountains, with smaller lodes in the Banat Mountains to the south (Boroffka 2006; Institutul de Geodezie 1982) (Figure 4.7). The Apuseni gold mines have been famed since at least the Roman Period (Földvary 1988; Rapp 2009). Here, gold (and numerous other metals, including copper, silver, and antimony) is found primarily in the Metalliferous Mountains, which are drained by both the Maros and Körös systems. In the Serbian Carpathians, gold is located in the Timoc District (Monthel, et al. 2001).

To the southwest in the Dinaridies, gold is found principally in the Kopaonik District of the Vardar Zone and adjacent Lece District of the Serbo-Macedonian Massif (Monthel, et al. 2001) (Figure 5.5). There is also gold in the rich ore bearing deposits of the Mid-Bosnian Schist Mountains (Palinkaš, et al. 2008). In the Eastern Alps, gold is housed in various metalliferous regions, perhaps most famously the Austrian Tauern Mountains (Figure 4.4), where gold has been extracted for at least 3000 years (Rapp 2009). In the Inner Eastern Carpathians, gold is found with copper ores in an arc from the Oaş-Ţibliş Mountains (Vihorlat-Gutin Area) into the northern portions of the Bistriţa and Caliman-Harghita Range. The Southern Carpathians also house gold, primarily in the Olt Valley between the Getic Subcarpathians and the interior Parâng and Făgăraş Ranges (Boroffka 2006; Institutul de Geodezie 1982). These Alpine and Eastern Carpathian sources are more distant from the study area and were less likely to have been important sources for the cultures in question.

Tin

Tin is a critical metal in the production of bronze, being one of the most commonly used metals for bronze alloys. *Cassiterite* is the primary tin ore, found within granites, pegmatites, and quartz veins, and is generally recovered through alluvial placer deposits. Tin distribution is very limited in Europe, with major sources in southwest England, Iberia, western France, Italy, Sardinia, and Germany/Czech Republic. Smaller deposits are also found in Bosnia-Herzegovina, Serbia, and perhaps Romania (McGeehan and Taylor 1987; Rapp 2009).

The largest tin sources near the Carpathian Region are found in the Erzgebirge Mountains along the German-Czech border and the adjacent Fichtelberge Range in Bavaria (Rapp 2009). However, there are a number of less well known sources within the Dinaridies and Carpathians (Table 4.2). There is tin in alluvial deposits draining the Podrinje-Valjevo Mountains (Vardar Zone) along the Serbian-Bosnian border[23] (McGeehan and Taylor 1987; Monthel, et al. 2001) (Figure 4.5). Tin is also found in the Vrtlasce deposit of the Mid-Bosnian Schist Mountains (Durmitor Nappe) (Palinkaš, et al. 2008). Sources have been suggested in the Maramureş

[23] This includes the localities of Iverak, Cigankulja, and Cer Mountain.

Mountains (IEC) (Radulsecu and Dumitrescu 1966)[24] and Southern Bulgaria (Taylor 1989) as well.

Importantly, it is not yet known which deposits were being exploited prehistorically. As Rapp (2009:171) aptly states, "[t]he literature is full of misinformation, or at least uncritical reporting, concerning ancient tin sources." Some of these smaller deposits, particularly those in the Carpathians, have not been substantiated and do not appear in the more recent geological surveys of Romania (Boroffka 2006; Institutul de Geodezie 1982). Further work is needed to evaluate potential tin sources in the region and to provide evidence of prehistoric extraction.

Amber

Amber is an organic fossil resin, hardened through the heat and pressure of overlying sediment. Globally, there is a variety of amber types, having different plant sources and chemical composition. The European ambers are conifer resins, mostly falling into the *succinite* class (Rapp 2009). Amber is one of the most important long-distance exchange items prehistorically. The vast majority of high-quality amber is from the Baltic Coast, concentrated near the modern Russian city of Kaliningrad. Well-established trade routes spanned the Baltic Sea to the Mediterranean by at least the Bronze Age. Most, if not all, amber found archeologically is assumed to derive from these northern sources, as the majority of analyzed artifacts do match this chemical signature. However, there are amber sources elsewhere in Europe, including Sicily, Spain, southern Poland, and Romania (Rapp 2009), which have not been extensively studied.

Romanian amber, or *romanite*, has been found in four geographic zones (Figure 4.8, Table 4.2). There is a small source on the Black Sea coast in Dobrogea, another in the Metalliferous Mountains of the Apuseni Range, several scattered along the southern edge of the Târnavelor Plateau (Transylvanian Plateau), and a large number located throughout the external arc of the Outer Eastern Carpathians and Southern Carpathians, contiguous with the extensive salt springs (see below) (Boroffka 2006). Amber from several of these latter sources has been analyzed through gas chromatography and compared against various Baltic sources. The small

[24] Casserite sources at Racoşul de Jos (Caliman-Harghita Mountains, IEC) and Camena (Northern Dobrogean Plateau) are listed as "doubtful." There are also stannite traces associated with copper deposits at Hondol in the Metalliferous Mountains (WRC) and with gold at Valea lui Stan (Făgăraş Mountains, Southern Carpathians) (Radulsecu and Dumitrescu 1966).

deposits in the Bucovina Ridges and Moldavian Subcarpathians differ chemically from the Baltic sources and are not related to any known archaeological materials (Heck 1999). Recent work has demonstrated that the largest, most accessible sources near Colţi (Buzău Mountains) now can be distinguished from Baltic supplies as well (Teodor, et al. 2010). This study has established that this amber source was being exploited by at least the Late Bronze Age (Hallstatt A1). Further research is needed to produce chemical signatures for other amber sources in the region. Additionally, chemical testing of Early and Middle Bronze Age artifacts is required to establish their origin and to assess the possibility of Carpathian traders supplementing or by-passing the Baltic amber routes in this period.

Salt

Although not commonly included in discussions of regional exchange, salt has been a significant trade commodity prehistorically and to the present day. Mineral salt, or halite, is comprised primarily of sodium chloride ($NaCl$), formed through evaporation of sea water. It was a central component in food preservation in the pre-industrial era, as well as being used for tanning, cheese making, and as a dietary supplement for both humans and animals. Historically, in the Carpathian Region, salt from Transylvania was shipped down the Maros to Szeged, Hungary, a major distribution node (O'Shea 2011). Salt has been extracted in the Carpathians since at least the Neolithic. In the salt springs of eastern Romania and Bulgaria, salt has been produced through boiling brine as early as 6000 BC (Nikolov 2011; Weller, et al. 2011). The mining of salt appears to be later, with Late Bronze Age materials found in mine shafts in Transylvania, Romania (Boroffka 2006; Cavrue and Harding 2011) and in the Austrian Alps (Grabner, et al. 2007).

Salt has a fairly wide distribution. Major halite beds are found in Triassic sedimentary rocks throughout Central Europe (Rapp 2009), including in all three of the major mountain systems forming the greater Carpathian Region. Romania is one of the leading salt producers in the world. It is home to one of the two European salt domes, creating large beds in the Transylvanian Plateau (Figures 4.7-8) and salt springs throughout the Outer Eastern and Southern Carpathians and their adjacent Subcarpathian Ranges (Boroffka 2006; Institutul de Geodezie 1982). Given the extensive nature of salt deposits in the region (Table 4.2), focus is placed here on the sources closest to the major waterways entering the study area.[25] These are located in the Transylvanian Plateau.

The Transylvanian salt deposits occur along the edges of the Plateau and surrounding highlands, forming a large arc in the northern half of the region and smaller, isolated patches to the south. Today, the most economically important salt sources are found in two primary areas (Figure 4.7). The first is found to the east in the Transylvanian Subcarpathians at the base of the Căliman-Harghita Mountains (IEC). Here, thick salt beds (42-96 m thick) are in places exposed as surface cliffs, such as at the famed Praid salt mines. To the west, there are deposits in the southern Târnavelor Plateau and along the Someş River. Salt is also available to the north in the Maramureş Depression (IEC) (Földvary 1988). The more northerly sources in the Transylvanian Plateau connect with the Tisza drainage system, while the southern deposits lie near the Maros and its tributaries.

Stone

During the Bronze Age, chipped stone was still used for many types of household tools despite the introduction of metals, although their frequency is greatly reduced from preceding periods. Chipped stone tools include sickle blades, prismatic blades, borers, scrapers, and points. Groundstone technologies were also maintained, particularly for axes, querns, ornaments, and metallurgical molds. As stone resources are largely absent from the Pannonian Plain, with the exception of river gravels, these materials were often imported within the same highland trade networks that brought in more valuable goods.

There is a very large number of economically useful stone types in the greater Carpathian region (Biró 1998, 2002, 2009, 2011; Crandell 2008, 2009), a full review of which is beyond the scope of this dissertation. More detailed sourcing and typological information is presented in Appendix 4.1. Knappable microcrystalline stone has a very wide distribution in the various mountain ranges encircling the Basin, as well as in interior uplands (Appendix Tables 4.1A and 4.2A). The most common and widespread types are cherts and related cryptocrystalline materials found in sedimentary outcrops throughout the region's highlands. There is also a large number of stone sources found in areas of volcanic and hydrothermal activity, especially in the

[25] The Outer Eastern and Southern Carpathian Sources have drainage systems that bypass the Carpathian Basin, flowing directly into the Lower Danube, primarily via the Siret and Olt, respectively.

Inner Western Carpathians and the Western Romanian Carpathians. Most notable of these are the obsidian deposits of the Slanské and adjacent Tokaj-Zemplén Mountains along the boundary of northeast Hungary and southeastern Slovakia (Figure 4.9). These regions also host a variety of economically important coarse-grained metamorphic and igneous stone used in groundstone technologies.

Soils

The Carpathian Basin is part of the westernmost extension of the Eurasian Pleistocene loess belt. The most common sediment in the region is infusion (or redeposited alluvial) loess that bounds major drainages and surfaces of alluvial fans. Primary loess covers much of the Transdanubian foothills, which can achieve depths of up to 50 meters, as seen along the Danube bluff, where many Nagryév/Vayta fortified tells are situated. On the Plain, loess overlies Plio-Pleistocene deposits to depths of 1500 meters (Pécsi 1997; Várallyay and Zilahy 1989). While the Carpathian Basin shares similar sediments, local soil development is highly variable, resulting from the complex interplay between underlying geology, climate, hydrology, vegetation, and human activities (Várallyay 2005). Brief descriptions of the major soil classes are presented here as they provide a better understanding of the local landscape, ecology, and agro-pastoral potential in the areas surrounding the study sites (see Chapter 6). Due to the vast array of soil types, focus is placed here on the Pannonian Plain.

Following the classification system used regionally, there are four major soil types on the Plain: chernozems, alluvium, meadow clays, and solonetzes (Kosse 1979; Munteanu, et al. 2005; Tóth, et al. 2005; Tóth n. d.; Várallyay 1989, 2005; Várallyay and Molnár 1989; Várallyay and Zilahy 1989). In highland areas, brown forest soils are common and would have been present in some lowland, wooded areas during the Sub-Boreal (Gyulai 1993). Regional soil types are correlated to standard FAO nomenclature when possible (Michéli, et al. 2006).

Chernozem soils are located primarily on the loess and loess-like soils of the major Pleistocene alluvial fans, although they also appear in dissected loess islands and plateaus within lowland areas. They form in relatively flat areas with hot summers, cold winters, low rainfall, and rapid evaporation with groundwater less than five meters below the surface. Chernozems are basic (from high carbonate levels) and associated with tall-grass steppe (Michéli, et al. 2006).

They have a very thick humus layer that can reach 1.5 meters thick in Hungary.[26] Chernozems are among the most fertile soils in the world; however they develop in drought prone regions and may be covered by heavy sods that are difficult to break up. They often become salt affected as well (Tóth n. d.). In the Basin, meadow chernozems, those with high water tables, are the most fertile (Kosse 1979). These tend to be found on the edges of higher loess deposits and lowland floodplains or basins. In the Bronze Age, settlements tend to be concentrated in these areas (see Chapter 5).

As the name implies, *brown forest soils* form in wetter, forested areas, largely in the upland regions of the Carpathian Basin, and tend to be acidic. In highlands, they mostly fall within the cambisols, which show only weak horizon development as they generally form on recent Pleistocene deposits in cooler climates. They are quite variable in their fertility. In many areas, particularly uplands with coniferous trees, forest soils are affected by leaching and podsolization (podzols), where they are only suitable for grazing (Michéli, et al. 2006). However, they can be highly fertile when they lose acidity and develop a rich organic layer as they grade towards chernozems (phaeozems) (Kosse 1979). These areas are common in Transdanubia.

Alluvium forms in major river floodplains. It is a fluvisol that is comprised of recent alluvial deposits with weak horizon stratification (Michéli, et al. 2006). In the Plain, the alluvium is typically comprised of infusion loess, although sand and clay are present depending on river grade and sediment load, with more clayey soils towards the lowlands. Although humus development is typically disrupted by seasonal flooding and sediment reworking, in drier areas fertile topsoil can form, grading into alluvial chernozems or meadow soils (see below). Well drained alluvium can be very productive and it is easily worked, particularly along natural levees. These levees were frequently occupied prehistorically and were prime farmland prior to the introduction of the plow (Kosse 1979). Alluvium is associated with various riverine habitats, particularly gallery forests and reedy marshes, depending on drainage.

Along small creeks, in poorly drained basins away from the active floodplain, and in areas with high water tables, heavy, wet soils form, called *meadow clays*. They vary in their composition, but are fine grained and typically have a very thick humus layer. The meadow clays generally fall within the vertisols and gleysols. Vertisols develop in areas with heavy clays

[26] It is from this rich humus layer, or “black earth,” that its name is derived from Russian.

that alternate between very dry and wet conditions, forming deep cracks in the dry season. Grasslands are common to vertisols, but forests may develop as well. Their poor drainage, drought susceptibility, and heavy sediments make them poor agricultural land without modern farming machinery, but are suitable for grazing. Gleysols are wetland soils that are saturated with groundwater for most or all of the year, forming a characteristic gleyic color pattern. They tend to develop on Pleistocene or Holocene sediments and can range from basic to acidic pH. In waterlogged areas with high humus, such as in oxbow lakes, acidic peaty bog lands develop (histosols). On the Plain, it is more common for the soils to be alkaline, grading into meadow solonetzes. Vegetation cover is wet sedge meadows or forested swamps and, because of frequent standing water, they are often only suitable for seasonal pasturage (Michéli, et al. 2006). Where dry enough to be cultivated, meadow clays are more fertile in areas with carbonate in the soil (Tóth, et al. 2005).

Solonetz is a type of salt-affected or alkali soil found in dry steppe regions with a high water table. There are a variety of types based on depth to salty groundwater. In areas with very high groundwater, as occurs frequently along the eastern Danube floodplain, solonchaks develop. True solonetz, having a water table one to two meters below ground surface, is most common throughout the eastern Plain, particularly in the Körös drainage and the Hortobágy (Figure 4.6). Here they form in poorly drained basins in zones between chernozems and meadow clays with stagnant saline groundwater. They are highly structured with a clayey horizon that is strongly alkaline (>8.5 pH) and contains free sodium carbonate. Alkali soils are vegetated by salt-tolerant grasses. In areas with high water tables (e.g., solonchaks and meadow solonetz), the land can only be used for pasture. Some solonetzes can be cropped if there is sufficient topsoil development (Tóth, et al. 2005; Tóth n. d.).

BIOTA

Flora

The Carpathian region is richly vegetated, with over 6,000 native species. Floral regions vary largely by altitudinal zones, particularly in the highlands (Bojňanksý and Fargašová 2007). In the Plain, regional soil classes and hydrology play a strong role in shaping local ecosystems (Deák 2005). A brief discussion of major vegetation zones and useful plant resources is presented in this section, along with a more detailed discussion of lowland systems characteristic of the study areas during the Bronze Age.

Highland Flora

In prehistoric times, most of the hilly and mountainous regions were covered by forests. While there have been a number of climatic fluctuations during and since the Bronze Age, the relative position of the current altitudinal vegetation zones would have been similar, with changes occurring primarily as vertical displacement of these ecozones with changes in temperature. The highest elevations, up to 1850 m, are covered by alpine and subalpine meadows. The alpine grasslands are dominated by low-quality graze species such as matgrass (*Nardus stricta*) and tufted hairgrass (*Deschampsia caespitosa*), but also contain sedges (*Carex spp*.) and sheep fescue (*Festuca ovina*), amongst others. These zones are used extensively for sheep pastures. The adjacent sub-alpine (or dwarf pine) zone is often covered with thick shrubby areas that contain mugo pine (*Pinus mugo*), dwarf juniper (*Juniperus nana*), rhododendron (*Rhododendron kotschyi*), and green alder (*Alnus viridis*) (Bojňanksý and Fargašová 2007).

The high mountain (or spruce) forests are found from roughly 900 to 1600 m. Above 1200 m, beech cannot grow and the forests are comprised largely of fir (*Abies alba*), pine (*Pinus spp*.), larch (*Larix spp*.), and ash (*Fraxinus spp*.). A lower mixed belt contains beech (*Fagus sylvatica*), spruce (*Picea abies.*), and fir. Like the Alpine zone, this region is used primarily for pasturage. The lower mountain (or beech) forests develop between 500-600 m up to approximately 1000 m. As the name implies, this zone is comprised primarily of beech forests. The lower portions of this zone contain some oak (*Quercus spp*.), maple (*Acer spp*.), birch (*Betula spp*.), and ash. The beech forests, in addition to providing mast, house a number of species with edible fruits, including members of the blackberry family (*Rubus spp*.), elderberries (*Sambucus spp*.), and currants (*Ribes spp*.). Historically, cleared beech zones were generally only cultivated with oats.

The lowest forest zone occurs from the plain margin up to 600 m. It is a deciduous and mixed forest zone containing primarily oak, but also maple, birch, pine, elm (*Ulmus* spp.), hornbeam (*Carpinus* spp.), and linden (*Tilia spp*.) (Bojňanksý and Fargašová 2007). This zone is rich in mast and other fruits, including open woodland species like Cornelian cherry (*Cornus mas*) and wild apple (*Malus sylvestris*). In the Bronze Age, the lower forest expanded into large areas of the Pannonian Plain (Gyulai 1993). Today, much of this forest has been cleared for agricultural use.

Lowland Flora

Much as the highland vegetation falls into adjacent zones based on elevation, the lowland flora tends to form zones based on hydrology. The region falls within the Pannonicum flora province, a subdivision of the greater Europannonicum area (Deák 2005). The Pannonian Plain is the westernmost part of a large belt of steppe-forest that runs east through Siberia, acting as a transitional zone between temperate grasslands (steppe) and broadleaf/mixed forests. The steppe-forest is a grassland region interspersed with woodlands, typically containing pendunculate oak (*Quercus robor*), but also hairy oak (*Q. pubescens*), silver linden (*Tilia tomentosa*), and tartar maple (*Acer tataricum*). The region is punctuated by a number of wetland habitats that vary by drainage and water/soil chemistry, forming belts paralleling rivers and wet basins (Kosse 1979; Sümegi and Bodor 2000).

Dry-steppe and steppe-forests on loess and sand

The flood free loess and sandy soils found in slightly higher elevations on the Plain, including Pleistocene terraces and major alluvial fans, support the steppe-forests that epitomize the Pannonicum floral zone. On the sandy soils typical of the Tisza-Danube interfluve and the Tisza fan in the Nyírség region (Figure 4.6), sand steppe forests are found. These are dominated by fescue-pendunculate oak associations. These forests grade into closed woodlands where there is sufficient water supply. These areas make low-quality farmland as the sandy soils have poor water retention, but can be used for grazing.

Much of the dry, loessic portions of the Plain, including the Maros Fan, western Nyírség, and the western flank of the Danube, develop chernozem soils that are covered by open, loess-steppe oak forest. The dominant trees include the pendunculate and hairy oak, turkey oak (*Q. cerris*), tartar maple, and field elm (*Ulmus minor*), which become more common with increasing moisture. In addition to the frequent mast-bearing species, other useful dry-climate species occur, such as slow blackthorn (*Prunus spinosa*). In the driest parts, trees are rare to absent and true steppe-grasslands form. Here alkali loess-steppe elements occur more commonly, including sage-fescue (*Salvia-Festucetum*) associations. Where chernozems form on moister alluvial loess, meadow-steppe vegetation occurs, characterized by the Aster-Hog's fennel (*Aster punctatus-Peucedanum officinale*) association (Deák 2005; Kosse 1979; Sümegi and Bodor 2000). Because steppe-forest develops on chernozems, this region has rich agricultural lands as well as high-quality pasture.

Salt-tolerant vegetation on solonetz

Solonetz soils are widespread throughout the region. They are frequently found in zones between loess meadows and floodplains and in old oxbow lakes. These salt-affected areas are common in the Körös basin, the Hortobágy, and in pockets throughout the Maros Fan. In the most salty soils, alkali-sodic grasslands develop with a hardy yarrow-sagebrush (*Achillea-Artemisia*) association. Alkali-sodic meadows form in moister areas. In the Maros region, this habitat is currently dominated by meadow foxtail (*Alopecurus pratensis*). Other major salt-tolerant species include sodic fescue (*Festuca pseodovina*), salt-meadow grass (*Puccinellia limosa*), and *Camphorosma ovata*, ranging from least to most tolerant respectively. The final association is an alkali-sodic oak forest with pendunculate oak and tartar maple (Deák 2005; Kosse 1979). The salinity of the solonetz soils precludes this zone from being fertile cropland but it can be used for pasture.

Alluvial vegetation

Along major rivers, a succession of reed beds to riparian forests develops. Closest to the river's edge , open water reed-grass, floodplain meadow/sedgefield, and floodplain swamps occur, characterized by reeds (*Scirpo-Phragmitetum*), tall sedges (*Magnocaricion*), and shrub willows (*Salix spp*.), respectively. Further back in the floodplain, there is a willow-poplar association (*Saliceto-Populetum*) with a dense shrub layer in which dewberries (*Rubus caesius*) frequently occur. In drier zones, particularly on the natural levees, elm-ash-oak forest emerges (*Querco-Ulmetum hungaricum*), with pendunculate oak, field elm, and sharp-pointed ash (*Fraxinus angustifolia*) being most common. Wild grapes (*Vitis silvestris*) also grow in this environment (Deák 2005; Kosse 1979; Sümegi and Bodor 2000). While most of these riparian zones are too wet to farm, they provide rich seasonal pasture and fodder. The drier elm-ash-oak areas on levees, while of limited extent, make fertile, well drained farmland.

Stagnant water associations

Other wetland associations develop in poorly drained areas away from active river channels. These stagnant water habitats are very common in the Körös basin and Tisza-Maros angle (Figure 4.6) and in pockets in many other low, wet areas in the Plain. They tend to follow the distribution of meadow clays. Local depressions carry reed beds and tussocks with clump sedges (*Carex elata*). Wet grass-moor forms in acidic, peaty areas with stagnant waters dominated by large rush (*Juncus subnodulosis*) and fenland sedge (*Carex davalliana*). As more trees develop, these marshy areas transform into a shrubby fen then wet-forest carr, which are the equivalent to wooded swamps in North America. Common species include sharp-pointed ash, grey willow (*Salix cinerea*), and resinous alder (*Alnus glutinosa*). In bogs, which are fed by rain water instead of groundwater, beeches are typical (Járai-Komlódi 1987; Kosse 1979). The high water table and often acidic soils in these poorly drained basins are generally not arable but can be used as seasonal pastures.

Anthropogenic Changes

Pollen cores throughout the Carpathian Basin demonstrate substantial human alteration of the environment since at least the Middle Neolithic (Willis, et al. 1998). Significant deforestation events appear to coincide with either major population expansions (i.e., land clearance for cultivation) or peaks in metal working. Both of these factors are found in the Early and Middle Bronze Age sequences (Sümegi and Bodor 2000; Willis, et al. 1998). In fact, during the Sub-Boreal period, it has been argued that humans largely stopped the advance of forests and, especially on the loess plateaus and alluvial fans, the steppe-forest may be largely anthropogenic (Somogyi 1987).

Fauna

The Carpathian Region belongs to the Central Danubian district of the Euro-Turanian faunal region, a biodiverse region that boasts 32,000 animal species, 540 of which are vertebrates (Vörös 2003). The district can be classified into four major zoogeographical zones based largely on lowland/mountain divisions[27] (Borhidi and Pécsi 1989). The Pannonian Plain falls within the

[27] The far western area into the Alps is part of the Noricum zone and the southwest through the Dinaridies lies the Illyricum zone. The low mountainous areas within Hungary, including the Bakony and Northern Hungarian

Pannonicum zone, a mosaic landscape housing a unique mixture of eastern steppe and temperate woodland species, as well as a rich array of wetland taxa. Many of these animals were important dietary supplements to prehistoric agricultural groups and provided a range of useful raw materials. The availability of economically important species varies strongly by ecozones. The natural distribution of game in the local environment was a major factor in the relative abundance of different species utilized at prehistoric settlements (Nicodemus 2010). An overview of major species native to the various habitats in the Pannonian zone is presented below. This list only includes taxa that are known to have been utilized by archaeological or historic populations with some regularity (Table 4.3).[28]

Steppe-Forest Species

Despite the Bronze Age cooling trend, steppe-forests would still have been widespread in the central portions of the Pannonian Plain, as they are today. The steppe-forest is home to several large ungulates, a number of important small and fur-bearing mammals, and several game birds (Chinery 1987). This vegetation zone currently is the most common habitat on the Plain, covering most of the well-drained areas away from rivers. The animals occupying primarily the steppe-forest habitat in the Carpathian Basin are a mix of steppe, open-forest, and edge species. Dry grassland species include steppe (*Mustela eversmannii*) and marbled (*Vormela peregusna*) polecats and the European (*Spermophilus citellus*) and speckled (*S. suslicus*) susliks (or ground squirrels). European hare (*Lepus europaeus*) and roe deer (*Capreolus capreolus*) thrive in a variety of steppe-forest environments, although hare can survive in more open steppic areas than roe deer. Both can occur at relatively high densities and thrive in anthropogenic areas, especially fields. The ecological preferences of aurochs (*Bos primigenius*) are poorly understood but they may have favored steppe-forest as well.[29] A number of game birds live primarily or exclusively in grasslands, such as the gray partridge

Mountains, belong to the Matricum zone, while the remainder of the Carpathians falls within an eponymous zone. The Pannonian zone encompasses all of the lowlands within the Basin, including the study sites.

[28] This excludes most birds (other than waterfowl and larger game birds), reptiles (except turtles), bats, insectivores, invertebrates (other than freshwater mussels), and other very small-bodied species.

[29] Note that the issue of aurochs habitat is complicated by paleontological finds and its final historic distribution (van Vuure 2005). Most of the well-known aurochs finds are from swamps and bogs, where the chemical conditions preferentially preserve bone. The last known aurochs herds were in remote forested areas in 16th Century Poland, probably only able to survive there because of minimal human interference (in fact, they were protected and managed by the royalty). It is not known whether aurochs in standard conditions would have been found in large numbers in either wetlands or closed forests.

(*Perdix perdix*), quail (*Coturnix coturnix*), and the great bustard (*Otis tarda*), which is the largest bird in Europe (Mullarney, et al. 1999).

Forest Species

During the Bronze Age, forests characterized much of the mountainous highlands and Transdanubia. While closed forests have a more restricted distribution than the open steppe-forest on the Plain, occurring primarily in uplands and along rivers, their distribution was considerably larger than today as forests expanded with the cooler and wetter climate, particularly along the margins of the Plain and in floodplains (Gyulai 1993; Járai-Komlódi 1987). Forest species in the Basin inhabit a number of wooded environments, ranging from open woodlands to more closed forests like floodplain carr and gallery, broadleaf, and mixed broadleaf-coniferous forests.

Forests support many important game species, including several large ungulates and a wide range of fur-bearers, especially carnivores (Chinery 1987). One of the largest and most abundant ungulates prehistorically is the red deer (*Cervus elaphus*), native to both open and closed broadleaf forests. This species was especially common during the Bronze Age with the spread of forested areas (Bökönyi 1988; Choyke 1984). Wild boar (*Sus scrofa ferus*) is most frequently found in broadleaf forests with ample mast and wetland woods. Beavers (*Castor fiber*) are found in gallery forests. Other major species preferring more closed forests include wild cat (*Felis silvestris silvestris*), lynx (*Lynx lynx*), brown bear (*Ursus arctos*), beech (*Martes foina*) and pine (*Martes martes*) martens, and red squirrel (*Sciurus vulgaris*). Many of these animals, particularly the carnivores, are currently restricted to alpine and coniferous forests but had larger ranges prehistorically. Moose also may have been present in the Bronze Age in northeastern portion of the Carpathian Region, where they are vagrants today. The hazel grouse (*Bonasa bonasia*) and capercaille (*Tetrao urogallus*) are also forest-dwellers (Mullarney, et al. 1999).

Wetland Species

The Carpathian Basin, with its diverse topography and hydrology, contains a wide range of wetland habitats in a complex mosaic of aquatic ecosystems. During the Sub-Boreal period, wetlands expanded greatly from the previous period given increased precipitation and a higher water table (Gyulai 1993; Somogyi 1987). The various bodies of water and their associated terrestrial habitats are the most productive areas within the region in terms of wild resources. A number of the forest species mentioned above are equally associated with wetlands, namely boar and beaver. European otter (*Lutra lutra*) and mink (*Mustela lutreola*) are important fur-bearing carnivores, found along major rivers and lakes (Chinery 1987).

There is a plethora of non-mammalian wetland species, including fish, waterfowl, turtles, and mollusks. There are around 60 species of fish in the Basin, just over half of which are economically important, but most could be caught opportunistically (Károly 1989). The principal fish in the lowlands include the wels catfish (*Silurus glanis*), northern pike (*Esox lucius*), pike-perches (*Stizostedion lucioperca* and *S. volgensis*), common carp (*Cyprinus carpio*), and about 20 other members of the carp family (Cyprinidae spp.). Several sturgeon species (*Acipencer spp*. and *Huso huso*) are also available in major rivers, like the Danube, Tisza, and Maros.

There are more than 40 species of water fowl found within the Carpathian Basin, although most are only available seasonally. Major taxa that are present the majority of or all of the year include the mallard *(Anas platyrhynchos*), gadwall (*Anas strepera*), and northern shoveler (*Anas clypeata*). Numerous species overwinter in the region, such as the greater (*Anser albifrons*) and lesser (*Anser erythropus*) white-fronted goose, bean goose (*Anser fabalis*), goldeneye (*Bucephala clangula*), Eurasian teal (*Anas crecca*), and common merganser/ goosander (*Mergus merganser*). The graylag goose (*Anser anser*), northern pintail (*Anas acuta*), garganey (*Anas querquedula*), and several of the diving ducks (*Aythya spp*.) are summer breeders. The corncrake (*Crex crex*), a member of the rail family, is also a summer visiting game bird that prefers wet meadows and marshy lowlands (Mullarney, et al. 1999).

There is only one species of turtle in the study area (Miklós, et al. 2005), the European pond terrapin (*Emys orbicularis*), preferring lowland wetlands surrounded by wooded areas. Of the myriad mollusks in the region, only three freshwater bivalves, all within the same genus, appear to have been exploited prehistorically for food: the painter's mussel (*Unio pictorum*), swollen river mussel (*U. tumidus*), and thick-shelled river mussel (*U. crassus*) (Grossu 1993; Gulyás and Sümegi 2004). The painter's mussel, the most abundant species on the Plain, and the swollen river mussel are found in stagnant waters or muddy river edges. The thick-shelled river mussel prefers moving waters with a sandy substrate and is more common in upland waterways.

Other Species

Alpine regions encircling the Basin are outside of the study area and are unlikely to have been utilized to any degree by lowland groups. The major high altitude species are Alpine marmot (*Marmota marmota*) and chamois (*Rupicapra rupicapra)* (Chinery 1987; Mullarney, et al. 1999). A number of important fur-bearing species are found in a wide range of habitats (Chinery 1987). These include the fox (*Vulpes vulpes*), badger (*Meles meles*), wolf (*Canis lupus*), and European polecat (*Mustela putorius*). Hedgehogs (*Erinaceus europaeus*) and black grouse (*Tetrao tetrix*) are also widespread.

RESOURCE DISTRIBUTION WITHIN THE CARPATHIAN REGION

From the previous sections, it is apparent that natural resources, from minerals to arable land, are unevenly distributed in the Carpathian Region.[30] This has had a major impact on settlement patterns, trade networks, and agro-pastoral systems both historically and prehistorically. In the Bronze Age, with expanding long-distance exchange of metals and other goods, regional differentiation became even more pronounced than in preceding periods, leading to often highly divergent socio-economic and political systems.

In the mountain belts surrounding the Carpathian Basin, numerous mineral resources are found, including metals, lithics, and salt. However, arable land is typically limited to river valleys and is often affected by the acidity of forest soils. On the other hand, these forests are rich in wood, game, and mast, and provide good pannage for pigs. Forest clearances and high alpine meadows also provide good grazing lands, particularly for sheep. The lower hills of Transdanubia and the mountain forelands also have mineral sources, although these are primarily limited to stone. Forest resources are abundant and agro-pastoral potential is greater than in the mountainous regions, particularly in areas adjacent to more open steppe-forest and major river valleys.

In the lowlands of the Pannonian Plain, mineral resources are very limited and in many areas wood is also scarce. However, the most fertile agricultural land and pasturage is also found here, although unevenly distributed and tied to local hydrology. The drier steppe and steppe-

[30] More detailed discussion of site specific parameters is included in Chapter 7.

forest regions provide good seasonal grazing land, especially for horses, and, where there is sufficient water, highly fertile cropland on chernozem soils. Drought is a primary issue in these zones and plows are required to break up the heavy sods. The best agricultural lands are found in the zone between these grasslands and floodplains where water shortage is less of a problem. The floodplain itself can also provide highly productive arable land but faces risk of floods. The natural levees along the major river systems contain some of the best agricultural soils, being easily worked and well drained, although limited in extent. The riverine areas also provide extremely rich wild resources in their gallery forests, wetlands, and rivers themselves, and provide abundant seasonal pasturage and fodder. Salt-affected areas and poorly drained basins are poor cropland but can be used for grazing.

The importance of river systems as central axes linking these regions and their respective resources cannot be understated. There is a clear complementary relationship between highland and lowland areas, although given the importance of metals in the Bronze Age, one that was often asymmetric. Control over river-borne transport was critical in the development of regional economic systems, particularly for the exchange of bulk goods. The development of land routes, facilitated by both the heavy ox-cart and high-speed but light-weight horse transport, were increasingly important during the Bronze Age. As we shall see in later chapters, regional production strategies became increasingly specialized. Particularly in the more centralized systems of the lowlands, including the Middle Maros area, economies emerged that were preferentially focused on export production to facilitate participation in these long-distance trade networks.

Table 4.3: List of economically important species in the Carpathian Region by ecozone

Ecozone	Description	Taxon	Common Name	Ecozone	Description	Taxon	Common Name
Steppe-Forest	grasslands, open	*Bos primigenius*	Aurochs	Wetland	rivers/lakes, marshes,	*Castor fiber***	Beaver
	woodlands, forest	*Capreolus capreolus*	Roe deer		bogs, fens, carrs,	*Lutra lutra*	European otter
	edge	*Lepus europaeus*	Hare		gallery forests	*Mustela lutreola*	Mink
		Spermophilus citellus	European suslik			*Anser albifrons*	Greater white-fronted goose
		Spermophilus suslicus	Speckled suslik			*Anser erythropus*	Lesser white-fronted goose
		Mustela eversmannii	Steppe polecat			*Anser anser*	Graylag goose
		Vormela peregusna	Marbled polecat			*Anser fabalis*	Bean goose
		Perdix perdix	Gray partridge			*Anas acuta*	Northern pintail
		Coturnix coturnix	Quail			*Anas clypeata*	Northern shoveller
		Otis tarda	Great Bustard			*Anas crecca*	Eurasian teal
Forest	open forests, closed	*Cervus elaphus*	Red deer			*Anas platyrhynchos*	Mallard
	broadleaf and	*Sus scrofa ferus**	Wild boar			*Anas querquedula*	Garganey
	coniferous forests,	*Sciurus vulgaris*	Red Squirrel			*Anas strepera*	Gadwall
	gallery forests	*Ursus arctos*	Brown bear			*Aythya spp.*	several diving duck species
		Lynx lynx	Lynx			*Bucephala clangula*	Goldeneye
		Felis silvestris silvestris	Wild cat			*Mergus merganser*	Common merganser
		Martes foina	Beech marten			*Crex crex*	Corn crake
		Martes martes	Pine marten			*Emys orbicularis***	Pond terrapin
		Bonasa bonasia	Hazel grouse			*Silurus glanis*	Wels catfish
		Tetrao urogallus	Capercaille grouse			*Esox lucius*	Northern pike
Mountain†	alpine meadows, rocky	*Rupicapra rupicapra*	Chamois			*Stizostedion lucioperca*	Pike-perch (zander)
	outcrops	*Marmota marmota*	Alpine marmot			*Stizostedion volgensis*	Volga pike-perch (zander)
Generalist	multiple habitats	*Canis lupus*	Wolf			*Cyprinus carpio*	Common carp
		Vulpes vulpes	Red fox			Cyprinidae spp.	20+ carp family species
		Meles meles	Badger			*Huso huso*	Beluga sturgeon
		Mustela putorius	European polecat			*Acipenser spp.*	3 sturgeon species
		Erinaceus roumanicus	N. white-breasted hedgehog			*Unio spp.*	3 freshwater mussel species
		Tetrao tetrix	Black grouse				

*Also can inhabit wetlands

**Requires gallery forests

†Only includes species limited to alpine habitats. Many of the forest dwelling species, especially those preferring coniferous forests, can also be found in mountains below the treeline

CHAPTER 5: THE ARCHAEOLOGICAL SETTING

The Carpathian Basin provides an ideal case study for the emergence of complex societies and their economic underpinnings during the Bronze Age. At this time, the region is comprised of a mosaic of social groups with highly variable political and economic organization. There is also a long tradition of archaeological inquiry, which provides a rich dataset with which to address questions of political economy using multi-scalar approaches. This chapter provides an archaeological overview of the Bronze Age Carpathian Basin that, along with the previous chapter, provides the necessary background to refine the general research questions presented in Chapter 3 and create a specific set of test expectations for the study region (Chapter 7).

This chapter has two main parts. The first presents a general discussion of the Bronze Age in Europe, including a review of its major features, a brief history of influential research and theories, and current models for the emergence of Bronze Age social complexity. The second part outlines the culture history of the study area, the Carpathian Basin, from the Neolithic to the Late Bronze Age. This overview includes basic space-time systematics as well as a review of major changes in sociopolitical structure and economic organization (including agro-pastoral innovations). Particular attention is paid to the Early-Middle Bronze Age cultures which are the focus of this dissertation.

THE EUROPEAN BRONZE AGE

What is the Bronze Age?

The European Bronze Age falls within the period from roughly 3000-500 cal. BC (Earle and Kristiansen 2010a). This time frame is not uniform across the continent, with the Bronze Age beginning earlier in the Aegean region and later to the northwest. There is some debate about its definition, which also affects how chronologies are constructed. Traditionally, the Bronze Age is marked simply by the use of bronze metallurgy, as defined by Thomsen's Three Age System in 1836 (see below). However, in some areas the first use of bronze may predate this period[31] and in other areas copper continues as the dominant metal well into the Bronze Age. Coles and Harding (1979:3) suggest that the first use of *tin* bronze and two-piece molds may be used. Pare (2000:2) would refine this definition to the period in which "bronze was the predominant material in metal production," with "bronze" meaning an intentional copper alloy with more than 4% tin and "predominant" referring to more than 75% of the metal artifacts. With this formulation, the transition to "full bronze use" occurs considerably later, first in areas with abundant tin sources, such as the British Isles (c. 2200/2000 BC), and spreading to Southeast Europe by 1600/1400 BC. This approach stands out as it explicitly divorces European developments from Near Eastern influences. While the exact definition of what constitutes the Bronze Age is a matter of debate, the vast majority of scholars uses the traditional, if not somewhat arbitrary, periodization listed initially.

The primacy of metals in defining the Bronze Age has been maintained for nearly two centuries, but there is a suite of social and economic changes that accompany this new technology that perhaps better characterize this period as an era of fundamental cultural transformation. It must be underscored here that these developments are by no means uniform in time or space, but rather provide a general view of changes that distinguish this period from the preceding Neolithic and Copper Ages. Some of the changes, as discussed in more detail below, actually predate the local Bronze Age in many areas, including the Carpathian Basin. Among these changes is a shift from a more communally structured multi-family system to one in which wealth is produced, accumulated, and transmitted within individual family units (Kristiansen and Larsson 2005). At the same time, burials are refocused from group cemeteries with little differentiation to those that are organized by specific lineages, and there is increasing wealth and status differentiation between individuals, including the appearance of "princely burials." These new statuses include a range of both horizontal and vertical personae, such as craft specialists, warriors, and in some cases, hereditary leaders. This new focus on vertical differentiation and warrior identity is often equated with the emergence of a Bronze Age "warrior aristocracy," with new symbols of power and authority consisting largely of metal weaponry, like axes and swords. Along with a more stratified society comes increasing complexity within regional settlement organization, with the development of two- to three-tiered settlement hierarchies in a number of

[31] Some arsenical bronzes are found in Copper Age, but it is not clear whether these alloys were intentional as some copper deposits contain arsenic naturally.

regions. The economy also becomes more differentiated and more formalized political economies emerge. These are generally viewed as wealth finance systems, based on long-distance trade and specialized production of prestige goods, especially for metalwork (Earle and Kristiansen 2010a). It is at this time that exchange networks first link the entire continent, with regular trade in necessary (but limited) raw materials as well as finely crafted finished goods.

In sum, the Bronze Age can be characterized by more complex metalworking, increased social differentiation, more intensive and specialized production systems, expansion of inter-regional trade networks, and heightened warfare, which together (in varying degrees) are viewed as fostering the emergence of complex regional polities in many areas of Europe. Again, metal is often seen, either explicitly or implicitly, as the driving factor for this suite of inter-related changes, a viewpoint that has been termed the "Bronze Age Hypothesis." Following Pare (2000:24), it states that (1) because bronze is essential to social and economic (re)production and (2) most societies could only obtain these geographically restricted resources through exchange networks, (3) there was a major intensification in regional trade that (4) was controlled by emerging elites. While this specific formulation is relatively recent, it draws on ideas emerging from a long history of Bronze Age research. And although metal production and long-distance trade still are held as prime movers by many scholars, the development of Bronze Age complexity has been examined with increasingly nuanced and multifocal frameworks that underscore the importance of multiple pathways for their formation. The following section provides a brief overview of the major theoretical approaches that have been used in the study of Bronze Age Europe.

Approaches to the Study of Bronze Age Europe

The study of the European Bronze Age, to a greater or lesser extent, has mirrored general trends in archaeological theory over time, with considerable influence from historical and political contingencies, especially at the national level. There are some notable differences between frameworks used in North America versus continental Europe, many of which stem from the contrasting intellectual origins of the discipline (Trigger 2006). In North America, archaeology developed within anthropology and was more strongly influenced by ethnography and general anthropological theories, particularly during its formative period. In contrast, European archaeology grew out of antiquarianism with stronger influences from history, art history, and (to varying degrees) the natural sciences, and continues to be more strongly linked with history as a discipline (Hodder 1991a). Nonetheless, over time this division has become less prominent, with growing theoretical and methodological convergence between the Old and New Worlds, especially in Anglophone countries and Scandinavia (Harding 2000). Central and Eastern European traditions, in contrast, have to a greater extent followed their own course. Eastern Europe in particular has engaged in far less international dialog due to the geopolitical landscape of most of the 20th century and the strong influence of Soviet ideology (Laszlovszky and Siklódi 1991; Trigger 2006). While there is increasing interaction between east and west, there remain considerable differences in the approaches used regionally. As a result, this section will review both general trends in the study of the Bronze Age, primarily through major synthetic works, as well as specific frameworks used within the study region.

Bronze Age research can be viewed as following a “theoretical cycle” that fluctuates between evolutionary, adaptationist, and generalized frameworks and those that are particularizing and diffusionsist (Kristiansen 1998:36-37), which parallels larger trends in both archaeology and in anthropology. Early study of the Bronze Age in the 19th century, like most archaeology at the time, was predominantly typological, focused on establishing basic space-time systematics. This was often cast in frameworks that implied an evolutionary trajectory, mirroring movements in both anthropology and the natural sciences. The most influential of these early works is J. C. Thomsen’s *Ledetraad til Nordisk Oldkyndighed (Guideline to Scandinavian Antiquity)* (1836) and his three-age system (Stone, Bronze, and Iron Ages), which was the first to establish a (widely applicable) periodization of technological development using typological-evolutionary methods rather than written records. The Bronze Age itself was later subdivided into three periods, the Early, Middle, and Late, by Sir John Evans in *The Ancient Bronze Implements* (1881), based on changes in the form of bronze weaponry. Through the turn of the century, much effort was spent to further refine the chronology of the Bronze Age, led by scholars such as Oscar Montelius and Paul Reinecke. In 1903, Montelius explicitly described “Die typologische Methode” in *Die älteren Kulturperioden im Orient und Europa*, which established standardized techniques used for creating systematic chronologies. This and some of his other works also presented the first well-defined culture-historical framework for the entire continent that was tied to chronologies for the Near East, laying the foundation for diffusionsist perspectives (Kristiansen 1998). In a series of papers published between 1906 and 1909, Reinecke, using similar methods, created a detailed chronological system for the Central European Bronze and Iron Ages, the basic divisions of which are still used widely today.

Because this early work was largely classificatory, descriptive, and focused on artifacts themselves, there was often little explicit discussion of mechanisms for change or any larger theoretical discourse. It was generally assumed that differences in artifact types occurred through the spread of ideas or peoples, with major innovations occurring in areas outside of Europe, following an *ex oriente lux* diffusionist perspective (Renfrew 1973; Trigger 2006). However, at the turn of the 20th century, more scholars were thinking critically about the concept of culture and mechanisms of change, giving rise to the culture-historical school. One of the most influential (and notorious) of these thinkers was Gustav Kossinna, who argued that archaeological material culture areas (Kultur-Gruppen) should be viewed as discrete ethnic groups (Völker) and further, that these could be traced to modern ethnicities (Jones 2008; Trigger 2006). Because of the assumption of cultural continuity, changes in the archaeological record were attributed largely to migrations, and much effort was spent tracing the presumed movements and reconstructing ancient homelands of ethnic groups. Unfortunately, Kossinna's works were also strongly tied to notions of racial and ethnic superiority and were quickly seized upon by various groups with nationalistic agendas, including the Nazis. Nonetheless, the concern with mapping cultures and their migrations was a central component of culture-historical archaeology, and even after WWII, many countries continued to follow this tradition, especially in Eastern Europe (see below).

To the west, Kossinna's idea of archaeological cultures, minus the racial baggage, was advocated by V. Gordon Childe, who produced some of the most influential early synthetic works on the Bronze Age, including *The Dawn of European Civilization* (1925) and *The Bronze Age* (1930). Also in contrast to Kossinna and his nationalistic agenda, Childe espoused a largely diffusionist perspective with innovations, from swords to settlement types, originating in the civilizations of the Near East. He was also explicitly Marxist in orientation and in his later works he also became increasingly concerned with social evolution. Importantly, Childe introduced a number of issues to the study of the Bronze Age that are still central concerns in modern research, including the economic and social impacts of metalworking and the role of craft specialists (Harding 2000).

After WWII, there was a strong backlash, primarily in Western Europe, against Kossinna's culture-historical framework as its ethnic linkages were viewed as too simplistic and could be easily appropriated by political movements. As a result, there was a general skepticism towards theoretical and interpretive works, with many scholars returning to a focus on classification and developing increasingly refined regional chronologies. However, tracing the expansion and diffusion of prehistoric ethnic groups was maintained as the dominant approach in much of Eastern Europe and the Balkans (Kristiansen 1998:20-21). Nationalistic frameworks often continued in countries within the sphere of Soviet influence, where the adoption of Marxist ideologies in the interest of political agendas was compulsory. This includes Romania,[32] where there had been considerable work in the communist era to establish a direct connection between modern Romanians, the Iron Age Dacians, and even the preceding Bronze Age populations, especially in the disputed area of Transylvania[33] (Bader 1978; Bârzu 1980; Morintz 1978). Interestingly, neighboring Hungarian archaeologists took an opposing approach. While there was still an equation between archaeological cultures and ethnic groups, they instead stressed discontinuities, with culture change being largely the result of the influx of new populations in a strongly migrationist perspective[34] (Bóna 1958, 1975, 1992; Kemenczei 1984; Mozsolics 1957) (Makkay 1996).[35]

The importance of migrations or invasions, often coupled with diffusion, has had considerable history in archaeological thought. Invasion as an explanation for culture change in the Bronze Age was vigorously revived in the post-war era, most notably by Marija Gimbutas' "Kurgan Hypothesis" (Gimutas 1956). In this theory, she argued that the dramatic social changes between the Neolithic (Old Europe) and the Bronze Age (New Europe) were spurred by the invasion of steppe people (Indo-Europeans) who brought with them a patriarchal and war-like society. Other scholars have stressed the importance of various invasions causing disruptions in Eastern Mediterranean world, whether Indo-Europeans, "Sea Peoples," or otherwise, that pushed new populations into the Carpathian Basin. For example, several of the southern Early Bronze Age groups in the study region, including the Maros (Pitvaros), are often

[32] Anghelinu (2007) has recently argued that while Marx and other communist writers were commonly listed in citations, very little, if any, Marxist ideology was actually incorporated into most prehistoric archaeological studies. Rather, theory remained strongly rooted in a cultural-historical approach.
[33] This region was part of the Austro-Hungarian Empire until the Treaty of Trianon in 1920, in which this territory became part of Romania.
[34] Which is likely influenced by the fact that Magyars (modern Hungarians) are themselves a migrant population.
[35] An excellent review of approaches used in Hungary (and Romania) can be found in Szeverényi (*forthcoming)*.

seen as immigrant groups fleeing the unrest in the Balkans (Bándi 1975-1976 [1980]; Bóna 1960, 1992; Kalicz 1968; Kovács 1977).

Since the 1960s and 1970s, archaeologists in the Americas and parts of Western Europe have been increasingly focused on internal sources of culture change, often in a neo-evolutionary framework, rather than the external forces of diffusion and migration. In North America, this was part of the shift towards a processual paradigm under the “New Archaeology” (Binford 1962; Binford 1963; Flannery 1968, 1972, 1973; Willey and Phillips 1958), where there was an explicit movement towards more anthropological, scientific, generalizing, and explanatory frameworks. In Western Europe, there was a parallel trend, but the evolutionary aspects of the New Archaeology did not have as great oan impact on mainstream Bronze Age studies (Harding 2000:8). In addition, processual archaeology had very little influence on Eastern European countries who were still working under a forced Marxist ideology and had little opportunity to engage in international scholarship (Laszlovszky and Siklódi 1991). Nonetheless, more processual approaches can be seen in a number of influential, synthetic works.

Among the early proponents of processualism in Europe is Colin Renfrew (1968, 1969, 1973, 1974), whose “social archaeology” stressed the examination of internal causes of social change and championed an autonomous development of Bronze Age societies. This viewpoint was strongly presented in his 1968 paper “Wessex without Mycenae.” His argument for an independent development was supported by new chronologies that were being established using radiocarbon dates rather than the traditional relative chronologies based on Aegean sequences, a revolutionary development in itself (Renfrew 1973). He also drew upon ethnographic sources to better understand social organization of these cultures. Renfrew, while utilizing neo-evolutionary frameworks of Service, Sahlins, Fried, and others, also saw limitations in their categorizations. He instead stressed the variability in middle-range societies, which foreshadowed much recent scholarship on the Bronze Age. For example, in “Beyond a Subsistence Economy” (1974), he suggested that chiefdoms could be divided into “individualizing” and “group-oriented” variants, a distinction that is often utilized in current works (see Chapter 2).

In Europe, the concept of political economy was more important than the New Archaeology (see also Chapter 2). Two frameworks in particular have impacted Bronze Age research considerably: world systems theory and structural Marxism. World systems theory was used to understand changes in the development of Bronze Age society within a more global perspective, based on economic relations of dependency. Building upon works by Frank (Frank 1967, 1969) and Wallerstein (Wallerstein 1974), Bronze Age scholars have focused on the inter-connections between large areas of the Old World through core-periphery relationships, established through asymmetrical production and exchange networks (Frank 1993; Kristiansen 1998; Shennan 1993; Sherratt 1993). The core-periphery relationship is variably viewed as existing between the Near East/Aegean and temperate Europe and/or between metal-producing centers and consumers within Europe itself.

Political economy in a more structural Marxist vein has been applied more widely and appears to have maintained its popularity in current literature to a greater degree. This framework stresses unequal access to productive resources and wealth as a means to integrate sources of power and the role of ideology to legitimize or mask these economic asymmetries (Earle 1997, 2002; Earle and Kristiansen 2010a; Frankenstein and Rowlands 1978; Friedman and Rowlands 1978; Gilman 1981; Kristiansen 1984). Exploitation is viewed as driving social change, which is typically equated with resource mobilization, where goods and/or labor are appropriated by elites via tribute, taxation, land rents, etc.

Since the 1980s, there has also been more critical self-examination of archaeology as a discipline and a greater awareness of the historical and political contexts in which theories and interpretations were developed. Much of this critique was framed within a post-processualist paradigm, aspects of which have been adopted within Bronze Age studies to varying degrees. Post-processualist approaches are highly varied, but there is a general movement towards more subjective, interpretive frameworks (Hodder 1982, 1990, 1991b). Some proponents take a strongly relativist stance (Tilley 1991), which has not been widely adopted by mainstream Bronze Age researchers. However, other aspects, such as theories of agency and materiality (De Marrais, et al. 1996; De Marrais, et al. 2005; Dobres 2000; Dobres and Robb 2000; Gell 1998), have been applied more frequently. These concepts have been used to stress the active role of material culture in the formation and reproduction of social institutions and the influence of individual actors in culture change.

It has become increasingly common for Bronze Age scholars to take a “middle-ground” or pluralistic approach in an attempt to draw on perceived strengths of both processual and post-processual frameworks, while rejecting the most extreme positivist or relativist positions (Earle and Kristiansen 2010b; Kristiansen 1998; Kristiansen and Larsson 2005), paralleling trends in North America (Hegmon 2003; Pauketat 2003; Preucel 1991; VanPool and VanPool 1999; VanPool and VanPool 2003; Wylie 1993, 2000). As stated by Kristiansen (1998:38):[36]

> "Thus the intellectual history of the past few hundred years has taught us that history is shaped by the conditions and interests of our own time. This has in recent years led to a dangerous relativism and pessimism in learning. But we have to accept the subjective foundations of knowledge without losing faith in the possibility of creating knowledge that is real and not subject to any kind of manipulation."

There has also been a re-examination of concepts of migration and diffusion (especially via mobility studies), returning external forces to the larger repertoire of mechanisms of cultural change (Anthony 2007; Kristiansen and Larsson 2005).

The lasting influence of post-processual approaches on our understanding of the Bronze Age remains to be seen. While in the past two decades there is growing corpus of post-processualist studies in Western Europe, especially within Britain, there does not yet seem to have been any significant reinterpretation of what the Bronze Age is or how it developed. This is in great part influenced by the scale of most studies in this vein, which are generally focused on small-scale phenomena (the settlement, the household, the individual) and actively reject broader, comparative work (Trigger 2006). Further, while concepts of materiality, praxis, personhood, embodiment, and lived experience permeate introductory sections of publications, they often have little effect on actual data analysis or the resulting conclusions except in a superficial manner, especially in works that are meant to be synthetic.

In conclusion, Bronze Age archaeology has undergone a series of cyclical patterns fluctuating between more generalizing and evolutionary approaches to those that are more particular and cultural-historical. Early work was focused on establishing space-time systematics and creating typologies for archaeological cultures. Diffusion and migration/invasion were viewed as the primary mechanisms for culture change. Through time, there was increasing divergence in intellectual traditions among regions. In Central and Eastern Europe, earlier frameworks have been largely maintained, but Western Europe and North America more readily appropriated ideas from other social sciences as well as developing novel frameworks within archaeology itself. While external forces were not completely abandoned in explanations for

[36] Note that he has more strongly incorporated post-processualist ideologies through time and this can be seen clearly in the introductory chapter of Earle and Kristiansen (2010).

Bronze Age origins, there was much greater focus on the varied internal mechanisms of culture change. Processual neo-evolutionary frameworks did not have the same impact in Europe as in North America. However, the study of political economy with varying degrees of Marxist thought became widespread and continues to be applied today. Post-processual approaches have been increasingly applied but have yet to have strong impact on models for the development of Bronze Age societies. Recent work has been explicitly pluralistic, blending different theoretical approaches, incorporating mechanisms of internal and external change, and utilizing comparative and multi-scalar frameworks that allow general patterns to be discerned within specific developmental sequences.

ARCHAEOLOGICAL HISTORY OF THE CARPATHIAN BASIN

Providing a concise overview of Carpathian Basin archaeology is a daunting task given the long history of research and wealth of available data. Consequently, this section maintains a relatively narrow focus geographically, temporally, and thematically. This discussion is centered on the Pannonian Plain, as the sites and culture groups used in the comparative study (Chapter 6, 13) are located within this region. The (brief) historical review begins with the Neolithic, a period that ushered in both the first agriculturalists as well as tell-based societies, laying the basic framework for later developments, and ends with the widespread collapse of Middle Bronze Age societies and the emergence of new Late Bronze Age formations. Major culture areas and radiocarbon based chronologies[37] are presented, along with a general discussion of features defining these periods (Tables 5.1-3). Special attention is paid to sociopolitical organization, economics, and technological changes that directly bear on the development of Bronze Age complexity. The section ends with a more detailed examination of the cultures used in the regional comparative study, namely the Maros, Ottomány/Gyulavarsánd, and Nagyrév/Vatya groups.

[37] The regional chronology used in this dissertation generally follows the periodization established within Hungary and the Banat, which covers the majority of the study region.

Table 5.1: Chronology and major culture groups in the Carpathian Basin (Neolithic-Copper Age)

Period	C14 dates (cal. BC)	Major Culture Groups	Region
Early Neolithic	6000/5900-5500/5300	Körös	S/E Plain
		Criş	E Plain, Transylvania
		Starčevo	S Transdanubia, S Danube
Middle Neolithic	5500/5300-5100/4900	AVK	Plain
		Vinča	S Danube
		DVK	Transdanubia
		Szakálhát	Plain
Late Neolithic	5100/4900-4600/4400	Tisza	Plain
		Csőszhalom	N Plain
		Herpály	NE Plain
		Vinča	S Danube
		Lengyel	Transdanubia
Early Copper Age	4600/4400-4100/3900	Tiszapolgár	Plain, S Danube, Transylvania
		Lengyel	Transdanubia
Middle Copper Age	4100/3900-3600/3500	Bodrogkeresztúr	Plain, S Danube, Transylvania
		Balaton–Lasinja	Transdanubia
		Ludanice	N Basin
Late Copper Age	3600/3500-2800/2700	Baden	Plain, S Danube, Transdanaubia
		Pit-Grave/Kurgans	Plain
		Coţofeni	Transylvania, SE Plain
		Vučedol	S Transdanubia

*dates based on ranges established for Hungary and the Plain.

The Neolithic

Few archaeological sites from periods pre-dating the Neolithic have been identified within the Carpathian Basin, being confined largely to the upland regions of the various mountain ranges encircling the region (Biró 2003a). This may in part reflect small hunting and gathering populations in the region, but this may also be due to the infilling of the Basin during the Pleistocene and early Holocene with very thick loess deposits, burying most early sites (see Chapter 4). Paleolithic sites do date back to the Lower Paleolithic, however, including the famous site of Vértesszőlős, Hungary (c. 600,000 BP), with its extensive burned bone deposits and early human remains (Dobosi 2003). The Mesolithic period (c. 10,000-6000 BC) is also well known for the sedentary fishing groups occupying the Iron Gates region (Mithen 2001; Zvelebil 1986).

The Neolithic is the first well-represented archaeological period within the Basin (Table 5.1). The Early Neolithic (c. 6000/5900-5500/5300 BC)[38] has received much attention by archaeologists as it marks one of the most dramatic cultural transformations in the region: the first appearance of agriculture. Farming populations quickly spread from the Balkans into the Carpathian Basin, settling along the major rivers and their tributaries. These people are known as the Starčevo-Körös-Criş culture, which spans the southern and eastern Carpathian Basin. This rapid initial expansion has been viewed largely as a demic colonization rather than the adoption of agriculture by indigenous hunting and gathering populations (Whittle 1996). It is interesting to note the presence of a strong northern boundary to these groups, the so-called "Central European-Balkanic agro-ecologic barrier," beyond which sparse Mesolithic populations continued to live. This boundary has been linked to more temperate ecological conditions that were unfavorable to the agro-pastoral systems that Körös people brought with them, which were adapted to Mediterranean climates (Sümegi 2003; Sümegi, et al. 2002). This can be seen in the dominance of sheep and goats in the animal economies, averaging between 60-70% of the livestock (Bökönyi 1988; Nicodemus 2003). Wild animals were also very important to their diets and hunting strategies were quickly adapted to the new fauna of the Basin. All of the major Near Eastern grains (emmer and einkorn wheat, two- and six-row barley) were used in the Early Neolithic, and continued to be central crops through most of the prehistoric period. However, few pulses are represented in this early period (Gyulai 1993, 2010). Crop production was based on shifting agriculture and was strongly tied to the fertile, well-drained, and easily worked alluvial soils along the major drainages (Bogaard 2004). This pattern also persists until the adoption of animal traction and the scratch plow in the later Copper Age.

Körös settlements were relatively small and short lived, tending to shift laterally along river levees or terraces bordering the floodplains. Not much is known about the internal layout of settlements, but small houses appear to be arranged in clusters. Burials were located in or beside houses and grave goods are rare, typically restricted to a pot or simple personal ornaments like shell arm rings (Oravecz 2003). We have a basic understanding of Körös social organization. There is no evidence of settlement hierarchies or substantial social inequalities

[38] Radiocarbon chronology for the Neolithic follows Horváth (2003), Gyucha (2010), and Parkinson and Gyucha (2012), which are based on Plain cultures. There is some regional variability in the chronological divisions, which is reflected in the ranges given for start and end dates.

marked in burials, house size/form, or material goods. These groups were tribally organized and relatively egalitarian, especially when compared to later groups.

During the Middle Neolithic (c. 5500/5300-5100/4900 BC), agriculture expanded into the remainder of the Basin (and beyond). Unlike the Early Neolithic (EN), these new Middle Neolithic groups are thought to be the result of the adoption of agricultural technologies by local hunter-gatherers and/or admixture between the invasive EN populations with indigenous Mesolithic groups. This period is marked by the presence of a geographically expansive pottery tradition, the Linearbandkeramik (LBK), which spans much of Central Europe. Important local variants within the Basin include the Dunatúl Vonaldiszes Kerámia (DVK) in Transdanubia and the Alföld Vonaldiszes Kerámia (AVK) on the Pannonian Plain in Hungary and Romania. It should be noted here that this emerging cultural divide between regions on either side of the Danube is evident in most prehistoric periods, to varying degrees of strength. In general, those to the west tend to more influenced by Central European traditions while those to the east have stronger ties to the Balkans. Vinča groups are found south of LBK groups in adjacent regions of Plain and southern Danube valley, with the Maros River acting as a boundary.

Significant changes in agricultural and settlement systems are found in MN cultures, especially in AVK[39] and Vinča groups on the Plain. Occupation expands into new territories and ecological zones, away from the major river systems. Sites in the southern part of the Plain start to be occupied for longer periods of time, up to several centuries, eventually forming the first tell settlements (north of the Maros). The houses on these early tells were small, nuclear family residences in the Balkan tradition, but multi-family longhouses occur at more open, single-component settlements, which is characteristic of LBK groups (Horváth 2003b). Settlements also sometimes have defensive palisades (Egry 2003). On the Plain, burials continue to be inhumations placed in open areas within settlements, often along the sides of houses in small family groups, with little individual distinction and few to no grave goods (Oravecz 2003). Little is known about mortuary customs in Transdanubia at this time.

Important economic changes occur in the Middle Neolithic. Crop production sees the addition of vernalized wheats. Animal economies undergo major transformations, shifting from a Mediterranean focus on ovicaprids to cattle or mixed livestock husbandry, adapting to the more

[39] There are a multitude of subdivisions of later AVK groups, particularly in northern parts of the Plain. On the southern Plain, the later MN is represented by Szakálhát.

temperate climate of the Carpathian Basin. This was critical to the spread of agro-pastoralism into the rest of Europe. Long-distance trade works were also expanded. Imported prestige materials include marine shells, precious stones, and copper (Oravecz 2003). Note that in this period, copper working was in a preliminary stage, using only cold hammering rather than smelting technologies.

Overall, there is little change in social organization from the Early Neolithic. There is some indication of increasing social inequality marked in burials that may be related to expansion of prestige goods trade. In addition, the emergence of tells at the end of this period also sets the foundation for the settlement hierarchies seen in later periods. The use of multi-family longhouses marks the emergence of more communal economic units, rather than the extended nuclear families of the preceding period.

The Late Neolithic (c. 4900/5000-4400/4500 BC) is another period of major cultural transformations that has been a major focus of local archaeologists, at least in part due to its spectacular material culture and massive tell settlements. There are three major groups on the Plain (primarily) north of the Maros: Csőszhalom, Herpály, and Tisza, located roughly north to south. Vinča phase continues to the south, entering its later phases. In Transdanubia, the Sopot culture is found at the MN-LN transition followed by Lengyel groups, which derive from the LBK.

In Transdanubia, settlements largely continue traditions of the previous period, with longhouses and relatively open sites. Lengyel groups have the first large, spatially discrete cemeteries in Transdanubia, although these are still located aside the settlements in non-residential areas (Biró 2003b). On the Plain, cultures develop along a strikingly different path. Tell-centered societies become dominant, forming a two-tiered settlement hierarchy between large, fortified tells (or large open settlements, especially in the Upper Tisza region) and smaller hamlets (Horváth 1989; Kalicz and Raczky 1987; Makkay 1982). Tells can reach up to 4 ha, and entire sites can be more than 7 ha when including the peripheral settlement (Horváth 2003a). Open settlements can be up to 11 ha in extent. Multi-family houses were used on the tells as well as open sites. These were arranged around a central open area and were sometimes clustered into fenced-off “neighborhoods” (Parkinson 2002).

In many ways, the Late Neolithic sees a continuation (and elaboration) of trends begun in the Middle Neolithic, including an intensification of long-distance trade and local craft production. Importantly, copper metallurgy begins in this period, which is intimately related to the expansion of regional exchange. There is no evidence that copper smelting or other specialized craft production was restricted to tells. Animal production systems are increasingly variable as husbandry practices become further tailored to local environmental conditions. There is a trend for more cattle rearing in Transdanubia versus ovicaprids on the Plain (Bartosiewicz 2005; Bökönyi 1988; Nicodemus 2003), a pattern that is maintained for millennia. While Neolithic sites of all periods tend to have a relatively high reliance on wild mammals, this is accentuated in the Late Neolithic.

Late Neolithic social organization has been the subject of much debate. It has been argued that the two-tiered settlement hierarchy, differences in house size, and unequal burial treatment indicate the presence of more complex political formations such as simple chiefdoms. However, the differences in grave wealth and house size are not substantially greater than in the preceding period. Further, while tells may have been acting as some sort of central places for regional groups, perhaps related to social, ritual, or defensive functions, there is no evidence of economic differentiation or regional political authority at tells that would demonstrate the development of complex polities (Parkinson 1999, 2002; Parkinson and Gyucha 2012). Rather, these changes reflect population nucleation rather than political centralization.

Neolithic tell societies come to a rather abrupt end throughout much of their distribution at the end of this period. The exact reasons for this are not known, but the arrival of new groups and or/environmental changes leading to economic collapse are often cited (Biró 2003b; Horváth and Virág 2003). The latter has been linked to the beginning of a cooling trend at the end of the Atlantic period, culminating in the Subboreal climate minimum during the subsequent Bronze Age (see Chapter 4). Alternatively, Parkinson and Gyucha argue that the breakdown of tell-centered societies was the result of inherent structural instabilities present within tribal societies (Parkinson 1999, 2002; Parkinson and Gyucha 2012). As populations grew and were more tightly packed, there was not an institutionalized, hierarchical political system present that could regulate the resulting scalar stresses. In the absence of such political structures, tells essentially collapsed under their own weight, and without any formal mechanisms holding them together, the various social groups residing on the tells dispersed into autonomous units (see below).

The Copper Age

The Early Copper Age (c. 4500/4400-4000/3900 BC) is an interesting period as regions east and west of the Danube continue to follow independent and opposing trajectories. In Transdanubia, Lengyel cultures remain relatively unchanged. However, the societies on the Plain undergo radical transformation, with the larger social groupings within both longhouses and settlements separating into their smaller, constituent units. Settlement systems shift from a two-tiered tell organization to small farming hamlets, typically less than 1-2 ha, that are widely dispersed throughout the landscape. At the same time, large multi-family longhouses are replaced by single extended family residences, as in the earlier part of the Neolithic. Hamlets themselves appear to represent the breakdown of an individual Late Neolithic longhouse unit. These settlements are occupied for shorter periods of time, on the order of 50-100 years, precluding the formation of deeply stratified sites. They frequently have substantial fortifications, despite the small resident populations. This dramatic reorganization coincides with the loss of regional groups on the Plain and Transylvania, including those south of the Danube, which now all belong to rather homogeneous Tiszapolgár culture (Horváth and Virág 2003; Parkinson 1999, 2002, 2006; Parkinson and Gyucha 2012).

At the same time, formal, spatially-discrete cemeteries first appear (Bognár-Kutzián 1963, 1972). These large burial grounds may have served as permanent territorial markers and central places for socially integrative rituals in the place of tells. There is increasing divergence between the amount and type of grave goods found in burials, suggesting a continuation of the trend towards increased social inequality. In addition to cemeteries, a new site type appears that also may have served a regionally integrative function: enclosures (Bánffy, et al. 2003; Parkinson and Duffy 2007). These ditch and embankment constructions are found throughout the Basin and temperate Europe. The interior of these enclosures often contain concentric rings of posts and central sacrificial/offering pits, reminiscent of henges elsewhere.

In the Early Copper Age, there are a few important economic developments. Gold ornaments first appear and copper metallurgy is intensified, although metal production is widespread among settlements. There is little known about the animal economies of this period as few sites have been examined in any detail and nearly all of these have been on the Plain. However, some significant changes are apparent, at least among Tiszapolgár groups (Nicodemus 2003; Nicodemus and Kovács *forthcoming*). In this period, the use of wild fauna drops dramatically, averaging less than 15% of the mammalian assemblages. This marks the start of an important trend towards increased livestock production at the expense of hunting and trapping among later prehistoric populations. This may reflect the loss of wildlife habitat through human population expansion and land clearance, which can be seen in pollen cores (Willis, et al. 1998). Alternatively, this may be related to increased pressure to produce surplus meat/animals for social obligations and/or wealth generation, associated with increasing socioeconomic inequality and later, political economies.

In the ECA, groups on the vast steppe-forest of the Plain refocus husbandry systems towards ovicaprids. Traditionally, this has been explained as the adoption of mobile pastoralism, linked to abandonment of tell societies due to climate change (Bökönyi 1988). There are several problems with this scenario. First, research within the past decade has demonstrated the presence of permanent and fortified settlements rather than solely small temporary campsites (Parkinson 2002), indicating that the level of mobility may not have been as great as previously assumed. Second, climatic changes were not particularly drastic in this early stage of the Subboreal and are unlikely to have prevented crop production. Further, these changes were not felt in adjacent regions, such as Transdanubia. I argue instead that this restructuring of animal economies may be linked to the larger organizational changes discussed above and below. The shift to small, independent households and dispersed settlements would have favored systems that are tailored towards small-scale, self-sufficient, and risk-adverse husbandry practices. On the grassy Plain, this would favor sheep and goat production (Nicodemus 2003).

Perhaps the most important change was a shift to individual extended families as the primary economic unit. In previous periods, co-resident multi-family groups acted communally as a productive unit. This discouraged the accumulation of wealth and prevented large and permanent social inequalities. With individual families becoming independent units, there is more opportunity for self-aggrandizers to accumulate wealth and establish relationships of obligations and dependency, which can evolve into institutionalized social inequality and hereditary leadership positions (Bogucki 1996). These significant organizational changes of the ECA laid the foundation for the development of complex polities in the Bronze Age.

Middle Copper Age groups (c. 4000/3900-3600/3500 BC) appear to evolve *in situ* with varying degrees of organizational change. To the east, Tiszapolgár groups become Bodrogkeresztúr, marked primarily by changes in ceramic styles rather than any major shifts in economy or socio-political structure. In Transdanubia, there are greater differences between ECA Lengyel and the MCA Balaton-Lasinja culture, mirroring changes that occurred on the Plain in the previous period. There is a great increase in the number of sites, settlements are smaller, and multi-family longhouses are replaced by separate extended family residences. Some degree of regionalization develops near the end of the period, but is lost during the homogenization of culture groups in the subsequent LCA (Horváth and Virág 2003).

The Late Copper Age (c. 3600/3500-2800/2700) hosts a number of important changes, many of which are linked to either technological innovations or the influence groups external to the region. Importantly, much of the Basin belonged to the Baden culture at this time, which is found over a wide area of Central Europe, indicating a new pattern of macro-regional interaction and integration. To the east, the Coţofeni culture expands into Transylvania and adjacent portions of the Plain from Eastern Romania. In the latter part of this period, the Vučedol group develops on the southwestern portion of Transdanubia, the southern Danube and Sava valleys, and the Dinaridies. Baden settlement patterns do not show any major changes from the previous period, although they increase in number and density, extended into more unfavorable ecozones, and occasionally larger settlements (several hectares) are constructed. There is also greater social status marking in burials, including the famed oxen-and-wagon sacrifices in graves. To the south, Vučedol groups return to tell-centered societies, which continue into the Bronze Age.

One of the most influential events in this period was the so-called "kurgan invasion" (Anthony 2007; Ecsedy 1979; Gimutas 1956). Unfortunately, the exact timing of the arrival of these eastern steppe people, also known as the Pit Grave culture, is not well known given the dearth of absolute dates. The later part of this period dates to around 3000-2700 BC. [40] There is very little evidence of any Pit Grave settlements; almost the entirety of what is known about this enigmatic group is from the kurgan burial mounds themselves. Interestingly, the kurgans are located in dry, grassland areas, especially on relict Pleistocene river fans, areas that were not well suited to prehistoric agriculture and avoided by Baden groups. It has been suggested that the Pit Grave and Baden peoples occupied contrasting ecozones and were able to coexist for centuries due to their complementary productive bases (mobile pastoralism versus settled agriculturalists) (Horváth and Virág 2003; Sherratt 1984). The kurgan people disappear as a distinct entity as abruptly as they appeared and some scholars believe that the revolutionary cultural changes of

[40] From one of the final kurgan burials at Kétegyháza, Hungary (Anthony 2007).

the Bronze Age were due to the blending of these two very different traditions. However, the nature of their relationship to Baden groups and any lasting influences on regional development is open to debate, and recent work has shown little to no effect on local groups at this time (Parsons 2011, 2012).

Economically, several significant technological and agricultural innovations appear in the LCA. These include wheeled vehicles, scratch-plows, wool sheep, horses, and bronze metallurgy.[41] The use of secondary animal products increases, resulting in more diversified animal husbandry systems. It should also be noted metal production greatly decreased and gold items are no longer present. Some scholars have attributed this to the influx of steppe populations from the east which disrupted trade networks with ore-producing areas (Virág 2003), but this has not yet been fully examined.

The Early and Middle Bronze Ages

The Early and Middle Bronze Ages of the Carpathian Basin have long been recognized as periods of great cultural transformation. At the same time, it is an era that has been poorly understood and often fraught with controversy. The basic chronology of the Bronze Age has yet to be settled, with strong differences not only between countries, but also between individual scholars. Gogâltan's (1997) review of nearly 50 published regional chronologies underscores this situation. Radiocarbon dates have begun to clarify the situation. Notably, they have shown that traditional ceramic-based chronologies, based on correlations to Bronze Age Mediterranean civilizations, placed the Bronze Age 500-800 years too late. However, there are still too few reliable dates from secure stratigraphic contexts to adequately place many cultural groups. There continues to be contrasting opinions on where to place the break between the Early and Middle Bronze Age[42] how many internal divisions there should be within each of these. This is further complicated by disagreement as to what actually constitutes a distinct and meaningful cultural entity. Some authors place each minor regional variant of ceramic styles into a separate "culture," especially when they fall across international borders, while others maintain much more inclusive groupings, allowing for substantial internal variation.

[41] Note that while horses and bronze working first appear in this period, they are not widespread and do not become fully integrated into economic systems until the second half of the Early Bronze Age.
[42] There is a division between scholars who place the EBA-MBA transition at 1800/1700 versus those who place it at 2200/2000. The author follows the latter.

For this dissertation, I use a radiocarbon based chronology that has been fairly well established in Hungary and southwestern Romania (Duffy 2010; Gogâltan 1997; Gyucha 2010; O'Shea 1991; Parkinson and Gyucha 2012). This places the Early Bronze Age at c. 2800/2700-2200/2000 BC and the Middle Bronze Age from c. 2200/2000-1600/1400 BC, with some variability introduced from developmental differences between specific regions and culture groups. The internal divisions are more problematic as traditional ceramic-based systems tend to make distinctions that are not always supported by absolute dates (e.g., large chronological overlaps, significant regional variation, or complete lack of dates). Both the Early and Middle Bronze Ages are typically divided into (the traditional) three periods, with varying numbers of subdivisions with each of these, again, showing much disagreement between scholars. For this study, a simpler system is used, one with internal divisions that are well correlated across the study region and which represent major organizational changes. This allows comparisons within and between periods to reflect meaningful analytic units. I use only two divisions within Early and Middle Bronze Ages, and for simplicity, call them “A” and “B,” representing earlier and later phases.[43] I also focus here only on the major, well accepted cultural groupings, allowing for internal variability.

It should be noted that there is still much that we do not know about Bronze Age societies in the Carpathian Basin. While certain classes of material culture have been well-studied (e.g., ceramics, metalwork, various import and prestige goods), there are still fundamental gaps in our understanding of settlement systems, craft and agro-pastoral production, and sociopolitical organization.[44] This is in no small part is due to the history of research in the region, which has focused on excavations at (the centers of) prominent tell settlements, and to a lesser degree at cemeteries, and on description of their more visually appealing artifact assemblages. There has been little work done on smaller settlements or peripheral occupation areas of tells. Many areas lack systematic surveys, so regional site distributions are not always known; Hungary is a major exception to this with its ongoing national survey program, which has resulted in full coverage for a number of counties. In general, the relationships between settlements, as well as social groups within them, are poorly understood. Further, there have been few analyses (or systematic collection) of less glamorous archaeological materials, particularly slags, plants, and animal

[43] Letters are used instead of numerals to avoid confusion with other systems.
[44] These problems can be extended to other periods as well.

remains, which are necessary to shed light on local production systems. As a result, many inferences about social organization among Bronze Age groups lack substantive supporting evidence, particularly where claims for complex political systems are made

Due to the aforementioned limitations, the following discussion of regional cultures, based largely on traditional interpretations, must be viewed as provisional. Groups used for the more detailed analyses in this dissertation, namely the Maros, Ottomány/Gyulavarsánd, and Nagyrév/Vatya, were chosen specifically because they have been studied more systematically and have datasets that can be used to assess models of economic and sociopolitical organization.

The Early Bronze Age A, c. 2800/2700-2500, represents the very earliest part of the period, one that shows general continuity with the previous Late Copper Age (excepting the Kurgans) in terms of basic organization. This period is not well defined in many areas. Very large regional groupings continue in this period. In much of Transylvania and the southern Danube region, LCA cultures persist with only minor changes (late Coţofeni and Vučedol, respectively). Although normally not included in traditional chronologies of the earliest Bronze Age, absolute dates from Kiszombor-Új Élet, Hungary, place the initial appearance of the Maros culture to c. 2700 cal. BC (O'Shea 1991), falling in this period. The Makó/Kosihy-Caka "culture" is extensive, found throughout much of the Plain and Transdanubia (Kulcsár 2003, 2009; Machnik 1991). However, this group is largely defined by a particular vessel type, a decorated bowl, and it is unclear whether or not this can be used to define a distinct cultural unit. Bell Beaker groups span temperate Central and Western Europe, extending into the northwestern Basin along the northern Danube corridor. Some kurgans continued to be built/used on the Plain at this time as well.

In general, social organization does not appear to undergo any great changes from the LCA. Settlements continue to be small and dispersed. Few large cemeteries are known. One of the most important changes is the adoption of more advanced bronze metallurgical technologies, which appear first in the southern Vučedol region. The Csepel group (near Budapest) of the Beaker culture deserves special mention. Several of their settlements appear to have been early centers of domestic horse breeding (Bökönyi 1988), perhaps facilitating their spread into Central Europe. It should be noted, however, that horses are still uncommon in the Basin as a whole, especially among southern groups.

Table 5.2: Chronology and major culture groups in the Carpathian Basin (Bronze Age). Cultures in boldface are represented in the comparative study.

Period	C14 dates (cal. BC)	Major Culture Groups	Region
Early Bronze Age A	2800/2700-2500/2400	**Maros (Early/Initial)**	Tisza-Maros
		Makó	Plain, Transdanubia
		Nagyrév (Early)	C Plain, M Danube
		Coţofeni	Transylvania
		Vučedol	S Transdanubia, S Danube
		Bell Beaker	NW Transdanubia
Early Bronze Age B	2500/2400-2200/2000	**Maros (Early)**	Tisza-Maros
		Nagyrév	C Plain, M Danube
		Hatvan (Early)	N Plain
		Nyírség	NE Plain
		Glina-Schnckenberg	Transylvania
		Somogyvár-Vinkovci	Transdanubia, S Danube
		Kisapostag	Transdanubia
Middle Bronze Age A	2200/2000-1800/1700	**Maros (Classic)**	Tisza-Maros
		Ottomány	Körös
		Hatvan (Late)	N Plain
		Füzesabony	NE Plain
		Vatya	C Plain, M Danube
		Weitenberg	Transylvania
		Vattina	SE Plain, S Danube
		Verbicioara	Iron Gates
		Encrusted Ware	Transdanubia
		Madárovce-Magyarád	NW Basin
Middle Bronze Age B	1800/1700-1500/1400	**Maros (Late)**	Tisza-Maros
		Gyulavarsánd	Körös
		Piliny	N Plain
		Füzesabony	NE Plain
		Koszider (Vatya)	C Plain, M Danube
		Weitenberg	Transylvania
		Suciu de Sus	NW Transylvania
		Vattina	SE Plain, S Danube
		Tumulus	Transdanubia
Late Bronze Age	1500/1400-800/700	Gáva	Plain
		Noua	Transylvania
		Urnfield	Transdanubia

*dates based on ranges established for Hungary and the Plain.

Table 5.3: Major characteristics of culture periods

Period	House Form	Settlement System	Burials	Social Inequality	Political Organization	Economics	Animal Economies	Technological Changes
Early Neolithic	single extended family	simple	within settlements	minimal	autonomous villages (tribal)	primarily domestic economies	Mediterranean type	agriculture
Middle Neolithic	multi-family longhouses	two-tiered (tells)					regional variation	
Late Neolithic							significant hunting	copper, gold metallurgy
Early Copper Age	single extended family	simple	formal cemeteries	pronounced			high ovicaprids little hunting	
Middle Copper Age								
Late Copper Age							horses, secondary products	wheeled transport
Early Bronze Age I		two/three tiered (tells)					regional variation	bronze metallurgy
Early Bronze Age II				institutionalized	centralized/ hierarchical (chiefdoms)	emergence of political economies?		
Middle Bronze Age I							increasing centralization?	
Middle Bronze Age II								chariots
Late Bronze Age		two/three tiered						iron metallurgy

Note: Organizational changes are not necessarily present or contemporaneous for all cultures in these periods. Features are focused on Plain groups.

It is during the second part of the Early Bronze Age (EBA-B, c. 2500-2100/2000) that organizational changes associated with more complex societies begin to appear in the Carpathian Basin. There is a re-emergence of regionalized culture groups, settlement hierarchies, and on the Plain, tell-centered societies (beyond Vučedol groups). There are a large number of recognized EBA-B groups in the Basin, and only the major cultures are mentioned here (Figure 5.1). The Early Maros culture is situated in the confluence region of the Tisza and Maros rivers. Nagyrév is found throughout much of the Plain and along the Middle Danube. Hatvan (early) and Nyírség span the north and northeastern portions of the Plain and adjacent highlands, respectively. The Glina III-Schneckenberg culture is centered in Transylvania and Somogyvár-Vinkovci is found throughout Transdanubia and along the Southern Danube valley. At the very end of the period, the Kisapostag horizon covers much of Transdanubia.

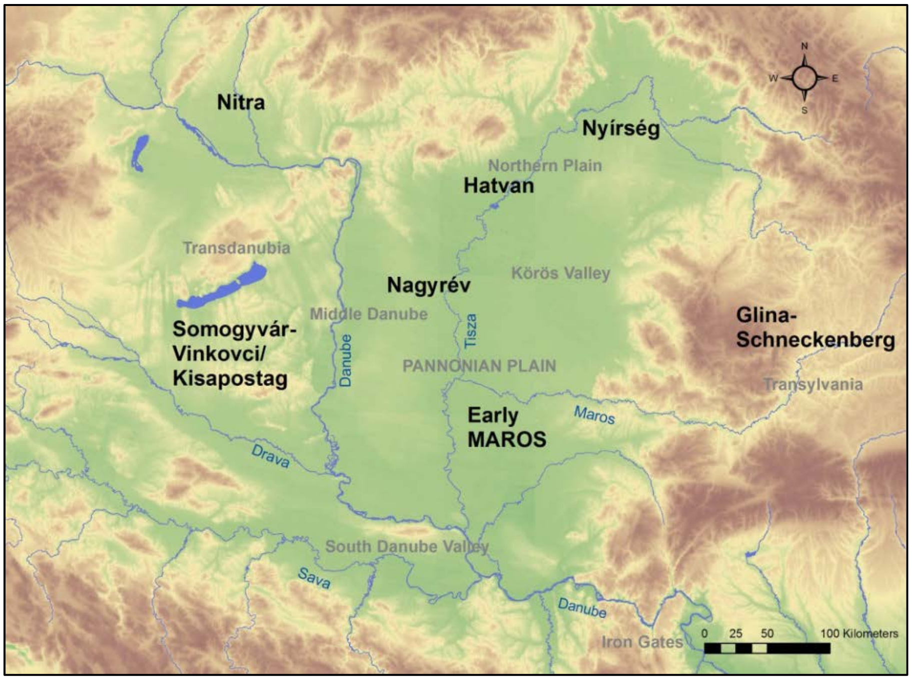

Figure 5.1: Major EBA-B culture areas

On the Plain, the return to tell-centered settlement patterns is important. While tells also characterized the Late Neolithic, Bronze Age tell organization differs significantly in terms of internal structure. Rather than multi-family longhouses, Bronze Age groups maintain individual extended nuclear family household units from the Copper Age. These small houses are typically arranged in rows around a central open area. In cemeteries, there is also increased marking of social inequality and leadership positions, which become institutionalized in many areas (O'Shea 1996). A more in-depth discussion of social organization among several of these EBA groups is presented in the subsequent sections.

This period also sees an expansion of long-distance trade networks, linking much of Europe. This is spurred largely by intensified metallurgical production and elite exchange of other prestige goods such as marine shells from the Mediterranean and Baltic amber. Less visible items, such as salt, timber, and textiles, may also have been important within intermediate scale networks. Metalworking and other crafts are made at and imported into both smaller settlements and large sites, to varying degrees. Animal economies continue to be regionally variable and strongly influenced by local ecology (Nicodemus 2010). There is some increase in secondary products use, resulting in increasingly broad-based husbandry strategies. Horses are found more regularly at settlements throughout the region, and were likely part of regional exchange as well.

While the Early Bronze age is a period of major transformations, there is little evidence of centralized polities at this time. Where mortuary evidence is available, there is no indication of leadership positions being marked beyond the community level, although these positions are shared across regions, nor of the cemeteries themselves arranged hierarchically. As in the Late Neolithic, a two-tiered settlement system exists on the Plain, but there has yet to be any substantiation of fortified tells acting as regional political centers.

The Middle Bronze Age continues many organizational aspects from the EBA, but in some areas more centralized polities emerge. It is important to note that social organization is highly variable at this time. As discussed in more detail below, some groups, like the Vatya of the Middle Danube, develop regional polities, while others, like those of the Lower Maros, maintain laterally organized, autonomous village societies. It has become increasingly clear that MBA groups followed very different developmental trajectories with distinctive endpoints. A goal of this dissertation is to elucidate some of the economic variables that influence these pathways and to identify both the site- and culture-specific dynamics leading to this regional variability, as well as common patterns shared among groups with emerging political complexity.

The earlier part of the Middle Bronze Age (MBA-A) dates to c. 2200/2000-1800/1700 BC (Figure 5.2). A high degree of regionalization of culture areas continues from the previous period. In the Tisza-Maros region, the Maros culture moves into its Classic phase and Hatvan continues on the northern Plain. The Ottomány culture forms in the Körös valley and the northeastern Plain and Vatya develops from Nagyrév in the Middle Danube region. Weitenberg groups are found throughout Transylvania. On the southern Plain and Danube valley, there is the Vattina culture and downriver related Verbicioara groups are found in the Iron Gates region. Kisapostag develops into Encrusted Ware in Transdanubia.

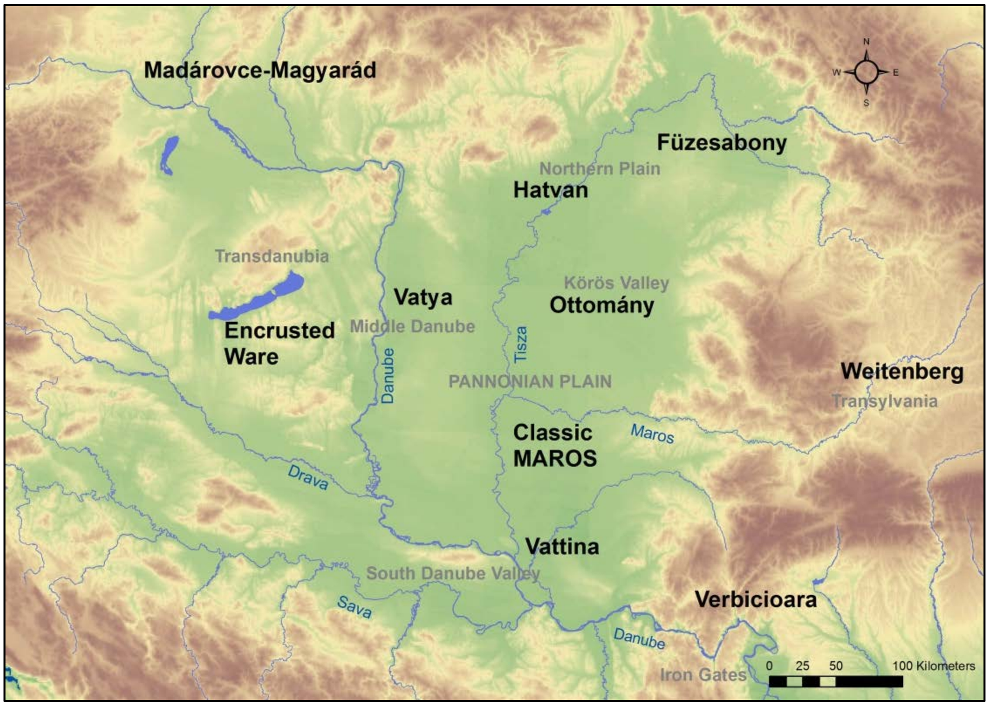

Figure 5.2: Major MBA-A culture areas

In many regions, the transition to the MBA is marked more by continuity than any radical shift in organization. This is the case for most groups on the Plain, where tell-centered societies continue with varying degrees of elaboration. However, in other areas features associated with more complex political formations appear, especially in the Vatya area (see below). In these we see new, specialized site types, including massive hilltop fortifications, which may have been acting as the apex of a three-tiered settlement hierarchy. It appears that different sites and regions develop into more complex forms and exert more regional influence at varying times (if at all), which is characteristic of middle-range societies (e.g, tribal and chiefly cycling) (Anderson 1990, 1994, 1996a, b; Parkinson 2002).

Like the earlier part of the MBA, the latter Middle Bronze Age (MBA-B, c. 1800/1700-1500/1400 BC) shows a mix of regional continuity and organizational change. Most of the regional divisions remain intact (Figure 5.3). Maros, Weitenberg, and Vattina enter their late phases. Ottomány groups in the Körös Valley develop into the closely related Gyulavarsánd and the Koszider horizon[45] appears at Vatya sites (and elsewhere) at the end of the MBA sequence.

[45] The Koszider horizon is somewhat problematic as it largely related to a metalworking tradition and hordes, spans a large area of the Plain, and has radiocarbon dates that show a more lengthy development than previously thought. For a critique, see Duffy (2010).

In Transdanubia, early Tumulus influence from the northwest becomes dominant. None of these groups undergoes radical reorganization, but their regional influence may have waxed or waned.

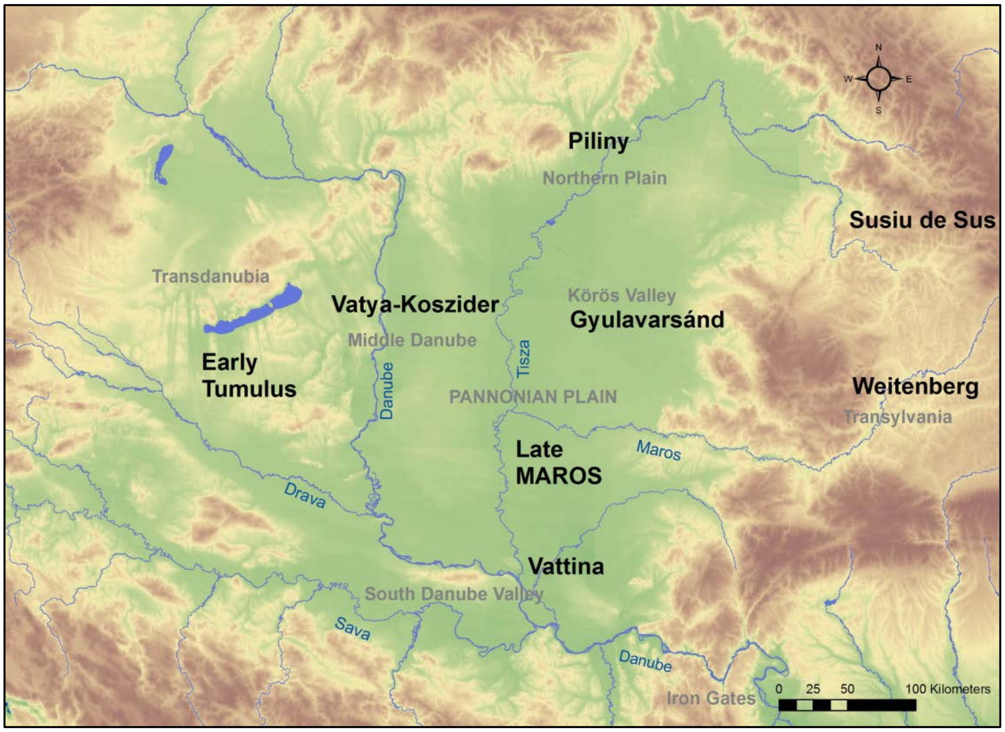

Figure 5.3: Major MBA-B culture areas

The end of the Middle Bronze Age is marked by the abandonment of most tells on the Plain, with the collapse occurring a bit earlier to the south. The reasons for this denouement are not well understood but the usual suspects have been suggested, environmental change, increased warfare, and the invasion of external groups, none of which have been substantiated. The well-documented Maros sequence at Pecica Şanţul Mare and contemporary sites may help to answer this question, at least in this part of the Carpathian Basin (see Chapters 9-12).

Late Bronze Age

The Late Bronze Age (c. 1600/1400-800/700 BC) differs greatly from its Early and Middle Bronze Age predecessors, especially on the Plain, where there was widespread collapse of tell societies.[46] There is also a return to large, relatively homogenous culture areas. Many

[46] Note that in the Middle Danube region, some of the major tells continue to be occupied, and even expanded (e.g., Százhalombatta).

groups within the Basin are related to the expansive Urnfield culture, which is found though most of Central Europe, emerging from preceding Tumulus groups. In the Basin, this includes the Middle Danube Urnfield culture in Transdanubia and, more distantly related, Gáva on the Plain. To the east, Noua groups are present from Transylvania to the Black Sea and show Pontic influence.

Overall, there is a great increase in the number of settlements during the LBA, particularly smaller, dispersed hamlets and farmsteads. At the same time, a strong settlement hierarchy also develops, headed by the period's well known hill-forts, and on the Plain, massive fortified settlements. In the Maros Valley, the well documented Corneşti-Iarcuri site represents one of these very large fortified settlements, dating to c. 1400-1000 cal. BC. It has four elaborate fortification ditch/rampart/palisade complexes, enclosing an area of 1722 ha,[47] which is more than an order of magnitude larger than any EBA-MBA site in the Basin (Szentmiklosi, et al. 2011). It is probable that these macro-sites represent the apex of a three (or more?) tiered hierarchy with strongly centralized military, economic, and political organization (Gogâltan and Sava 2010; Medeleţ 1993; Rusu, et al. 1996; Sava, et al. 2011; Szentmiklosi, et al. 2011). It also is argued that these large sites directly controlled ore sources in the neighboring mountain ranges and were primary centers of metal production (Gogâltan and Sava 2010). Unfortunately, few excavations have been done on the smaller settlements, so the exact relationship between sites of various sizes and forms requires further exploration.

The LBA is known for its numerous hoards of spectacular and advanced bronze and gold metalwork. This is a period of large-scale metallurgy, with bronze now being used for wide range of everyday items, not just prestige goods and occasional small tools. By the later part of this period, iron is being used as well. High levels of social differentiation are assumed based on the accumulation and deposition of prestige goods (Sava, et al. 2011). Burial traditions primarily use urn cremations, placed in large cemeteries (hence "Urnfield").

EARLY-MIDDLE BRONZE AGE CULTURES ON THE PLAIN

This section provides a more in-depth description of the Early and Middle Bronze Age cultures which are used in the regional study of economic and political organization. The Maros

[47] Szentmiklosi *et al*. (2011) note that this site is the largest prehistoric settlement in Europe and perhaps should be considered a town. The greatest extent of this site, however, likely dates to the early Iron Age.

culture is the focus of this dissertation, with Pecica Şanţul Mare, a large fortified tell, serving as the principal study site (Figure 5.4). Groups in the Körös River valley (Ottomány/Gyulavarsánd) and in the Middle Danube region (Nagyrév/Vatya) are used as out-group comparisons. The following discussion provides a basic outline of regional development, settlement patterns, mortuary practices, and, where possible, social organization. Further evaluation of economic organization is made in Chapters 13 and 14, including long-distance exchange, local craft production, and subsistence systems. Information about site selection criteria and individual site descriptions are provided in Chapter 6.

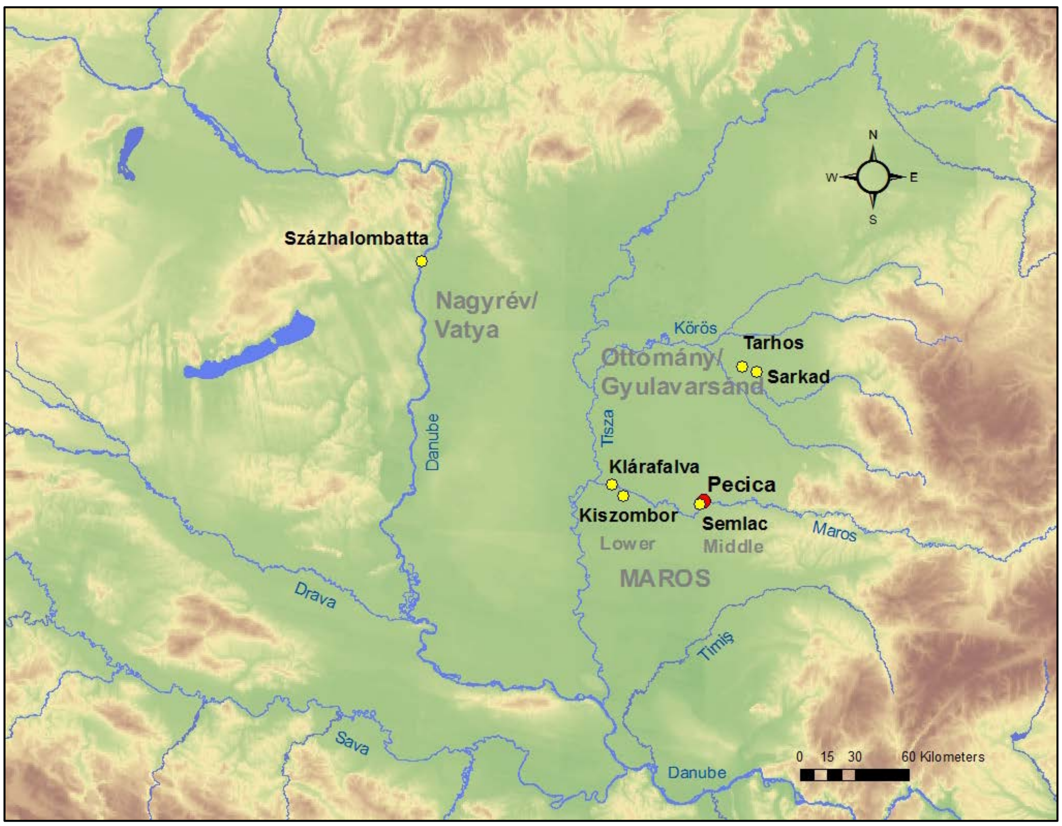

Figure 5.4: Study sites and associated culture groups (EBA-MBA)

Maros Culture

The Maros (Mureş in Romanian)[48] culture is centered in the Tisza-Maros confluence region (Figure 5.4). Sites lie along the Maros River east to the Apuseni Mountains in Romania and along the Tisza south to the Timiş River and perhaps as far as the Danube-Tisza confluence

[48] Also known as Sőreg, Pitvaros, and Periam-Pecica for its various phases in older literature.

in Serbia during its maximum extent around 2000 cal. BC.[49] It spans the entire Early-Middle Bronze Age sequence, with radiocarbon dates from c. 2700-1500 cal. BC (O'Shea 1991). Its internal divisions correspond largely to the periodization of the Bronze Age in general: Early Maros c. 2700-2200 BC, Classic Maros c. 2200-1700 BC, and Late Maros c. 1700-1500 BC. These phases represent the development, peak, and denouement of the Maros culture. Recent work was shown that there may be considerable organizational variability present, with significant differences between groups inhabiting the marshy confluence region (Lower Maros) and those living further upstream (Middle Maros). These will be considered separately.

Lower Maros

Lower Maros groups are fairly well understood compared to other cultures in the Carpathian Bain. Several important cemeteries have been the focus of mortuary studies (Banner 1931; Giriæ 1984; O'Shea 1995, 1996, 1997; O'Shea and Barker 1996) and systematic excavations have been conducted at two major settlements, Klárafalva-Hajdova and Kiszombor-Új Élet (O'Shea *forthcoming*). These two settlements are included in the regional analysis and are described in detail in Chapter 6. Lower Maros sites, both settlements and cemeteries, are largely tied to the distribution of flood-free land on relict loess islands and plateaus (Figure 5.5), which is not unexpected given the severity of bi-annual flooding and extensive distribution of permanent and seasonal marshes in this region (see Chapter 4). Both tells and flat sites are present and often fortified, but there do not appear to be very large size or functional differences between these settlement types. Site size and form are influenced by the availability of dry land, with sites in more open areas being more spatially extensive. Settlements do not appear to be much larger than 1-2 ha in size, but some tells, such as Klárafalva, can have stratified deposits up to 4 meters in depth. There is no evidence of a salient settlement hierarchy.

Settlements follow the basic layout for most Bronze Age sites. Although few houses have been excavated in their entirety, they appear to be relatively small and rectangular and rebuilt in the same location over time. The earliest houses in the Bronze Age (EBA-A) are semi-subterranean, which are also found in contemporary cultures (e.g., Makó) as well as Late Copper Age sites (Kulcsár 2009). The density of houses on settlements is related to the amount of

[49] Note that the apparent concentration of Maros sites in the Hungarian portion of the confluence region reflects the fact that only this area has undergone systematic survey. The exact areal extent of the Maros culture through time has not yet been well established.

habitable land around the site, being more dispersed at open sites with ample dry land. Hearths and pits are found both inside and outside of houses and the general fill layers tend to have rich habitation refuse. There is evidence of local craft production, from weaving to bronze working, at all site types. The latter is evidenced by various metal working tools, accessories, and debris (Papalas 2008).

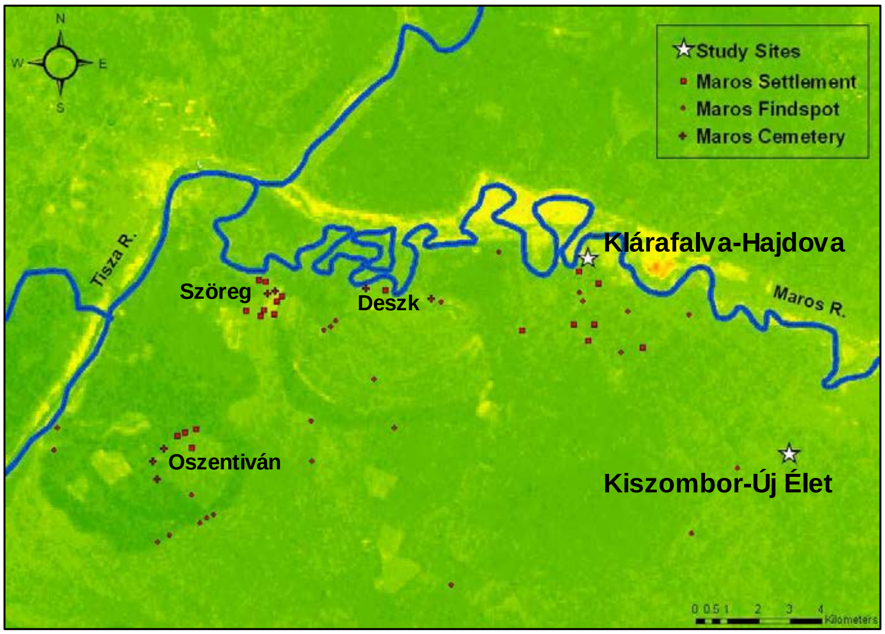

Figure 5.5: Distribution of Lower Maros settlements, cemeteries, and findspots (Csongrád County, HU). Elevated loess and levee areas are shown in yellow. Major sites are labeled.

Mortuary studies of the rich Lower Maros cemeteries have provided great insight into social organization (O'Shea 1996). The distribution of grave goods and burial treatment indicates the presence of a range of horizontal distinctions as well as substantial social inequality, including hereditary leadership positions. While political influence was held in the hands of a few within settlements, it does not appear that this power extended to any sort of regional, centralized polity. Further, there is little economic differentiation between settlements. The Lower Maros was laterally organized into autonomous village societies.

Middle Maros

It has become increasingly apparent that there are considerable differences between Maros groups occupying the lower and middle stretches of this river. While people occupying both regions share basic conventions for ceramic styles, there are significant contrasts in site location, form, and likely organization. Unfortunately, the Middle Maros region in Romania has not been systemically surveyed like the Lower Maros area in Hungary. The settlement system is consequently not well documented and nearly all of the Middle Maros sites are prominent tells. We lack basic knowledge about the smaller settlements and no cemeteries have been found to date. While this limits our ability assess Middle Maros sociopolitical organization to some degree, there are other methods and lines of evidence that allow us to do so (Chapters 9-12).

Middle Maros groups are located in the area midway between the marshy Tisza-Maros confluence and the foothills of the metal-rich Apuseni Mountains in Romania. This region is higher in elevation than the confluence, situated on extensive Pleistocene loess deposits. Flood-prone land is largely confined to the deeply incised floodplains of the major river systems. Sufficient dry land for settlement and agriculture is less problematic here and site locations, for at least the major tells, are chosen for their defensibility and/or access to water-borne trade and transportation routes. These Middle Maros tells clearly differ from those of the Lower Maros in terms of scale. Middle Maros tells, such as Pecica Şanţul Mare and Periam, are larger than those of the Lower Maros (5-6 ha versus 1-2 ha), have deeper stratified deposits, and more elaborate fortifications. There is also evidence for extensive habitation beyond the fortifications. Recent excavations at Pecica have found preliminary evidence for functional differentiation, including unique public/social architecture, ritual activities, and economic intensification and/or specialization (Nicodemus 2012; O'Shea, et al. 2012). Features associated with these are described in the following chapter and will be discussed in more detail as part of the analysis of economic and political centralization.

Ottomány/Gyulavarsánd

The Körös river drainage of the eastern Pannonian Plain is home to some of the most famous tell cultures in the Basin, namely the Ottomány (MBA-A) and Gyulavarsánd (MBA-B).[50] This region is largely a mosaic of steppe forest and expansive marshes and much of the area would have been marginal for human occupation. Nonetheless, major tell settlements were founded on more favorable lands along the elevated Körös levees and in higher plains at the base of the Transylvanian mountains. There has been a long history of major tell excavations in this

[50] Note that Ottomány (Otomani) is often used outside of Hungary to refer to both of these groups.

region, which have contributed greatly to our understanding of the Bronze Age both regionally and as part of continent wide developments (Bóna 1975, 1992; Bóna and Raczky 1994; Poroszlai 2003b). This study focuses on groups inhabiting the marshy regions between the major Körös branches in Békés County, Hungary, which have undergone systematic survey (Szatmári n.d.) and excavations of a variety of site types, including smaller hamlets (Duffy 2010).

Duffy (2010) has developed a radiocarbon based chronology for the Middle Bronze Age of the Körös region. While there is considerable overlap for the Ottomány and Gyulavarsánd, they can be divided into three phases: Ottomány (2150-1750 BC), Transitional (1750-1650 BC), and Gyulavarsánd (1650-1400 BC). The origins of the Ottomány culture are not well known as there are few sites, excluding the kurgans, from the earlier Bronze Ages (Makó/Nyírség) in the region, none of which have been studied systematically. MBA settlements in the Körös valley show a two-tiered settlement hierarchy with distinctions between larger fortified tells and smaller open settlements (Figure 5.6), which is typical for this period on the Plain. Compared to neighboring groups, tells here are not as large as found along the Tisza or Danube in either areal extent or depth of deposits. It will be noted, however, that there is evidence for often substantial occupation outside of central fortified areas, although it seems to be largely confined to the later Gyulavarsánd period (Szatmári n.d.). There is also a substantial increase in the number of smaller settlements in this later period. There is some modularity in settlement patterns, with a central tell and peripheral open hamlets, which does suggest some sort of structured regional organization. Despite these differences in settlement size, form, and spatial distribution, excavations have not found any evidence for economic or political centralization (Duffy 2010).

Like the Middle Maros, few cemeteries have been found in the region. For the Ottomány period, the burials that have been uncovered are largely cremations and have been little studied. These are similar in form the preceding Nyírség phase. In the Gyulavarsánd, inhumations are more common, but cremation is used as well.

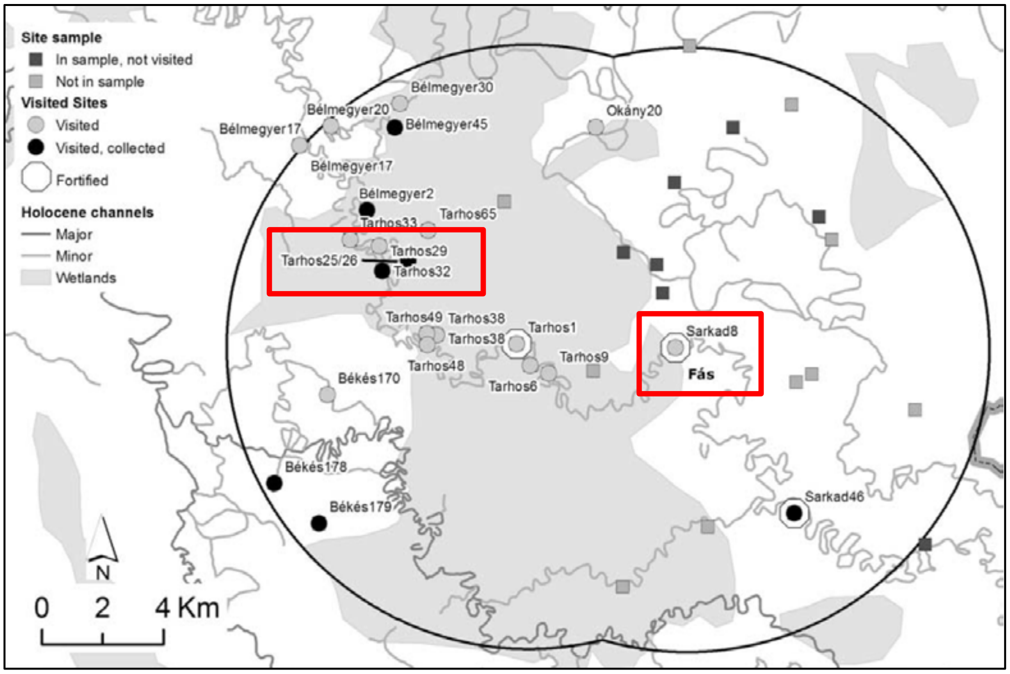

Figure 5.6: Map of MBA settlement system in along the Fás (Békés county, HU) and reconstructed wetlands (shaded) (Duffy 2010: Fig. 8.5). Study sites of Tarhos 26 and Sarkad 8 are marked.

Nagyrév/Vatya

Societies of the Middle Danube valley and adjacent regions of the Danube-Tisza interfluve show much continuity in their development from the Early through Middle Bronze Ages. The MBA Vatya culture, a focus of this study, evolves directly from preceding EBA Nagyrév groups. In fact, most large Vatya settlements have an underlying, and often extensive, Nagyrév component, which allows for examination of long-term organizational change. A brief review of the Nagyrév culture is necessary to frame the changes that occur during the MBA Vatya period.

Nagyrév groups occupied a larger portion of the Carpathian Basin than the Vatya, spanning the Danube and Tisza valleys, abutting Maros groups on the southeast Plain. They were a tell-centered society and their prominent settlements, located primarily on productive lands along major waterways, are well known. Smaller settlements were characteristic of less fertile areas. There are few analyses of faunal remains from Nagyrév settlements that have sufficient sample sizes or are not mixed with later periods. However, the general pattern for more cattle west of the Danube is present with meat production being the primary goal (Choyke and Bartosiewicz 1999; Vretemark 2010; Vretemark and Sten 2005). Cemeteries show a variety of burial practices, each with strict rules for deposition, with some preference for cremation. There is a trend for more grave goods to be placed with the cremations versus inhumations (Csányi 2003).

At the end of the EBA, Nagyrév settlements on the eastern Plain were (variably) destroyed and reoccupied by Hatvan, and later, Füzesabóny groups (Tárnoki 2003). To the west, in the greater Middle Danube region, Nagyrév groups develop into the Vatya culture. Vatya groups have one of the most complex settlement patterns in the Basin at this time, with the possibility of a multi-tiered settlement system (Earle and Kolb 2010; Poroszlai 2003a). This has been explored most systematically in the Benta Valley, a western tributary of the Danube just south of Budapest (Earle and Kolb 2010; Vicze 2000; Vicze, et al. 2005). Here there are several dimensions of variability: size, location, and fortifications. As in other regions during the Bronze Age, there is a distinction between large fortified tells and smaller, unfortified flat settlements. But there are also very large non-tell settlements and the fortified sites vary greatly in size and location. Earle and Kolb (2010) suggest an unusually complex regional system that has two separate economic power bases. The flat settlements are found primarily in the most fertile agricultural land in the valley. These very large, open settlements may have acted as centers controlling staple production (both crops and livestock). The fortified sites are located at important points along the major waterways, with the largest of these, Százhalombatta-Földvár, being a massive hilltop fortification overlooking the Danube (see Chapter 6). These were in a position to control the movement of people and goods along water transportation routes and may have housed the region's armed warriors. The authors suggest that these two systems may have operated independently in a functionally divergent but complementary relationship.

However, Százhalombatta and other major fortified sites are traditionally viewed as the apices of three-tiered systems, belonging to a special class of substantial fortifications that ring the Vatya territory along important rivers and mountain chains, ruled by a warrior aristocracy whose wealth was based on prestige goods trade (Kovács 1977; Poroszlai 2003a). These fortified settlements are strategically placed on prominent, defensible locations and are regularly spaced, suggesting a higher order of organization. Unfortunately, the exact relationship between these different site types needs to be clarified through systematic excavations at the open and smaller fortified settlements. Nonetheless, the range of site forms does suggest some level of functional differentiation and the modularity and structure of settlement groups within coherent geographic units provides evidence for the development of regional polities. Importantly, the complexity of this settlement system does differ from those described above for Lower Maros and Ottomány/Gyulavarsánd groups on the eastern Plain.

The structure of Vatya settlements differs little from tells of contemporary cultures, with the exception of the scale of the occupation area and fortifications. Houses are small and systematically arranged in rows around a central open area. Interestingly, many tells see a reorganization of their internal layout during the EBA-MBA transition, underscoring this as period of substantial change. Occupation can be quite expansive, extending well beyond the fortifications. Economically, there is distinction between settlements. The major fortified sites not only were in a position to control the prestige goods trade works across their territory, especially along the Danube and Tisza, they were also centers of craft production, including metallurgy. Again, due to the lack of excavations at smaller settlements, it is not yet clear how strong economic centralization was, but regional asymmetries were present (Earle and Kristiansen 2010b).

Very large cemeteries are used in the Vatya period, with sites like Dunaújváros-Dunadűlő containing over 1600 graves. Cremation was the normal practice, with the burned remains placed in urns, with some suggestion of anatomical sorting. Grave goods were included occasionally, but metal offerings were very rare (Vicze 2003). Vatya cemeteries do not shed much light on social organization since burial practices were so standardized, human remains are generally not analyzed, and the paucity of grave goods limits more detailed mortuary analysis. That being said, the restriction of metal to such a limited portion of the population may be significant. However, unlike the Lower Maros region with its rich mortuary offerings, there is no indication of specific leadership positions being marked.

The end of the Vatya period is marked by the Koszider horizon (c. 1700-1400 BC), a phase that was widespread across the Basin. It is marked by its elaborate metalwork which has been frequently recovered from the period's many hoard deposits. While some Vatya settlements were abandoned previously, the majority of sites were depopulated during the Koszider phase of the later Middle Bronze Age, as they were throughout the Plain. It should be noted, however, that a few sites were continuously occupied into the Late Bronze Age, including Százhalombatta.

CONCLUSION

The Bronze Age was a period of major technological, economic, and sociopolitical change throughout Europe and has been the focus of archaeological research for over a century. While its spectacular metalwork first drew the attention of scholars, the importance of the fundamental social changes of this period was soon recognized. While early scholars invoked endless invasions and migrations, patriarchal war-gods, and even itinerant bronze workers, recent work has taken a more sophisticated, multi-faceted approach. New models of the emergence of Bronze Age complexity incorporate the high level of organizational variability that has come to light in recent decades. Multidimensional approaches have been developed that examine social, economic, political, and environmental factors independently, looking at both regionally specific trajectories as well as larger patterns occurring across the continent and beyond. This dissertation continues in this vein.

To frame this study, it was necessary to provide the basic cultural background of the Carpathian Basin. A brief review of the preceding Neolithic and Copper Ages was presented, highlighting the major developments that later influenced the emergence of Bronze Age complexity (or lack thereof). A more detailed examination was made of the Early and Middle Bronze Ages and the specific culture groups used in the regional comparative study (Chapters 13 and 14), focusing on their organizational variability. The specific settlements used in the comparative analysis are described more fully in the next chapter.

CHAPTER 6: SITE DESCRIPTIONS

The Bronze Age is well represented in the Carpathian Basin, with hundreds, if not thousands, of settlements, cemeteries, hoards, and findspots documented to date. However, the quality and range of data available from these sites are highly variable, due to different levels of data collection (e.g., stray find collection, surveys, and excavations) as well as research methodology (e.g., date of excavation, rescue versus systematic excavations, recovery and analytical techniques). As a result, comparative sites must be chosen carefully in order to both fulfill research objectives and to ensure data standards. This chapter presents selection criteria for the settlements used in the regional study (Chapters 13 and 14) and descriptions of the chosen study sites themselves, including Pecica Şanţul Mare.

SITE SELECTION CRITERIA

Faunal data from more than 150 sites in the Carpathian Basin, spanning the Late Copper through the Late Bronze Ages, have been collected for this study (Figure 6.1). However, the quality of these data is highly uneven and these sites represent a wide range of settlement types, locations, and time periods. While the majority of these can be used for basic regional comparisons, more selective criteria must be used in order to conduct a detailed assessment of factors structuring economic organization. First, it is necessary to ensure valid inter-site comparability. Sites were chosen that fall within the same time range, were excavated with modern methods, had systematic faunal recovery, and produced faunal assemblages with sufficiently large samples that were analyzed with equivalent methods. Second, sites must adequately represent variables that affect political economies generally and animal production systems specifically. These variables include regional organization, settlement type, cultural affiliation, geographic location, and physical setting.

Chronology

It is important to maintain as tight control over chronology as possible in order to minimize variability introduced from long-term processes within the Carpathian Basin. These long-term changes include environmental change, technological innovations, population growth, and a general trend towards increasing complexity through time. However, it is not always possible to assign sites, occupation layers, or excavated materials to specific phases within the Bronze Age (see Chapter 5). Many prehistoric settlements within the Basin are occupied for long periods of time. This is especially true for tells, which are common in the Bronze Age. Unfortunately, many older excavations were conducted with little stratigraphic control, mixing layers dating to different periods. This lack of chronological control is exacerbated in faunal reports, where animal remains from all periods are often lumped together, obscuring any temporal changes and limiting inter-site comparisons. In addition, few absolute dates are available to provide a check on traditional ceramic-based site chronologies.

The principal sites used in this study have well-established chronologies that are supported by radiocarbon dates and have analyzed materials separated into distinct occupation phases. For multi-component settlements, regional comparisons utilize only contemporary occupation phases. These phases are limited to Early and Middle Bronze Age components, dating to c. 2700-2200/2000 and 2200/2000-1400 cal. BC, respectively. Where possible, data are further separated into earlier (c. 2200/2000-1700 cal. BC) and later (1700-1400 cal. BC) Middle Bronze Age occupations.

Recovery strategy

Excavation and faunal recovery methods greatly affect data reliability. The majority of sites with published faunal data in the Carpathian Basin were excavated prior to the 1980s, a period when modern, systematic excavations were rare. There are also a substantial number of sites excavated in recent decades that continue to use non-systematic methods, especially for collection of faunal remains. This results in assemblages that are biased towards well preserved larger elements and bones from large-bodied taxa. This same bias is extended to all artifact classes, but especially affects smaller materials like seeds, chipped stone, metallurgical debris and small metal fragments. This study focuses on settlements where systematic strategies were employed, meaning careful hand excavation (versus spade/shovel) by natural stratigraphic units, thorough collection of all artifacts and material classes encountered, sampling systems that include both screening and flotation.

Faunal Sample Size

Adequate sample sizes are necessary for reliable assessment of animal economies. Largely due to unsystematic faunal collection, sample sizes at most prehistoric sites in the Carpathian Basin are very small. For example, nearly 1/3 of the Late Copper through Late Bronze Age settlements have samples smaller than 100 specimens, rendering them virtually unusable except for presence/absence calculations. For the larger regional comparison, which is restricted to taxon representation, only settlements with sample sizes of more than 300 are used. This small sample size is less than ideal, but allows a greater number of settlements to be evaluated. Nonetheless, this sample size is far too small for more complex analyses, such as constructing mortality profiles and body part representation. Sites chosen for detailed examination have at least 1500 specimens in their Bronze Age components.

Faunal Analysis Methods

There is considerable variability in the methods zooarchaeologists use in analyzing fauna. These methods include basic choices about which materials to include (e.g., all fauna, only vertebrates, only mammals, etc.) as well as decisions about specific analyses undertaken (e.g., taxon abundance, body part representation, demography, taphonomy, etc.) and quantification techniques (e.g., NISP, MNI, meat weight, bone weight, etc.).[51] Different methods may introduce significant inter-observer variability, particularly for MNI calculations and demographic-profile construction. Analytical methods are rarely presented in publications so variability introduced in this manner generally cannot be assessed in any detail. In addition, most of the faunal reports available only present basic taxon abundance and therefore are of only limited use for answering more complicated questions concerning animal economies. In order to achieve maximum standardization and analytical utility, all of the assemblages used in the detailed study (except one) were analyzed by the author. The other, from Százhalombatta-Földvár, was examined by specialists using similar, well-documented methods (Choyke 2000;

[51] See Chapter 8 for discussion of these quantification methods.

Choyke, et al. 2004; Vretemark 2010; Vretemark and Sten 2005). They also present primary data for all of the major analyses used in inter-site faunal comparisons.

Regional Organization

Understanding organizational variability is a major focus of this study. To evaluate economic differences underlying these larger socio-political systems, it is necessary to include sites from a range of apparent organizational types. Three major categories have been identified thus far in the Carpathian Basin Bronze Age: 1) autonomous village societies, 2) simple hierarchies, and 3) complex hierarchies. There is still much that is not known about each of these systems, but basic features are presented below (see also Chapter 5).

Autonomous village societies are laterally organized and lack major distinctions in settlement size and function. While hereditary social inequality and leadership positions may be present, political authority does not extend beyond a single village; each settlement is politically independent. Groups inhabiting the Lower Maros exemplify this type (O'Shea 1996). Simple hierarchies have a two-tiered settlement system, with distinctions between large versus small and fortified versus open settlements. However, there is no significant functional differentiation or economic/political asymmetries between these site types. There is some degree of standardization in these settlement systems suggesting small polities, but they lack strong centralization. This organization characterizes the Körös region (Duffy 2010). Finally, there are complex hierarchies with three-tiered settlement systems, having divisions between small hamlets, larger open villages, and major fortified centers. There is evidence for substantial functional differentiation among these site types and some degree of economic and political centralization. The Middle Danube region, including the Benta Valley, provides an example of this formation (Earle and Kristiansen 2010b; Poroszlai and Vicze 2000, 2005). Preliminary work in the Middle Maros region indicates regional asymmetries, but the nature and extent of these differences have not yet been evaluated systematically. A primary goal of my study is to better assess the political organization of these groups and the role of Pecica Şanţul Mare in particular.

Site Type

Within the organizational systems described above, it is important to include settlements occupying different tiers in these hierarchies to examine any differences in economies related to political position. Within hierarchical groups, sites were chosen that represent both regional centers as well as subsidiary hamlets. In less hierarchical systems, site size and the presence/absence of fortifications were also considered.

Culture Group

Regional ceramic traditions are used here as a proxy for cultural affiliation, as this is what traditionally has been used to distinguish archaeological groups in the Basin. In most cases, culture areas correspond to organizational differences as well. However, this is not always the case and one cannot assume these two variables to be congruent. For example, there is emerging evidence for substantial organizational differences between Maros groups occupying the Lower and Middle reaches of the river (O'Shea, et al. 2012). Regardless of socio-political organization, there may be ideological or other culture-specific traditions affecting economic and animal production systems that must be considered. To this effect, culture group and organization are examined independently.

Physical Setting

The environment, to a greater or lesser extent, affects economic systems. This includes factors such as the distribution of raw materials, proximity to major waterways, vegetation, soil types, and climate. Previous work on sites from the Lower Maros and Körös regions has shown substantial differences in animal economies that are directly related to local ecological conditions, particularly in regards to the relative importance of different livestock species and utilization of wild resources (Nicodemus 2009, 2010). This study takes into account environmental and geographic variability in order to evaluate the relative influence of local ecology versus socio-political organization in shaping economic systems (see also Chapter 4).

SITE DESCRIPTIONS

This section presents information on the settlements used in the detailed comparative study (Chapters 13 and 14), describing the variables presented in the preceding section for each. Site locations are shown in Figure 6.1, along with other settlements used in the more general regional analysis of faunal use in the Carpathian Basin. Tables 6.1-6.4 provide summary information about site characteristics, chronological placement, physical setting, and which analyses are conducted on materials from these settlements.

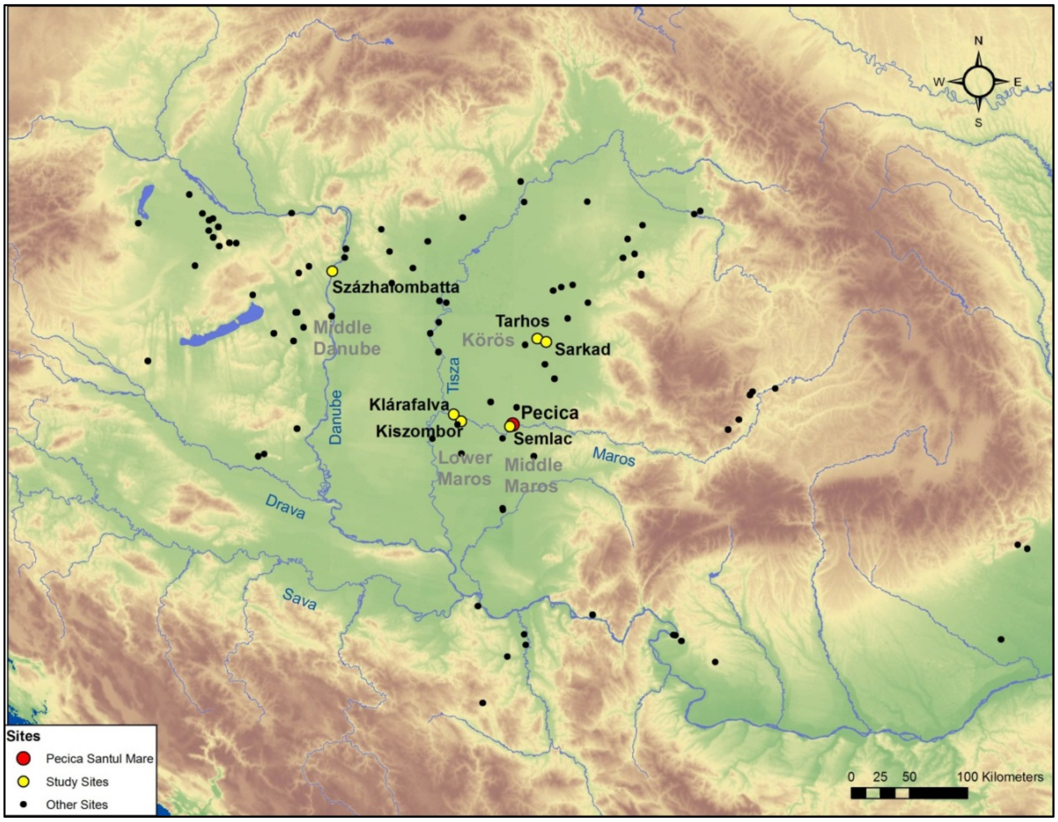

Figure 6.1: Map of the Carpathian Basin showing sites used in the general regional study and those chosen for more detailed analysis.

Table 6.1: Summary of basic characteristics for sites used in comparative analyses

Site	Region	Location	Period	Culture	Regional Organization	Site Type	Excavators	Faunal Analyst
Pecica Şanţul Mare	Middle Maros	Arad, Romania	E-MBA	Maros	unknown	large fortified tell	O'Shea et al. 2005-2009	Nicodemus, this volume
Semlac Şanţul Mic	Middle Maros	Arad, Romania	E-MBA	Maros	unknown	small fortified tell	Gogoltan 1994, O'Shea 2007	n/a
Klárafalva-Hajdova	Lower Maros	Csongrad, Hungary	E-MBA	Maros	autonomous village	small fortified tell	O'Shea et al. 1987-1988	Nicodemus 2010
Kiszombor-Új Élet	Lower Maros	Csongrad, Hungary	EBA	Maros	autonomous village	fortified open site	O'Shea et al. 1988-1989	Nicodemus 2010
Sarkad-Peckes	Körös Region	Békés, Hungary	MBA	Ottomány-Gyulavarsánd	simple hierarchy	large fortified tell	Jankovits and Medgyesi 1991-1993	Nicodemus 2009
Tarhos-Gyepesi Átkelő	Körös Region	Békés, Hungary	MBA	Ottomány (Gyulavarsánd)	simple hierarchy	small unfortified open site	Duffy 2008-2009	Nicodemus 2009
Százhalombatta-Földvár	Middle Danube	Pest, Hungary	E-MBA	Nagyrév, Vatya, Koszider	complex hierarchy	large fortified tell	Poroszlai and Vicze 1989-1991, 1999-2005	Choyke 2000, Vretemark and Sten 2005, Vretemark 2011

Table 6.2: Chronological placement of study sites (cal. BC)

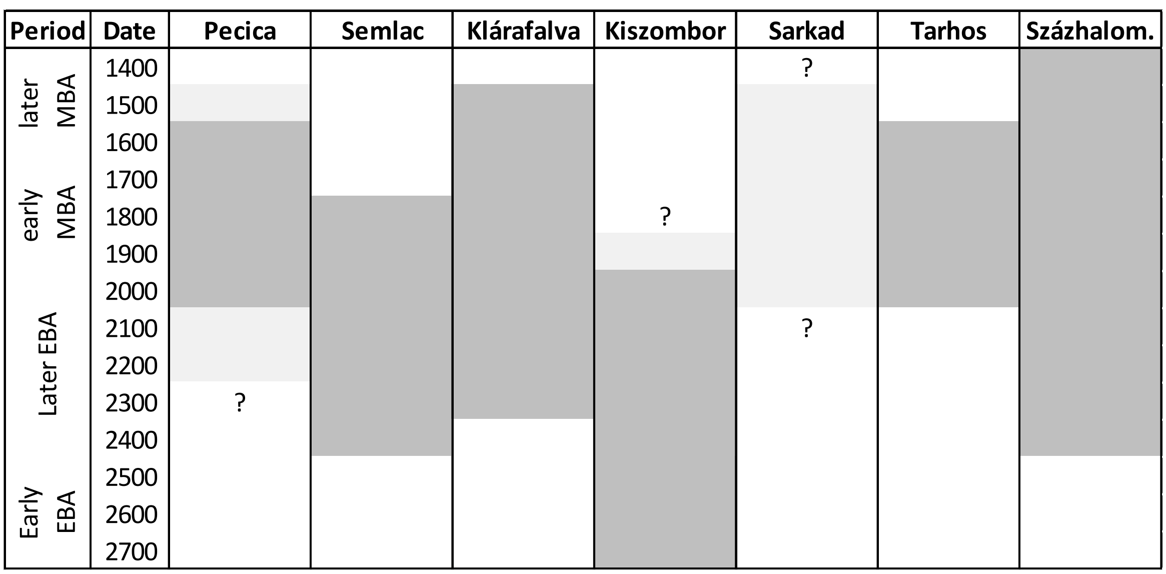

Table 6.3: Environmental setting for sites used in comparative analyses

	Waterways			Habitats		
Site	Major River	Major Tributary	Stream	Forest	Steppe-Forest	Wetlands
Pecica Şanţul Mare	X			X	XXX	XX
Semlac Şanţul Mic	X			X	XXX	XX
Klárafalva-Hajdova	X			XX	X	XXX
Kizombor-Új Élet			X		XXX	X
Sarkad-Peckes		X		?	XX	XXX
Tarhos-Gyepesi Átkelő		X		?	XX	XXX
Százhalombatta-Földvár	X			XX	XXX	X

X=present
XX=significant
XXX=dominant

Table 6.4: Analyses available for comparative study

Site	Excavation Strategy	Volumetrics	Fauna Sample Size	Fauna	Flora	Craft/ Exchange
Pecica Şanţul Mare	systematic	yes	20,230	X	X	X
Semlac Şanţul Mic	mixed	yes*	n/a		X	
Klárafalva-Hajdova	systematic	yes	16,165	X	X	X
Kiszombor-Új Élet	systematic	yes	2,221	X	X	X
Sarkad-Peckes	non-systematic	yes**	4,378	X†		X††
Tarhos-Gyepesi Átkelő	systematic	yes	7,580	X	X	X
Százhalombatta-Földvár	systematic	no	c. 150,000	X	X	X††

*volumetrics for flotation samples only
**estimated volume
†Only a subset of faunal comparisons can be used, not collected systematically
††Limited subset of materials only

Pecica Şanţul Mare

Pecica Şanţul Mare (Pécska Nagy Sánc in Hungarian) is one of the most important Bronze Age sites in the Carpathian Basin. It has served as a standard for regional ceramic chronologies for over a century and continues to be a principal site defining the Maros culture. Pecica is a large tell situated on a loess terrace overlooking the Maros (Mureş) river in Arad county, Romania (Figures 6.1-6.4). As it name implies, Pecica "Şanţul Mare," or "big ditch," has a series of large fortification ditches that encircle the tell. The site is multi-component, with Medieval, Iron Age (Dacian), and Bronze Age occupations. The Bronze Age settlement belongs to the Middle Maros group of the Maros culture. While the organizational system in this region is not yet well understood, preliminary work suggests that Middle Maros groups may be more complexly organized than those of the Lower Maros. This study will help to clarify the economic and political structure in this area.

Figure 6.2: View of the Pecica Şanţul Mare tell from the largest fortification ditch, looking south.

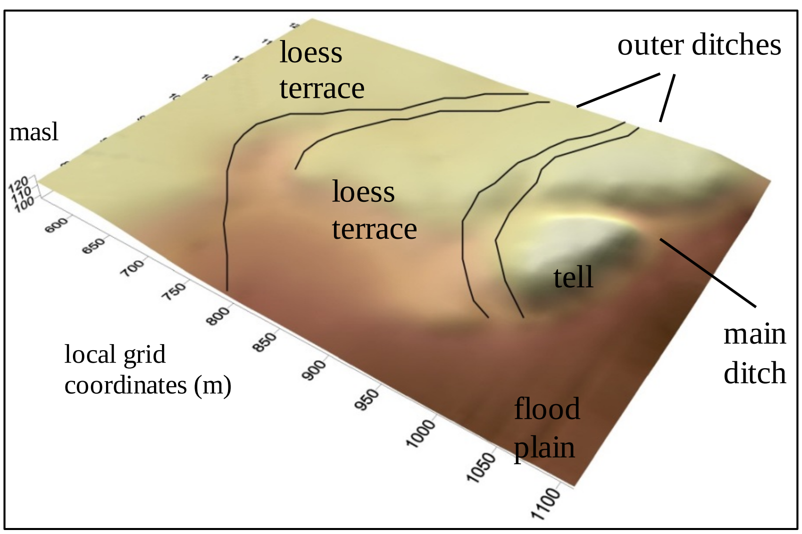

Figure 6.3: Topographic map of Pecica tell and environs (from J. O'Shea).

Physical Setting

The tell was constructed on the edge of a steep Pleistocene loess terrace, sitting 15-20 m above the floodplain (Figure 6.3). The site lies approximately one kilometer from the current Maros meander loop, but given the migration of the river bed over the millennia, it may have been closer to the river during the Bronze Age. The environment surrounding the settlement is quite variable (Figure 6.4). The loess terrace is comprised primarily of fertile chernozem soils, which would have supported a steppe-forest habitat dominated by grasslands with areas of open oak-maple woodland. The wide floodplain below the terrace differs sharply. Most of this low-lying area is covered by seasonal wetlands, dominated by sedges and reeds. Today, the floodplain is used to graze livestock and the vegetation is harvested for hay fodder. A dense gallery forest lines the banks of the Maros itself.

Figure 6.4: Environment around Pecica Şanţul Mare. Grasslands on terrace (foreground), seasonal wetlands in floodplain (midground), and gallery forest along the Maros (background).

History of Excavations

Pecica has been subject to a number of archaeological campaigns since the late 19th century. The first excavations were conducted by L. Dömötör between 1898 and 1902 (Dömötör 1901a, b). He dug a series of trenches that produced a rich assortment of Bronze Age materials, including two antler cheek pieces. Not long after, M. Roska continued excavations at Pecica. He put in additional trenches in 1910-11 (Roska 1912) and again in 1923-24. In these he described a series of sixteen Bronze Age layers, which helped to define the Periam-Pecica (Maros) culture in Romania. In 1943, D. Popescu excavated six more trenches (Popescu 1944). Larger-scale work at Pecica was undertaken by I. H. Crişan between 1960 and 1964. This project focused on the Iron Age occupation, which he thought to be the legendry Dacian fort of Ziridava (Crişan 1978). He excavated six large trenches, four on the tell itself, and two beyond the main fortification ditch. Importantly, these latter two suggested the presence of substantial Bronze Age habitation in the off-tell area. He also expanded the on-tell excavations, opening six large blocks (Figure 6.5). While these previous excavations established basic site stratigraphy and produced a large collection of artifacts, none of these excavations were conducted systematically and few of their results can be used for comparative analyses.

In 2005, an international collaboration between the University of Michigan, the Arad County Museum, and the Museum of the Banat returned to Pecica with the aim of establishing a long-term archaeological project that would systematically excavate the Bronze Age occupation. Hereafter, this collaborative program will be called the Pecica Archaeological Project (PAP). In order to minimally affect the overlying Medieval and Iron Age deposits, new units were placed within areas previously excavated by Crişan (Figure 6.5). Two exploratory trenches were dug into Crişan's old trenches III/A1/E1 (PAP Trench 1) and II/F (PAP Trench 2), in which backfill was removed to re-expose the profile walls (O'Shea, et al. 2005). Trench 1 served as a guide for the larger block excavations (10 x 10 m) that were extended to the east in 2006-2013 (O'Shea 2007; O'Shea and Barker 2008; O'Shea, et al. 2012; O'Shea, et al. 2006).[52]

Four test units (OTTU's) were excavated by the author in the off-tell area (Figure 6.6). These were done to 1) confirm Bronze Age occupation beyond the fortification ditches, 2) establish its chronological relationship to the main tell occupation, and 3) document any socio-economic differences between central and peripheral residential areas. OTTU 1 and 2, located in a low-lying area south of the tell, only encountered a dense field of large Iron Age and Medieval pits. This area may have been seasonally flooded given its low elevation and a higher water table during the Bronze Age. OTTU 3 and 4 were placed in areas where Bronze Age deposits had been encountered in Crişan's off-tell trenches and in a series of geological test pits and cores taken by geomorphologist S. Sherwood in 2005 and 2006. These off-tell test units did find Maros culture settlement in the both areas between the successive ditches (Nicodemus 2012).

[52] At the time of this writing, only materials from 2005-2009 have been analyzed and included in this study.

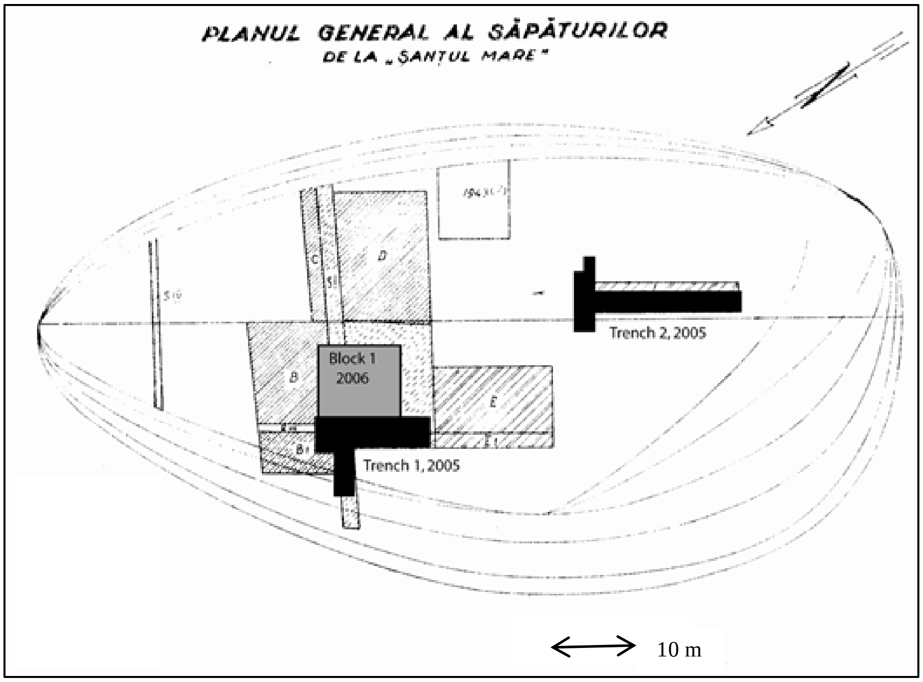

Figure 6.5: Plan map of tell excavation units by Crişan and the Pecica Archaeological Project (adapted from O'Shea et al. 2006)

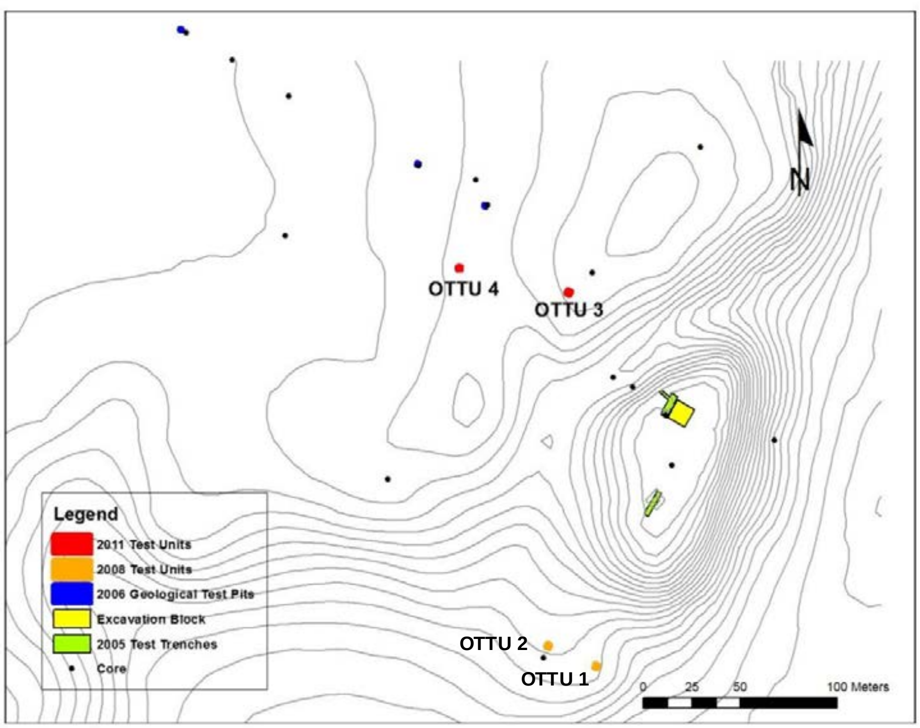

Figure 6.6: Map of excavation blocks, test units, and geological cores from the PAP project (Nicodemus 2011)

Details of the excavation methodology used for both on- and off-tell work are presented in the various publications listed above. A brief overview is provided here. The back fill within both exploratory trenches was removed by spade and shovel. A series of 2 x 2 m units were opened in intact archaeological deposits within Trench 1, which were excavated using the systematic methods described below. These contained the base of Iron Age deposits and the top of the Bronze Age occupation. In the main part of Trench 1, below the base of Crişan's trench, shovels were used to remove general fill, with features being hand excavated. A small area of intact Bronze Age deposits was also hand excavated within the base of Trench 2. Flotation samples were taken from features and stratigraphic layers. Artifacts were hand collected. Volumes were not recorded and screen samples were taken from features only. Given the non-systematic collection methods used in the exploratory trenches, with the exception of the square units in Trench 1 and features, the materials can only be used in a limited set of analyses as they are not directly comparable to the other collections.

The 10 x 10 m block that was opened off of Trench 1 was excavated systematically. Strata were hand (trowel) excavated by natural layer, with thick deposits subdivided into arbitrary 10 or 15 cm levels. The block was divided into 2 x 2 m units that were recorded individually (see Appendix 6.1 for sample recording form). Features (including structures) were excavated and recorded separately. All features and unit layers were photographed, hand mapped, and digitally mapped with a Sokkia Total Station. Any diagnostic ceramics (e.g., rims, bases, handles, and decorated pieces) and other special finds (lithics, metals, beads, articulated animal bones) were mapped with the Total Station and collected separately. Soil was removed using 10L buckets, which were counted to provide volume estimates. In the general fill deposits, one of every ten buckets was screened with a ¼ in mesh (10% screen sample). Features were 100% screened. Two 10L flotation samples were taken from each 2 x 2 m unit per layer, one from the NW ¼ and the other from the SE ¼. A 10L flot sample was also taken from each internal layer within features. For large structure exposures, sampling was subdivided into 2 x 2 m units to maintain spatial control.

Site Description and Chronology

The tell itself is roughly oval in shape, between 0.4-1.5 ha in area at its surface (Figure 6.6). The total Bronze Age habitation area is currently unknown, but the area within the inner ditch measures 5.7 ha and 20.8 ha is enclosed within the outer ditches. Systematic survey has not been possible during the previous study seasons due to dense crop coverage. In addition, extensive later occupation phases, especially those from the medieval monastery, have tended to obscure the underlying Maros deposits. However, the aforementioned coring and test unit work has found Bronze Age materials at least 100-250 meters west of the main fortification ditch. There is no evidence of Maros habitation in the floodplain. Coring has found cultural deposits on the tell to be at least six meters in depth and up to four meters in the near off-tell area (Figure 6.7).

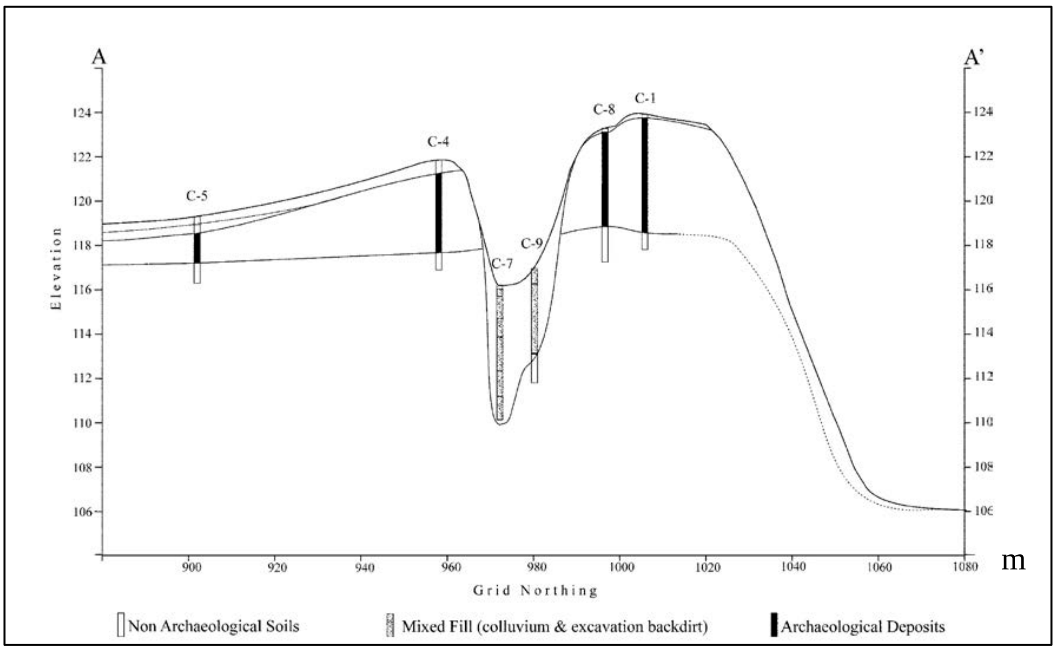

Figure 6.7: Core profiles from Pecica, see also Figure 6.6 (O'Shea et al. 2005)

The uppermost layers on the tell contained a cemetery from a medieval Hungarian monastery, which was removed by Crişan in the 1960s. Extensive medieval occupation was also found throughout the surrounding off-tell area. Under the medieval deposits was an Iron Age (Dacian) settlement, represented by a series of houses, large storage pits, and midden debris/fill. These were also largely cleared by Crişan in the PAP block excavation area, although the pits (and some of his excavations) cut well into underlying Bronze Age deposits. Note that the largest and innermost fortification ditch appears to have either been an enlargement and reshaping of an earlier Bronze Age ditch or perhaps an entirely new Dacian construction. Further work is needed to clarify its relationship to site phasing.

The Pecica Archaeological Project trench and block excavations quickly encountered intact Maros layers after clearing backfill and erosional deposition. To date, six major Bronze Age phases have been identified (Table 6.5). Phases 1 and 2 represent the final Maros occupation, corresponding to the later part of the MBA (Late Maros). A precise date for Maros site abandonment (post-Phase 1) has not been established due to extensive reworking (and perhaps leveling) of the uppermost Bronze Age layers by the later Dacian settlement. C14 dates do not indicate occupation much beyond 1600-1500 cal. BC. Phase 2 begins roughly 1700 cal. BC. Phases 1 and 2 have relatively sparse occupation density compared to earlier phases (Figure 6.8). There are few features other than occasional hearths and small pits. This is particularly evident in Phase 1, where there is only a single house present, represented by the uppermost and final use of Structure 0. The bulk of Structure 0 is contemporary with Structure 1 in Phase 2.

Phases 3-5 represent the earlier MBA (Classic Maros into Late Maros transition), with C14 dates c. 2000-1700 cal. BC. During Phase 3, a large fired-earth platform (layer D0) was constructed in the middle of the tell, extending beyond the excavation block (Figure 6.9), and was surrounded by houses. It is made of reworked site deposits (up to 1 m thick) that were burned at very high temperatures, hot enough to calcine bone and vitrify daub. It seems to be some form of public architecture. This feature is thus far unique in the Carpathian Basin. Note that Structure 1 (Phase 2) shifted orientation in this period and was designated as Structure 4. This house was rebuilt extensively and was occupied throughout Phases 3 and 4 (Layers D1-3). Structure 2 is south of and contemporary with Structure 4.

Excavations within Phase 4 and 5, encountered in 2009, were limited to the western portion of the excavation block, in the area external to the platform.[53] In Phase 4, a different house, Structure 3, was built just to the west of Structure 2. This continued to be occupied into Phase 5, with some alteration, where it was designated Structure 5. A short-lived house, Structure 6/7 was built between the Structure 4 complex and preceding Structure 8 (which was only partially excavated in 2009). Of great interest in Phases 4 and 5 (and perhaps into early Phase 3) are a series of unusual features that are constructed of vertically oriented animal bones,

[53] Note that in 2013 excavations expanded Phases 4 and 5 throughout the excavation block and Phase 6 in the western area adjacent to the profile trench, but these new areas are not included in this study.

primarily horse (Figure 6.10), located in the area between the platform and the houses. These bone deposits appear to be a unique feature type in the region.

Table 6.5: Phase summary for Pecica Şanţul Mare (adapted from O'Shea 2012).

Period	Phase	Site Layer	Date (cal. BC)	Architecture	Ceramics	Comments
Late Period	1	B1-3	Post-1600	Fragments only	Baroque styles, Classic Maros vessels	Final BA occupation, possibly deteriorating environment
	2	C1-3	1600-1700	Structures 0, 1	Baroque styles, Classic Maros vessels	
Florescent Period	3	C4-5/ D0-2	1700-1750	Platform, Structures 2, 4 (upper), final horse bone features?	Baroque styles, Classic Maros vessels	Intensive metallurgy and horse rearing, Off-tell A
	4	D3, Upper E	1750-1850	Structures, 3, 4 (lower), Horse bone features	Classic Maros vessels	Intensive metallurgy and peak horse rearing, Off-tell B
	5	Lower E	1850-2000	Structures 5-8, Horse bone features	Classic Maros vessels	Intensive metallurgy and horse rearing?
Early Period	6+	F+	Pre-2000		'rusticated' wares	Lower trench deposits

Little is known about the occupation prior to c. 2000 cal. BC, termed here Phase 6+. This occuaption lies near the regional EBA-MBA chronological boundary and, in part, spans the Early to Classic Maros transition as well. These deep occupation layers encountered during clearing of Trenches 1 and 2 in 2005 were not excavated systematically. There is a series of hearths and houses present, but they did not appear to be as concentrated as in Phases 3-5. Note that these trenches only reached a maximum depth of around 3 m, which includes only half of the known six meters of cultural deposits at the site. It has not yet determined when the site was founded. Excavating to the base of the tell is planned in future work. More detail concerning the PAP tell excavations from 2005-2009 will be presented in an upcoming site monograph by O'Shea and Nicodemus.

Importantly, the major changes in occupation described above, those found between Phases 1-2, 3-5, and 6+, do not precisely mirror traditional Maros culture periodization as determined by ceramic styles, which are based largely on mortuary assemblages from Lower Maros cemeteries. As a result, a site-specific chronology is used for analysis that 1) reflects significant organizational restructuring and 2) is strongly tied to radiocarbon dates (Table 6.5).

These are termed “Late Period” (Phases 1 and 2, c. 1700-1500), “Florescent Period” (Phases 3 to 5, c. 2000-1700), and “Early Period” (Phases 6+, pre-2000 BC).

In the off-tell units, much of the excavated area was post-Bronze Age. In OTTU 3, there was a medieval semi-subterranean house (Structure 9) that produced a C14 date of 1050 AD. A later medieval pit cut through this and into Maros strata below. Due to time constraints, these Bronze Age deposits were not able to be excavated. Work instead was focused on OTTU 4. A substantial portion of this 2 x 4 m unit was disturbed by a large medieval pit house complex. However, intact Maros deposits were found external to this feature, including a hearth, habitation debris, and part of a house (Structure 10). The hearth lies in the upper Maros deposits and produced a C14 date of 1720 cal. BC. These layers (4-5a) are grouped as Phase A, which is equivalent to Phase 3 on the tell. The deeper deposits (Phase B, layers 6-9), which primarily are comprised of house floor and collapse debris, date to 1770 cal. BC and are contemporary with Phase 4 on-tell. It appears that the off-tell occupation beyond the second fortification ditch was restricted to a relatively narrow window of time within the Florescent Period. More information of the off-tell units is presented in Nicodemus (2012).

Figure 6.8: Major features and constructions by phase at Pecica (O'Shea et al. 2012)

Figure 6.9: left—extent of platform in block and core samples (orange); right— in progress platform excavation (O'Shea et al. 2008).

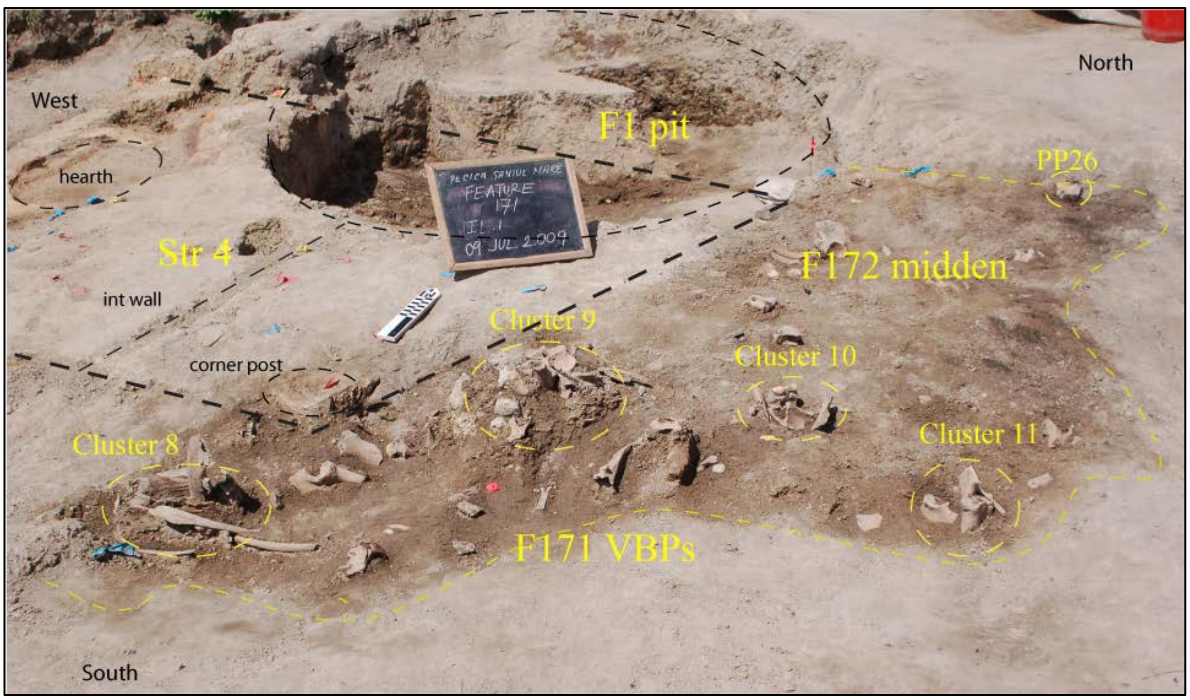

Figure 6.10: Vertical bone pile (VPB) features. F171 is a series of 4 bone piles, labeled clusters 8-11, shown here with only their tops exposed. These lie just east of Structure 4, within a large midden deposit abutting the house (F172). Note also the hearth basin in Structure 4 and the large Dacian pit (F1) which cuts into the house.

Semlac Şanţul Mic

Semlac Şanţul Mic is a relatively small fortified tell located three kilometers downstream from Pecica Şanţul Mare. It is also part of the Middle Maros group. There are two small fortification ditches present, which enclose areas of 4.7 and 6.4 ha respectively, about the same area as found within the inner ditch at Pecica. Its relationship to Pecica is currently unclear; it may be autonomous, like settlements in the Lower Maros region, or part of a more hierarchical system, with Pecica being a regional center. This study will help to clarify the organization of these Middle Maros settlements.

Figure 6.11: Clearing erosional debris from Gogâltan's trench at Semlac in 2007

Like Pecica, Semlac is situated at the edge of the loess terrace that overlooks the Maros/Mureş floodplain and shares the same ecological setting. F. Gogâltan excavated a small trench through the site in 1994, uncovering Maros culture deposits to a depth of 1.3 m (Golgâltan 1996). Unfortunately, results of this work have not been published in any detail. In 2007, the PAP project removed erosional debris and recut the profiles in Golgâltan's trench in order to better define the site's chronological relationship to Pecica and other Maros culture sites (Figure 6.11). The profile walls were cleaned and redrawn, a column sample (1 x 2 m) was taken from the east wall, and a series of radiocarbon and flotation samples were collected (Figure 6.12). The dates demonstrate that most of the occupation at this site was relatively early in the Maros sequence, spanning c. 2400-1800 cal. BC, which spans the latter half of the EBA and early MBA (Early-Classic Maros). It appears to be largely abandoned during Pecica's peak occupation period, Phases 3-5 (c. 1850-1700 cal. BC), perhaps indicating settlement consolidation.

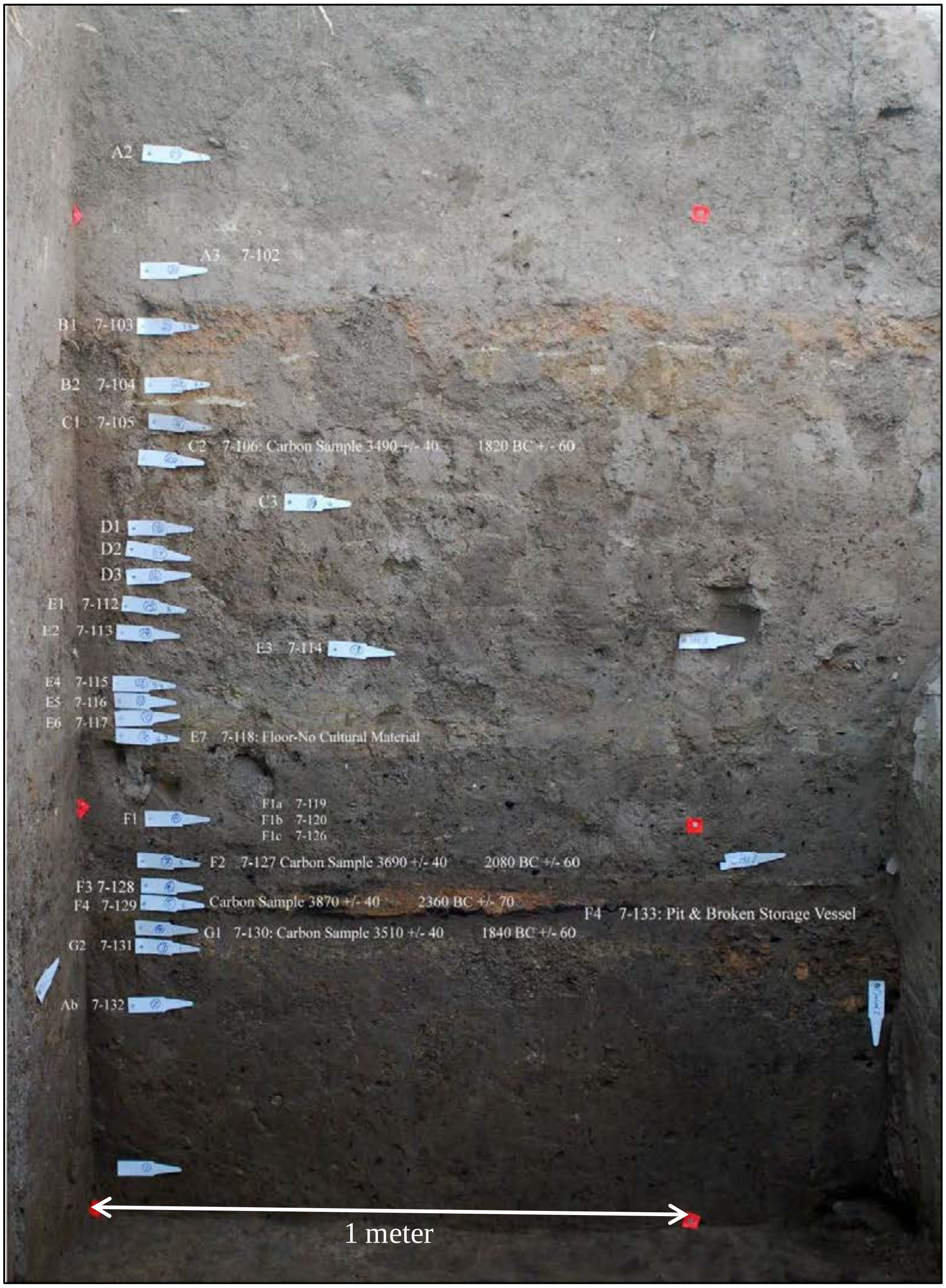

Figure 6.12: East profile column sample, Semlac Şanţul Mic. Stratigraphic layers are lettered. Flotation samples are numbered 7-XXX. Radiocarbon dates and major features are labeled. (From Oas 2010, Plate 8).

The profiles are similar to those exposed at Pecica in 2005, containing a series of house floors (some of which were burned), pits, and general habitation debris in fill layers. However, occupation is less dense than at Pecica. Houses at Semlac were not resurfaced as frequently and considerable amounts of sediment accumulated between major construction events. The only materials systematically collected in 2007 were obtained from the column sample and associated flotation samples. While these have proven useful for botanical analysis (Oas 2010), they have not produced large enough samples for analysis of other artifact classes, including fauna. As a result, Semlac is used only for comparison of crop production and processing.

Klárafalva-Hajdova

Klárafalva-Hajdova is a relatively small fortified tell located in Csongrád County, Hungary, situated approximately 350 meters south of a large bend of the Maros River (Figure 6.13). It belongs to the Lower Maros component of the Maros Culture, a group that is characterized as an autonomous village society (O'Shea 1996). The settlement lies in a low, wet floodplain. As they were historically, large areas around the settlement either would have been flooded seasonally or carried permanent wetlands, corresponding to the distribution of alluvium and meadow clays, respectively. Given modern flora-soil relationships, there likely would have been substantial gallery forests along the river and areas of open steppe-forest on the loess terrace in the southern portion of the site’s catchment,

Klárafalva was first excavated in 1969 by O. Trogmayer (Móra Ferenc Múzeum, Szeged) who dug a series of test units (Fischl 1997, 1998a, b; Horváth 1982; Trogmayer 1969, 1970a, b). The site was later systematically excavated in 1987-1988 by a collaborative project between the University of Michigan (J. O’Shea) and Móra Ferenc Múzeum (F. Horváth). A 1 x 7 m test trench was dug to establish site stratigraphy which served as a guide for the larger block excavations that extended a further four meters into the tell. These excavations used similar techniques as the Pecica project and produced comparable data. The central tell deposits were found to be at least four meters in depth. Habitation bounded by the fortification ditch covers 1.4 ha, which is significantly smaller than most Maros enclosures, which range from ~5-6 ha for the inner ditches (Figure 6.14). Three major occupation phases were defined, spanning c. 2300 to 1500 cal. BC. Phase 1, representing the later MBA (Late Maros) sequence (c.1800-1500 cal. BC) is the largest component of the tell, with five layers of alternating house floor and fill episodes (Layers A-E). Phase 2, containing Layers F-H (2200-1800 cal. BC), spans the transition between the EBA-MBA (Early-Classic Maros), and Phase 3, containing Layers I-K (2300-2200 cal. BC), falls within the latter half of the EBA (Early Maros).

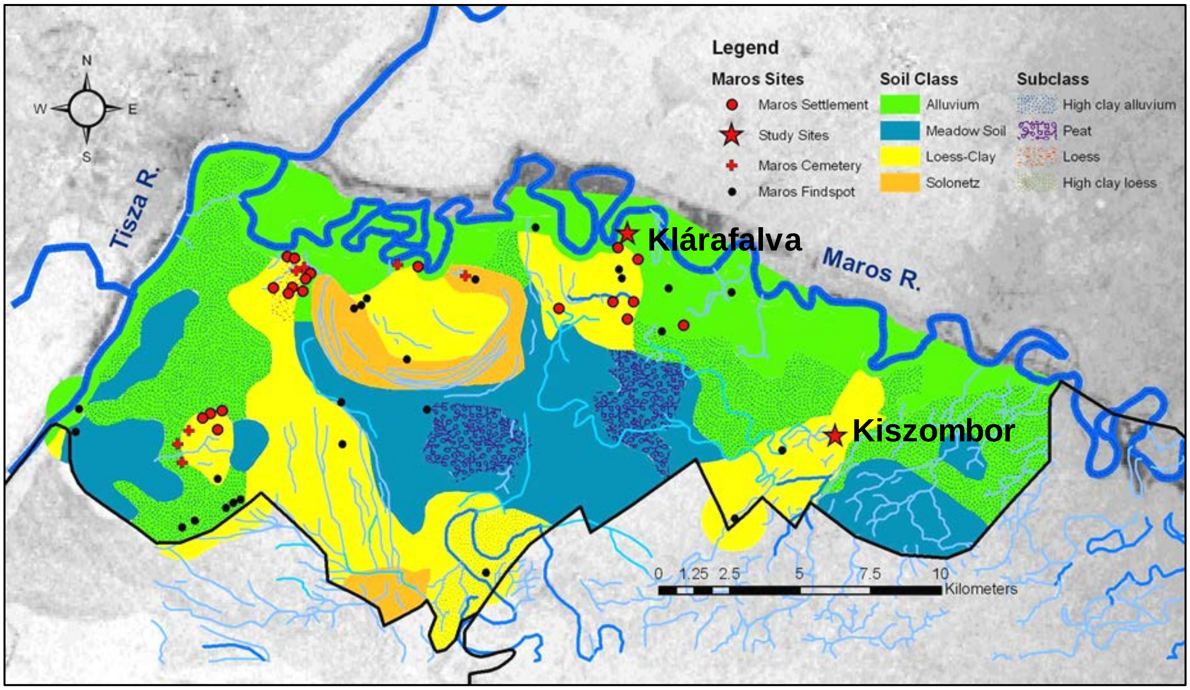

Figure 6.13: Settlement patterns and soil regimes in the Tisza-Maros angle (Lower Maros). Yellow loess areas correspond to flood-free land (Nicodemus 2010).

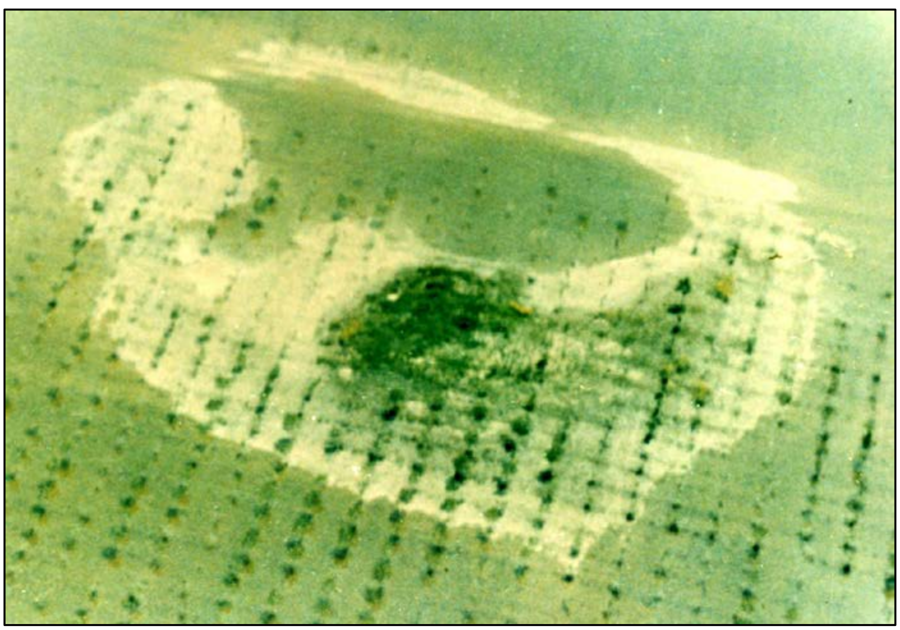

Figure 6.14: Aerial view of Klárafalva-Hajdova (after plow destruction and tree planting)

Like Pecica, the stratigraphy at Klárafalva is highly complex. House floors are frequently warped and layers are often significantly disturbed by pits and surface reworking during later habitation episodes. As typical for tells, houses were rebuilt in the same locations with open spaces between that contain dense concentrations of pits and ovens/kilns. 23,826 L of sediment were excavated in non-feature deposits with an additional 4,080 L of feature fill. A very large and representative faunal assemblage was produced from these excavations, with over 16,000 specimens analyzed to date. The results of this analysis are presented in Nicodemus (2010). More detailed descriptions of excavations, stratigraphy, features, and recovered materials will be presented in the forthcoming site monograph (O'Shea *forthcoming*).

Kiszombor-Új Élet

Kiszombor-Új Élet is a low, stratified site nine kilometers southeast of Klárafalva, also belonging to the Lower Maros group of autonomous villages. It is situated along a branch of the Porgány creek in a 1-1.5 km wide strip of flood-free land (loess steppe-forest) bounded by marshes and wet meadows on clayey alluvium and heavy meadow clays (Figure 6.13). The agricultural cooperative, on whose land the site is located, opened a series of 11 silage trenches in 1981 (Figure 6.15). These measured 4 m wide and between 35-50 m long. Archaeological materials eroding from these trenches and profile stratigraphy were first described by L. Horváth (1983), who also opened five test units. In 1988-1989 the research collaboration working at Klárafalva reopened these trenches, cleaned and drew the profiles, collected radiocarbon samples, and conducted limited systematic excavations in Trenches 1 and 5. The same excavation and recovery strategies were used as at Klárafalva.

This work found that the site is greater in areal extent than Klárafalva, 5.8 ha within the fortification ditch, but only three meters in depth. There is also evidence that this site had been at least partially leveled by the agricultural co-op, bringing into question whether Kiszombor should be considered a tell settlement or not. Nonetheless, the occupation area is less constrained than at Klárafalva, which likely reflects the greater availability of flood-free land for habitation. A more open settlement pattern is also evidenced by the lower occupation density and greater house spacing.

Figure 6.15: Satellite image of Kiszombor-Új Élet (from Google 2010). Remnants of several of the silage trenches can be seen.

There are four phases spanning the entire Early Bronze Age (and perhaps into the transition to the Middle Bronze Age), as well as more recent Sarmatian (Iron Age) and Medieval disturbances. Phase 1 (Layer A) belongs to the final EBA/MBA transition (Classic Maros) and has produced a C14 date of 1990 cal. BC. It is not clear when exactly Kiszombor was abandoned, but given the minimal deposits overlying this date, it probably was not occupied much past this time. Further, there are no diagnostic Late Maros baroque style ceramics present, even in disturbed areas. Phase 2 (Layers B1-2) lacks absolute dates but likely falls within the period from c. 2200-2000 BC. A fortification ditch was constructed at this time and occupation had spread beyond this by Phase 1. Phases 3 and 4 date to c. 2700-2300 BC (Early Maros). In this period, occupation was restricted to the central part of the site and, unlike the later phases, the houses are semi-subterranean. More detailed descriptions of the site will also be available in forthcoming site monograph.

The limited excavations produced over 2000 faunal specimens, the bulk of which represent Early Maros materials. A small sample (322 specimens) was collected from the Classic Maros occupation. The analysis of these materials is presented in Nicodemus (2010). Small samples of other artifacts classes limit other analyses, but preliminary analysis of the botanical remains has been completed.

Sarkad-Peckes

Sarkad-Peckes (Sarkad 8) is a relatively large tell settlment located on the Fás Ér, an extinct tributary of the Kéttős ("double")-Körös in Békés County, Hungary (Figure 6.16). It is part of an organizational system that is charactezied here as a simple hierarchy, with substantial size distinctions between large fortified tells, such as Sarkad, and smaller open villages/hamlets. However, there is minimal evidence for significant functional differentiation between these site types that would suggest political centralization (Duffy 2010).

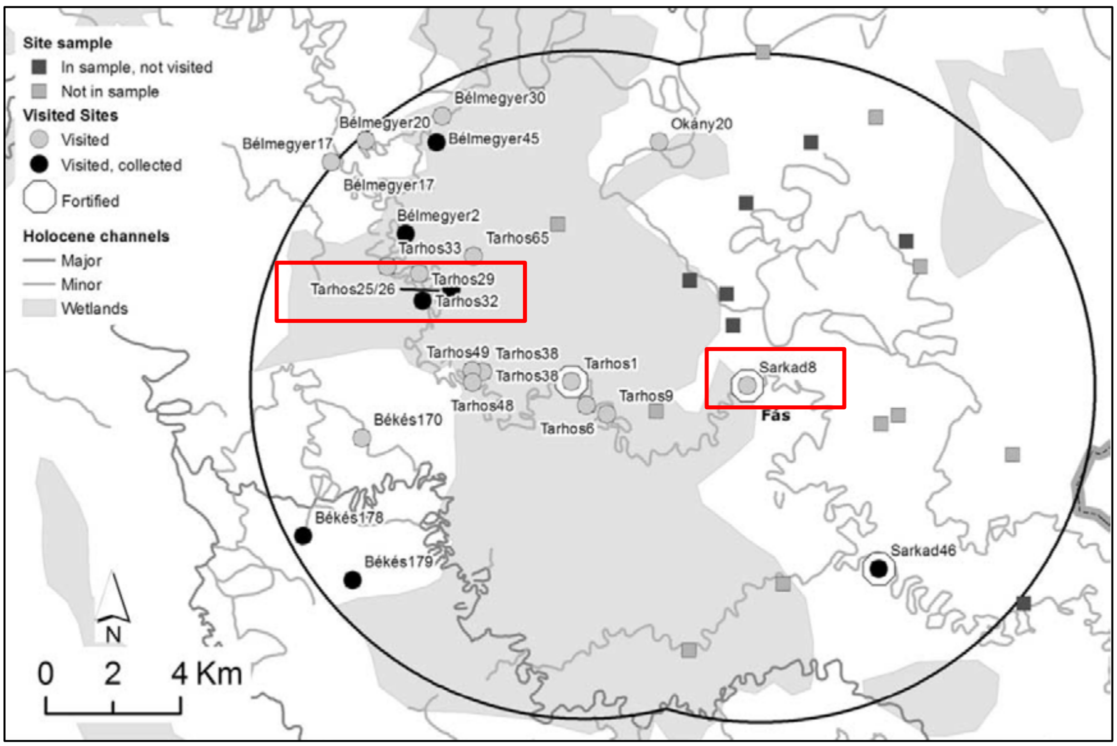

Figure 6.16: Map of the reconstructed Fás, wetlands (shaded), and location of MBA settlements, including Sarkad-Peckes (Sarkad 8) and Tarhos-Gyepesi Átkelő (Tarhos 26) (Duffy 2010: Fig. 8.5).

The site lies on the margins of a large (now drained) wetland, the Nagy Sárrét ("big marsh"), which covered much of the Körös drainage on the Pannonian Plain. While the settlement was constructed on the eleveated Fás levee (alluvium), a substantial amount of the surrounding land would have been seasonal or permanent wet meadows (meadow clays). There also may have been some degree of gallery forest development along the Fás, but this is uncertain in the absence of botanical and palynological data.

Sarkad is actually comprised of a series of sites that were indiviually defined during the Magyarország Régészeti Topográfiája (MRT) survey of Sarkad-Gyula parish (Figures 6.17, 6.18) (Szatmári n.d.). This includes Sarkad 8 (the tell), Sarkad 5, 7, 88-89 (the peripheral occuaption), and Sarkad 9 (a kurgan). The peripheral occupation spans both banks of the Fás and that the tell created an artifical island within the meander loop, effectively making a moat-like fortification ditch. The areal extent of the tell itself is 0.46 ha and around 25-27 ha including the peripheral occupation (Duffy 2010), which is comparable to the area within the outer fortification ditch at Pecica.

The site was excavated by K. Jankovits and P. Medgyesi from 1991-1993. No formal site report has been published to date. However, P. Duffy and the author had access to field notes during their respective analyses and Duffy has provided a basic site summary in his dissertation (Duffy 2010). Jankovits' team opened a series of two large blocks and six exploratory trenches. They found typical tell deposits, with several fill zones, houses, pits, and an oven in an open area. Intact cultural deposits only reached about 1 m in depth, but the excavation units were not placed directly on the tell center. However, the central deposits do not appear to reach the great depth of habitation found at major tells like Pecica and Százhalombatta. The tell occupation spanned much of the Middle Bronze Age, including both Ottomány and Gyulavarsánd components. Unfortunately, there are no radiocarbon dates to refine this chronological phasing. Surface collections from the peripheral habitation are overwhelmingly Gyulavarsánd ceramics (Duffy 2010; Szatmári n.d.), suggesting significant site growth during this later MBA period.

Unfortunately, excavations were done largely by spade and shovel, a systematic sampling strategy was not employed, and flotations for archaeobotanical analysis were not taken. Duffy was able to provide site volume for the excavations (127 m^3) and an inventory of major artifact classes related to craft production and import goods, so this site can be used for inter-site comparison of these items. Collection bias is a significant issue for the fauna recovered from Sarkad, which produced a sample of nearly 4400 specimens. As a result, I had to develop novel measures in order to ensure comparability of certain aspects of this assemblage (Nicodemus 2009).

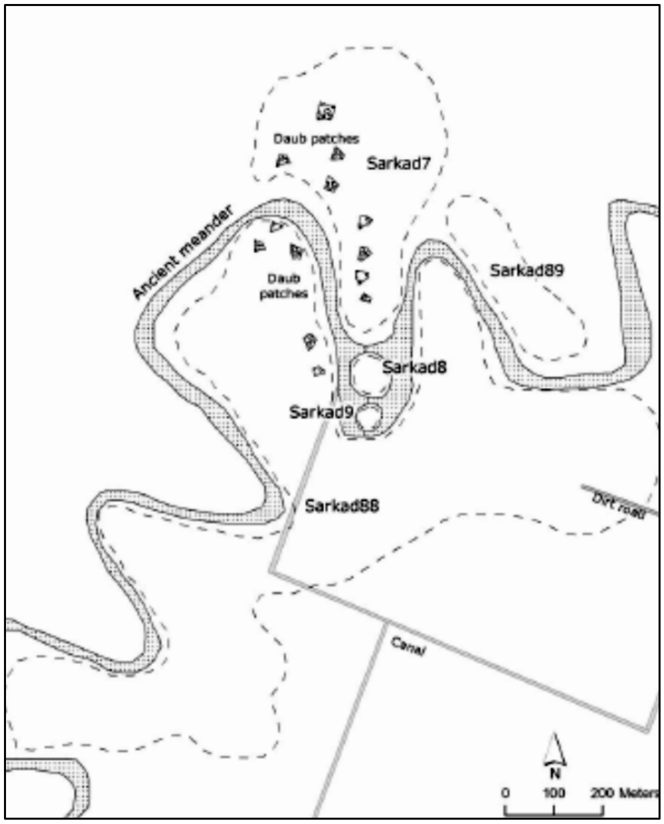

Figure 6.17: Map of the Sarkad-Peckes complex (Duffy 2010: Fig. 7.3).

Figure 6.18: Photo of the Sarkad-Peckes kurgan (front, Sarkad 9) and tell (rear, Sarkad 8), looking north across an extinct meander of the Fás (retaining water in early spring) (from P. Duffy).

Tarhos-Gyepesi Átkelő

Tarhos-Gyepesi Átkelő (Tarhos 26) is a small MBA settlement also located on the Fás, lying approximately eight kilometers northwest from Sarkad (Figure 6.16). It is one of the smaller settlements within a simple site hierarchy, with Békés-Várdomb (Tarhos 1) being the major fortified tell in the region (analogous to Sarkad). It has a similar environment to Sarkad, but since it lies further within the large Nagy Sárrét marsh, flood-free land was even more restricted.

The site was identified by the MRT survey for Békés parish (Jankovich, et al. 1998). In 2006 and 2007, it became a focus of the BAKOTA project led by P. Duffy (University of Michigan), with the assistance of the Békés County Museum (Duffy 2010). The site was surface collected, mapped with a magnetometer, then systematically excavated using methods comparable to those used at the Pecica project. I assisted field work in 2006. Through systematic field collection, the site area has been estimated to be between 2.4 and 3.3 ha. Magnetometry identified several pit disturbances and a house, the latter of which was targeted for excavations.

The settlement dates primarily to the Ottomány (earlier MBA) period although there are transitional and later MBA deposits as well. The earliest phase (Layer C) is a series of fill and habitation debris layers dating to 1970-1890 cal. BC. Several pits cut into Layer C, including Feature 9, which produced a C14 date of 1750-1680 cal. BC, falling within a transitional period between the earlier and later parts of the MBA. The house is part of Layer B, the final occupation phase (Figure 6.19). This house appears to have been accidentally burned as it contained several intact pots and other ceramics. A C14 sample from a wall post dates to 1690-1510 cal. BC. While this date falls within the traditionally defined Gyulavarsánd period, there are no Gyulavarsánd ceramics, so the site may have been abandoned during the latter part of the transitional period. Layer A is a calcareous deposit on the house rubble and there are a number of intrusive pits (at least one of which is Iron Age, c. 200 BC) and large animal burrows.

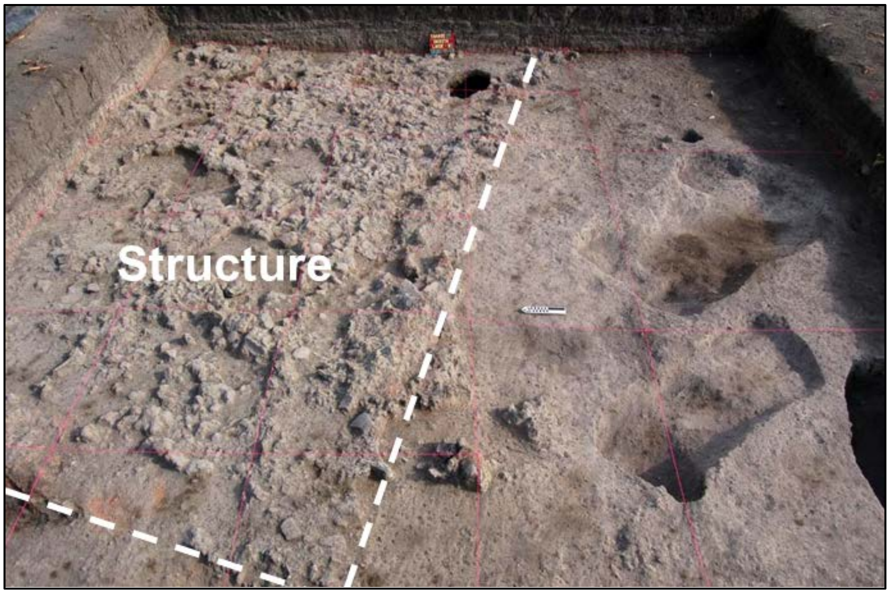

Figure 6.19: Excavation block from Tarhos-Gyepesi Átkelő showing F5 structure and later intrusive pits (from P. Duffy).

Despite the relatively small volume excavated at Tarhos (13.7 m^3), a large and systematically collected faunal assemblage was produced. The total sample contains 7580 specimens, which are divided into the distinct chronological periods described above. Fauna used in this analysis represent Layer B. Seeds and trade/craft related artifacts can also be used in comparative analyses.

Százhalombatta-Földvár

Százhalombatta-Földvár is a major fortified tell situated on a high loess terrace overlooking the Danube River in Pest County, Hungary. It is part of a polity spanning the Benta Valley (a Danube tributary), an area of roughly 50 km^2. Earle argues that there may be two forms of centralized systems coexisting, perhaps in a heterarchical relationship (Earle and Kolb 2010). One is based on staple finance, being headed by large open settlements on prime agricultural land within the Benta Valley. The other is wealth financed, with fortified sites strategically placed along the major waterways, controlling regional trade and housing warriors. Given the size and location of Százhalombatta, it is also possible that this site acted as the primate center for a three-tiered system. Further work is needed to clarify the functional roles of the dominant open and fortified settlements. However, Százhalombatta has been characterized as a semi-urban settlement with central functions (Earle and Kristiansen 2010a:26). During

MBA, the site was about 5.5 ha in size, with 2.5 ha enclosed within the fortification ditches (Artursson 2010), which is considerably smaller than Pecica.

Extensive palynological, vegetational, and sedimentological work at Százhalombatta and the Benta Valley allow detailed environmental reconstruction during the Bronze Age occupation (French, et al. 2010; Füleky 2005; Kalmár 2005; Kovács 2005; Terpó 2005). The loess terrace on which the site is located consists primarily of chernozem soils that supported a typical steppe-forest vegetation, with varying proportions of grassland and mixed oak forests on the hilltops and slopes. The Danube floodplain was dominated by gallery forests of oak, elm, ash, and beech with sedges and reeds along the riverbed itself. The forests were likely more extensive at Százhalombatta than at the sites on the Pannonian Plain given the increased humidity (and elevation) in Transdanubia. The pollen profile suggests that agriculture was largely restricted to the loess terrace with perhaps the floodplain used for animal husbandry.

Százhalombatta has long been recognized as an archaeological site due to the prominent Iron Age fortifications (Vicze 2005). In 1963, T. Kovács conducted rescue excavations because of destructive clay mining on the southern part of tell (Kovács 1969). In a series of five small trenches, he found that the site was occupied continuously through the Early and Middle Bronze Age. Later, it was recognized that Százhalombatta was one of a series of major hilltop fortifications that ring the MBA Vatya culture area along the Middle Danube valley and adjacent portions of the Danube-Tisza interfluve (Kovács 1982; Vicze 2000) . Since 1998, the site has been the focus of a major international collaborative project, the Százhalombatta Archaeological Expedition (SAX), between the Matrica Museum, Göteborg University, University of Cambridge, University of Southhampton, and Northwestern University (Earle and Kristiansen 2010b; Poroszlai and Vicze 2000, 2005).

In addition to regional survey and extensive environmental reconstruction work, the SAX project has been excavating a 20 x 20 m area of the central Bronze Age occupation, using well documented, systematic excavation and recovery techniques that are comparable to those used at the various University of Michigan affiliated projects (Vicze 2005). Coring across the site has found cultural deposits to a depth of around six meters, similar to Pecica. In the central block, six major occupation phases have been identified thus far, spanning the Early Bronze Age through the Iron Age. Level 1 is mixed Late Bronze Age and Iron Age deposits. Levels 2-4 are MBA Vatya period, with radiocarbon dates c. 2000-1400 cal. BC. Layers 5-6 are Nagyrév culture, dating to c. 2400-2000 cal. BC, the second half of the Early Bronze Age (Vretemark 2010). The Nagyrév occupation was not as expansive as the Vatya component and does not appear to have been fortified. No absolute date ranges have been presented for the constituent levels. The site publications also have not yet described the features or strata in any detail, but it seems that Százhalombatta resembles other major tells in the range of features and occupation density. Notably, like Pecica, there is a central open area in the earlier occupation period, perhaps a low platform, around which the houses are arranged (Sørensen 2010).

The SAX excavations have produced a very large faunal sample, with over 150,000 specimens collected thus far (Vretemark 2010). As of the 2005 report, 4158 specimens have been analyzed (Vretemark and Sten 2005). These cover all six phases, which allows for the assessment of diachronic changes within the site in addition to inter-site comparisons of both EBA and MBA components. Unfortunately, Százhalombatta can only be used for a limited comparison of materials other than fauna and flora since the context volumes and a complete artifact inventory have not been published yet.

CHAPTER 7: TEST EXPECTATIONS

In this chapter, I develop a series of testable hypotheses that allow economic centralization to be identified archaeologically, utilizing frameworks from Chapters 2 and 3 and introducing additional middle range theory where necessary, particularly for the agro-pastoral sector. I create a set of expectations for organization under centralized and non-centralized systems for each of the economic sectors that are targeted in this study: regional exchange networks, craft production, crop agriculture, and animal husbandry. Special attention is paid to the latter since animal economies have not been given extensive treatment or featured prominently within studies of political economy. Within each economic component, a general set of expectations is developed that are broadly applicable. These are then refined to the specific case study, the Carpathian Basin Bronze Age, drawing on information presented in the previous three chapters. Note that these test expectations are presented as two ends of a continuous spectrum of variability. These are not constructed as a set of absolute values with specific "cut-off points," above or below which groups are either centralized or not. Rather, these expectations are used to facilitate and structure comparisons between datasets, whether different periods at a single settlement, site occupation areas, or settlements in different regions.

REGIONAL EXCHANGE

General Patterns

Elite regulation of prestige goods production and exchange and the intensification of trade networks are important means to finance emerging political economies. The production side of prestige goods economies is addressed below; here I examine regional exchange networks. Three major classes of imported goods are considered: raw materials for utilitarian crafts, raw materials for prestige good manufacture, and finished prestige items. The relative value of goods, both finished items and raw materials, should affect the likelihood that they will fall under centralized control and to what degree, with higher value goods being more likely to become regulated by elites. Therefore, these three classes of import goods are considered individually. Table 7.1 presents a generalized set of expectations for patterning of imported goods of various classes in centralized and non-centralized economies. Four variables are included in this study: concentration, abundance, diversity, and origin.

Table 7.1: Expectations for imported goods in non-centralized and centralized economies

Variable	Measure	Artifact Class	Non-Centralized	Centralized
Concentration of Goods	spatial distribution (individual piece plot locations, items per grid unit/feature, context association)	raw materials-- utilitarian raw materials-- prestige finished prestige goods	uniform ↓ random	uniform ↓ elite associated
			independent procurement →	elite regulation
Abundance of Goods	density, number items per unit volume (#/kL)	raw materials-- utilitarian raw materials-- prestige finished prestige goods	moderate ↓ very low	high ↓ moderate
			lower frequency →	greater frequency
Diversity of Goods	types of artifacts per unit volume (#/kL)	raw materials-- utilitarian raw materials-- prestige finished prestige goods	moderate ↓ very low	high ↓ moderate
			lower diversity →	greater diversity
Origin of Goods	sourcing (macroscopic ID, chemical analysis)	raw materials-- utilitarian raw materials-- prestige finished prestige goods	limited ↓ limited	moderate ↓ high
			limited sources →	diverse sources

The *concentration* of imported goods refers to their spatial distribution and contextual association within settlements. In centralized economic systems, imported items, especially prestige goods, are expected to be unevenly distributed, being concentrated in elite households. Imported utilitarian raw materials will be more evenly distributed among households and settlement sectors as they do not carry the same degree of social significance. This is not to say that their importation was not arranged by elites along the same trade networks as prestige goods, but their distribution through local exchange networks would not have been as regulated. Importation of utilitarian raw materials also may have been open, with many households independently engaging in these networks. This may be further evaluated through the organization of craft production for these respective items (see below). In non-centralized systems, imported goods will be more uniformly distributed as their importation is less likely to be controlled by a single or small group of households, especially for utilitarian raw materials. The spatial distribution of prestige goods should be uneven due to their rarity. But unlike in centralized systems, their frequency will not be as strongly correlated with elite residences, more likely having a random distribution.

When imported goods form an important component of political economies, elites are motivated to intensify and expand exchange networks to increase the overall amount of wealth and status items that can be controlled and converted into political power (Friedman and Rowlands 1978). This will cause an increase in the frequency, diversity of types, and range of sources of imported materials. In centralized systems, there will be a greater *abundance* of imported goods overall, although unevenly distributed, which can be assessed through basic density measures. These goods will be more frequent in elite households within settlements and the central settlement will have more on average than subsidiary settlements. As a whole, the entire polity will have greater access to imported goods than non-centralized village systems.

The importance of imported goods should also be considered qualitatively. Increasing elite influence over exchange networks will not only intensify the level of trade quantitatively, but will also expand their scope. The ability to procure a greater range of items from more diverse and distant regions can be used to reinforce status distinctions (Kristiansen and Larsson 2005). Not only are these items symbolically charged, but their social value increases with their relative rarity, distance of procurement, and association with particular outside groups. This symbolic value can be converted to economic and political spheres through local exchange, strategic gift giving, and public display. The expansion of regional exchange networks can be seen through an increase in the *diversity* of types, both for raw materials and finished items. Similarly, not only should the types of items increase, but so too should their *origins* in terms of geographic and cultural sources. Changes in the sources of materials can also be used to trace the specific patterns of regional interaction over time.

Note that these diversity measures follow the same scalar considerations as abundance. Diversity should be greatest within elite households and regional centers and increase within the overall system. However, the diversity of imported raw materials for utilitarian crafts is not as likely to expand to the same degree as prestige items as they do not carry the same symbolic weight. Further, if there are not large differences in the physical properties of raw materials, one source may be substituted for another. There is little increase in return rates for utilitarian materials imported from more distant sources given the transport costs involved compared to the value of finished products.

Test Expectations

In the study region, there is a limited set of imported artifact types that can be identified archaeologically. Those used in this study are presented in Table 7.2. This is not meant to be a comprehensive list of all artifact types within these categories. Rather, these are chosen based on their archaeological visibility, ability to be sourced, and their economic and social importance. For example, there are a number of items that may have been imported that are not readily identifiable in the archaeological record. This includes salt and a variety of perishable goods (textiles, wood, foods) that generally do not preserve. Other goods, such as livestock or worked bone/antler, may only be distinguished from local sources using chemical or isotopic analyses that are beyond the scope of this study. Utilitarian finished items are not included as these are less likely to be imported from distant sources or regulated by elites. These are more likely to be part of smaller-scale exchange networks that operate outside of centralized control.

Table 7.2: Artifact types within import good classes

Class	Types	Use
raw materials-- utilitarian	cryptocrystalline stone	chipped stone items
	coarse grained stone	utilitarian groundstone items
	wood/charcoal	construction, metallurgy
raw materials-- prestige	fine grained stone (groundstone)	prestige groundstone items
	metal ore (copper, gold, tin)	metallurgy
finished prestige goods	fine metalwork	prestige /display
	amber beads	prestige /display
	marine shell ornaments	prestige /display
	fine ware ceramics	prestige /display
	faience	prestige /display

Raw materials that are used primarily in the production of utilitarian goods include stone for chipped and groundstone items, such as sickle blades and querns. Note that stone is rare in lowland areas in the Carpathian Basin and is generally restricted to river gravels. As a result, most stone, especially for larger items, must be imported from highland sources. Utilitarian raw materials may also include wood or charcoal, depending on the types and amount of locally available wood at settlements, which can be low at sites situated on grasslands or marshes. Raw materials used in the manufacture of prestige goods include various metal ores and fine-grained stone for polished groundstone items (e.g., axes, amulets, beads). Note that ores may also be used to make utilitarian items like fish hooks and simple metal tools. It is also possible that amber and marine shell may be included in the raw materials category, if these were imported unworked and manufactured into prestige goods locally (see craft production below). Finished prestige goods include fine metalwork, fine ware ceramics, amber beads, marine shell ornaments, and faience.

The specific measures used to evaluate the variables used in this study are presented above in Table 7.1. The concentration of imported goods is assessed through the spatial distribution of these items within settlements. This is determined by three-dimensional piece-plot data for individual artifacts as well as density measures per grid unit and within features/structures. Attention is paid to their specific associations with households, workshops, and elite versus non-elite occupation areas. At Pecica, this is considered for the habitation area within the central tell versus the peripheral occupation as well as for individual households in the tell center. Abundance of items is calculated as the number of artifacts per unit volume, a standardized density measure that can be compared within and between settlements. Diversity of artifact types is similarly calculated, using the number of discrete artifact types per unit volume.

Establishing artifact origin is more complicated. Artifact classes differ in their ability to be precisely sourced. Some items can be sourced through basic macroscopic characterization, including stone, amber, and shell. These can be further refined using chemical or isotopic methods. Metals are more difficult as they generally require chemical analysis, which also may be problematic if raw materials from multiple sources, including recycled scrap metal, are used. Finished items can also be sourced through their stylistic attributes, particularly ceramics, but also metalwork. Wood and charcoal species identification may shed light on their origin, if the presence of non-local species, such as conifers, is established. More detail concerning the analysis of specific artifact classes, including those done by specialists, can be found in the following chapter. Known sources of raw materials in the study region are presented in Chapter 4 and appendices.

CRAFT PRODUCTION

General Patterns

Like exchange, elite control over craft production is often a central component of complex political economies. Valuable craft items can be exchanged locally and regionally as payments for goods and services, to reinforce alliances, and as symbolic markers of social and political status. However, craft production cannot be treated as a singular entity. Different types of crafts are more or less likely to come under centralized/elite influence or control. As a result, it is important to evaluate a range of crafts, from simple utilitarian items to elaborate sumptuary goods, to better understand variability in the organization of production systems (Costin 2001). The organization of craft production varies based on the availability of necessary raw materials (local versus imported), production requirements (knowledge/skills, special facilities and tools, labor), and the end-use of the produced items (domestic/export, utilitarian/prestige). The specific configuration of these variables makes a craft more or less likely to come under some degree of centralized control, particularly where there is a bottleneck in raw material procurement, production, or finished goods exchange. As a result, I have divided crafts into four classes based on these variables for analytical purposes (Table 7.3).

Class 1 crafts are made of local raw materials that have no restriction in their availability and can be made without specialized knowledge, facilities, or large labor/time investments. They are low value items that can be made at the household level. These crafts are unlikely to fall under centralized production in pre-market, pre-state societies. There is little way to control access to their raw materials or the skills/facilities used in their production. Exchange of these goods is likely very small scale, for example locally between individuals or households.

Class 2 crafts are also made on readily available raw materials, but require additional technological and energy investment and a higher skill level or more complex facilities to produce. These are typically prestige or specialized items. While their raw materials are not controllable, the knowledge, technical skills, and facilities needed for their production may not be available to the general populace. They also require an additional investment of time and labor, which may demand some level of specialized producer, but not necessarily full time. These goods may be exchanged at a larger scale and are more likely to become centralized.

Class 3 crafts, like those of Class 1, are fairly simple items created primarily for domestic use. However, they are made from imported raw materials that may not be equally accessible to all households and individuals. Depending on the nature of regional exchange networks and the relative value of raw materials, importation may be monopolized by a subset of the population, creating a bottleneck where centralized control may be exerted. Given that these are utilitarian goods without elaborate manufacturing requirements, the production and distribution/exchange of finished items are likely to be carried out locally at the household level.

Class 4 crafts are high value items made from imported raw materials and require specialized knowledge, facilities, or high labor investment in their manufacture. These are most likely to be become centralized as both the necessary raw materials and production can be monopolized. These prestige goods are likely to stay largely within elite exchange networks, both locally and regionally, and may form a central component of political economies.

Table 7.3: Classes of crafts and likelihood for centralization

	Raw Material	Type	Use	Raw Material Procurement	Production	Exchange	Centralization
Class 1	local	utilitarian	local	household	household	household	unlikely
Class 2	local	prestige	local/export	household	household/elite	household/elite	possible
Class 3	import	utilitarian	local	household/elite	household	household	possible
Class 4	import	prestige	local/export	elite	elite	elite	likely

Expectations for organizational changes caused by centralization within different craft classes and methods for their assessment are presented in in Table 7.4. These focus on measures of specialization and intensified production. Craft specialization can be defined in a number of ways, but it is usually characterized by an increase in the degree of elite sponsorship (independent versus attached), spatial nucleation, scale of production, and the time-spent engaged in crafting (part versus full time) (Costin 1991), although there is a large number of other variables that can be included as well (Costin 2001). Not all of these are readily identifiable in the archaeological record and some are more commonly associated with state level societies and market systems.

The c*oncentration* of production is perhaps the most important variable examined. This combines Costin's (1991) categories of "context" and "concentration" of production, as it includes both the spatial distribution (degree of nucleation) and contextual association of manufacture (specific households, workshops, elite areas, etc.). Together, these are used to identify elite sponsored or controlled workshops, which are strongly related to the development of pre-state political complexity (Clark and Parry 1990). In centralized systems with more elite sponsored crafts, it is expected that the production of higher value items (e.g., Class 2 and 4 crafts) will be spatially segregated in elite occupation areas. Other classes of crafts will be less regulated. Utilitarian items made from local resources (Class 1) will be fairly ubiquitous, being made domestically by most if not all households. These same patterns are expected at a larger scale, with prestige craft production being disproportionately represented at central settlements.

In decentralized economies, craft production of all classes is not expected to be highly segregated. Crafts will be made at the household level. The production of prestige goods however, especially those requiring imported raw materials (Class 4), is not expected to be uniform. More valuable and skilled crafts may be differentially produced by certain households, but this spatial differentiation will not be as pronounced as in centralized systems nor as strongly associated with elite households. Rather, their distribution of various types of valuable crafts is more likely to be random, distributed unevenly between households rather than concentrated within a few. There will also not be significant inter-site differentiation.

As craft production is increasingly used as a means of wealth finance by elites, there will be increased pressure to expand the output of production and the range of items being manufactured. Again, this will affect higher value crafts (Classes 2 and 4) to a greater degree, especially those that will enter regional exchange networks. Here I refer to increased output of production as *intensity*, which differs in part from Costin's usage, in which intensity refers specifically to the amount of time spent crafting (e.g., intermittent, part time, full time).[54] While increased output can be achieved by more time spent crafting per individual, it also may be increased by a larger number of people involved in production, which overlaps with Costin's notion of scale. Intensified production output can be assessed by the density of manufacture debris, tools, and production facilities. This measure can be compared between occupation phases within a single settlement to track changes in production output over time for particular crafts. It can also be compared between settlements to identify differential intensity of production at a regional scale. In decentralized economies, the overall output of craft production is relatively lower, with crafts being made primarily to meet the needs of the household, although some local and regional exchange occurs as well. There will be very large differences in the intensity of prestige crafts between settlements within decentralized and centralized economies, with low levels of production in the former.

The *diversity* of crafts being produced will increase in more centralized systems. In general, there is a relationship between size of the largest community in a regional system and the diversity of craft specialties (Clark and Parry 1990). Because complex polities are associated

[54] A variable that is difficult to define archaeologically.

with larger population sizes, this diversity is expected. But focus is placed here on elite directed diversification, where there is an intentional expansion of the range of craft types being produced, especially prestige goods. Diversity is assessed in a similar manner as intensity. The number of craft types being locally produced per unit volume can be calculated, which is comparable both within and between settlements. A significant increase in the diversity of higher value craft types (Classes 2 and 4) will be associated with periods of increased centralization and greater diversity is expected at political centers than subsidiary settlements. In decentralized economies, it is expected that there will be a much lower diversity of crafts being produced, especially for prestige items.

Standardization is often used as measure for degree of specialization. An increase in standardization is generally argued to reflect a decrease in the number of individuals involved in a craft's production. But standardization can be caused by a number of other factors as well. Standardization can be divided into intentional and mechanical forms (Costin 2001:302). Mechanical standardization includes attributes that are affected by unconscious motor habits of the individual artisan and are more likely to reflect a decrease in the number of producers per unit output (Costin and Hagstrum 1995). Intentional standardization is caused by conscious decision-making by the producer. These relate to a number of concerns, including stylistic considerations, functionality (gross form), improving transportability, value regularization, or to achieve economies of scale (Arnold and Santley 1993). While not all of these factors are direct responses to increased specialization, many of these are. Increased standardization, as measured through statistical variation, therefore can be used to assess the relative degree of specialization within particular crafts when compared between spatial and temporal contexts. Crafts made in small-scale domestic contexts are unlikely to be highly standardized in either centralized or decentralized economies. The greatest differences will be seen in prestige crafts, which are more likely to be the focus of specialized production in centralized systems.

Table 7.4: Expectations for organization of craft production in non-centralized and centralized economies

Variable	Measure	Class	Expected Trend	Non-Centralized	Centralized
Concentration of Production	spatial distribution of tools, facilities, debitage context of production	Class 1 Class 2 Class 3 Class 4	↓ decreasing ubiquity	uniform ↓ random	uniform ↓ elite associated
				independent production →	attached specialists
Intensity/Scale of Production	density of tools, facilities, debitage (# items/kL)	Class 1 Class 2 Class 3 Class 4	↓ decreasing intensity	high ↓ very low	high ↓ moderate
				lower intensity →	greater intensity
Diversity of Production	diversity of locally crafted goods (# types/kL)	Class 1 Class 2 Class 3 Class 4	↓ decreasing diversity	high ↓ very low	high ↓ moderate
				lower diversity →	greater diversity
Standardization of Production	statistical measures of variation within artifact types	Class 1 Class 2 Class 3 Class 4	↓ increasing standard-ization	low ↓ low	low ↓ high
				unstandardized →	greater standardization

Test Expectations

The four craft classes defined above were created as a heuristic classification to better understand variability in organizational strategies among craft types, highlighting potential bottlenecks in raw material procurement and manufacture. These were based on idealized and discrete criteria. In practice, assigning particular crafts to these classes can be challenging as many crafts fall within two classes, depending on the particular objects being manufactured. This phenomenon has been described elsewhere for metalworking for the Bronze Age, where a two-tiered production system has been hypothesized, one that is divided into the manufacture of simple utilitarian items and one based on more elaborate prestige goods (Pare 2000). These two systems vary greatly in the organization of production, with the latter requiring higher quality raw materials, special tools and facilities, greater labor investment, and perhaps most importantly, a specialized (and perhaps restricted) knowledge and skill set. This two tier division, I would argue, is equally applicable to many craft types as both utilitarian and prestige items are often produced using the same or similar raw materials, although prestige goods may not be crafted by all community members and are more likely to be specialized to some degree. However, it is often difficult to distinguish between the two, since both types may be manufactured by the same individuals in the same activity areas, but at different times. Further, there may not be significant differences in the facilities, tools, or debris produced by their manufacture, hindering the ability to separate utilitarian versus prestige items made from the same materials or using similar methods.

Table 7.5 presents the classification system for Bronze Age crafts used in this study. Note that most crafts fall into more than one class and production indicators that can be used to separate utilitarian and prestige good production are listed, which vary in their ability to be identified archaeologically. As with import goods, this list is not meant to be comprehensive. It includes craft types that have strong archaeological correlates, are common, and cover a range of items with contrasting production methods and end uses.

In the study area, there is a range of Class 1 crafts, which are utilitarian items made on local raw materials, but most also have prestige components. Hide working and chipped stone working on local cobble jaspers are exceptions. Crafts with both utilitarian (Class 1) and prestige forms (Class 2) include woodworking, bone working, weaving, and pot making. However, the majority of goods would have been utilitarian items. Where they preserve, finished products of these classes can be readily distinguished. These include ceramics and worked bone (and antler, horn, teeth, and shell). However, other items are perishable, including fine textiles and complex wooden or composite items like carts, chariots, and boats, and little is known about their distribution or use. Nonetheless, it is more difficult to distinguish the *production* of crafts with Class 1 and 2 components, which is the focus of this study. Archaeological correlates of each are presented in Table 7.5 as well.

Similar issues exist between Class 3 and 4 crafts. Some Class 3 crafts, those that use imported raw materials in the manufacture of utilitarian goods, are readily distinguishable, including chipped stone denticulates and blades made on obsidian and other non-local cryptocrystalline materials. However, groundstone manufacture and metallurgy have utilitarian (Class 3) and prestige components (Class 4), the production of which may be difficult to separate. It will be noted, however, that fine groundstone items, such as polished axes and ornaments, are less likely to enter regional exchange networks as they do not carry the same social value as elaborate metal objects, and therefore are less likely to become centralized.

Table 7.5: Craft classes and archaeological indicators for the Carpathian Basin Bronze Age

Class	Craft	Examples	Prestige Production Identification*
1: local raw materials, utilitarian goods, domestic use	*chipped stone (river cobbles)*	sickle blades, arrowheads	
	hide working	clothing, bags, composite tools	
	wood working	architectural components, simple implements	
	bone working	needles, hoes, hammers, scrapers	
	textiles	basic clothing, bags, rugs, blankets	
	ceramics	coarseware vessels	
2: local raw materials, prestige goods, some export	wood working	finely carved items, boats, chariots	n/a
	bone working	finely carved items, hilts, pommels, horse gear, ornaments	n/a
	textiles	fine textiles	whorl/loom weight size/form, frequency of flax seeds
	ceramics	fineware vessels, specialized objects, figurines	frequency of burnishing and decorating tools
3: imported raw materials, utilitarian goods, domestic use	*chipped stone (obsidian and other "cherts")*	sickle blades, blades	
	ground stone	querns, hammer stones	
	metal working	simple tools, fishhooks	
4: imported raw materials, prestige goods, some export	ground stone	polished axes, ornaments, molds	types of debitage (raw materials)
	metal working	ornaments, weaponry, armor	type of slags/casting debris, molds, specialized tools/facilities

*excluding distribution of finished items, see Chapter 8 for a more exhaustive list of indicators
note: only crafts in italics can be easily distinguished into discrete classes based on production indicators

Methods used to assess concentration, abundance, and diversity in craft production follow those outlined above for import items and are described in more detail in the following chapter. However, the focus is placed on manufacturing tools, debris, and facilities (Table 7.6 and Chapter 8) rather than the finished items themselves. Standardization is documented using basic statistical measures of variation where standardized measurements can be taken. Raw material types are also considered. In this study, standardization analyses are limited to chipped stone and worked bone given issues of measurability and sample size.

AGRO-PASTORAL PRODUCTION

The following sections consider changes in plant and animal production strategies that are related to increasingly centralized and expansive political economies. These are primarily associated with the implementation of staple finance systems in which food production is increased and the surpluses mobilized by elites for institutional maintenance. But these changes also include specialized production of high value goods (including non-food products) that are meant for exchange, often within elite networks, rather than redistribution to people supported by elites (craft specialists, administrators, religious personnel, military, elite households, etc.). Crop husbandry is first addressed, including the organization of production, processing, and distribution/storage. Expectations for changes in the animal economy are then discussed, assessing patterns of production, distribution, and consumption. These are then tailored for the particular species known to be in production at this time as well as to Bronze Age technologies.

Agriculture (crop production) is considered first as intensification in plant husbandry has received far more attention by archaeologists, both theoretically and methodologically. Animal economies, in contrast, are strongly under-theorized, especially for pre-state societies, although there are a (growing) number of notable exceptions (Atici 2005; Bogaard 2004a; Crabtree 1990, 1996a, b; deFrance 2009; Gamble 1982; Halstead 1992, 1999, 2001, 2003, 2011; Monahan 2007; Redding 1991, 1992; Thurston 2006; Thurston and Fisher 2007; Zeder 1991). An important contribution of this dissertation is to create better methods to identify the effects of increased centralization on animal husbandry systems. I draw on the basic principles underlying intensification strategies in crop production to establish correlates for animal production.

Agriculture

General Patterns

Intensification Proper

Intensification proper is an increase in output per unit of land (Brookfield 1972). This is created through increased input, but with diminishing returns per unit area (Table 7.7). There are a number of ways intensification may be implemented but they involve additional investment in facilities, resources, and labor. The most archaeologically visible means of intensification proper is through the construction of *landesque capital* improvements (Blaikie and Brookfield 1987; Brookfield 1972), which include a range of land modification strategies, usually involving water management systems. *Landesque capital* improvements, while being quite visible on the landscape where they are used, are not equally likely to be built in all environmental settings at a given level of intensification. More widespread intensification methods employ increased labor or resources but are not as readily identifiable in the archaeological record. These include reducing fallow period length, double cropping, manuring and other fertilization methods, and the use of more labor-intensive preparation and maintenance practices like seed-bed preparation, tilling, weeding, and watering. These are documented primarily though changes in weed assemblages and crop composition.

Extensification

Extensification methods allow a greater amount of land to be worked with the same energy input through the use of less labor intensive or more efficient farming practices (Bogaard 2004b). This may entail a shift in labor allocation in which additional fields are utilized but with a decrease in labor expended per field. Not only will there be an areal expansion of field systems, but these new fields may also be established within different, and perhaps sub-optimal, ecozones. Extensified farming often employs more efficient technologies, especially those that exploit animal labor, such as plows and carts. While these technologies greatly increase the scale of farming, they may also require significant investment in their manufacture, purchase, and/or maintenance, which needs to be balanced against longer-term labor efficiency. Extensification can be identified through the presence of new technologies (where preserved) as well as changes in weed composition, as lower field maintenance results in different flora than more intensive measures. Where animal labor is employed, this will cause changes in livestock species abundance, demographic profiles, and traction-related pathologies, which are described in more detail below.

Table 7.6: Crop production strategies

Strategy	Principles	Features of Crop Production
small-scale independent farming	risk buffering self sufficiency energy conservation	diverse areas under production diverse crops (including maslins) hardy species staggered planting schedule longer fallow period lower cost field maintenance
intensification	increase output per unit area increase energy input per unit area	landscape improvements shorter fallow period double cropping higher cost field maintenance
extensification	increase area under production decrease energy input per unit area	labor efficient technologies larger area under production diverse areas under production (lower quality land in production)
expansion	increase area under production no change in input per unit area	larger area under production no change in methods
diversification	increase in the # of components mixed strategies targeted production (exchange)	diverse areas under production diverse crops higher value/labor/risky crops
specialization	decrease in the # of components targeted production (exchange)	low crop diversity or monocropping higher value/labor/risky crops

Expansion

Expansion brings new land into production without a corresponding change in farming practices. Expansion is finite due to limits in available land and labor. When these limits are reached, alternative strategies must be employed, the exact form of which is dependent on environmental conditions, established farming technologies and methods, and available land or labor. Because expansion does not require the use of different farming strategies, it is best identified through an increase in the areal extent of fields without parallel changes in weed species or other indicators of systemic change, as outlined in other sections.

Diversification

Diversification is an increase in the number of components within a production system (Morrison 1994:144). Importantly, it is a response to different pressures under centralized and non-centralized economies, the latter of which is discussed below. In centralized systems, diversification may be a means to maximize overall food production in diverse landscapes. This includes bringing different types of land into production, particularly those that require alternative farming practices. It can also be implemented in order to increase the production of high value species for exchange that are not principal crops in subsistence farming, such as fiber or oil plants, spices, or luxury foods. Diversification can be identified archaeologically through an increase in the types of areas in production (increased ecological variability), cropping strategies, and range of crop species. In targeted exchange production, these additional crops will include high value, low utility species that are not staples.

Specialization

Specialization is the opposite of diversification. It is a reduction in the number of production components, and in farming systems, is directly related to exchange (Morrison 1994:143). In pre-market economies, specialized production is unlikely to develop outside of elite sponsorship given the corresponding loss of self-sufficiency by the producing group. As Morrison (1996, 2007) and others have stressed, the scale of analysis must be taken into account when identifying specialized production. Only under certain conditions is there specialization in crop production at the settlement or regional level. In most cases, specialization will only occur within a limited number of households as most families will produce a range of crops to meet their own subsistence needs and to achieve a normal surplus. Specialization typically occurs alongside other production strategies at the settlement level. As a result, it is important to observe a range of occupation areas to establish contrasting production systems. If this is not possible, then specialization may appear to the archaeologist as a diversification strategy that has added the production of high-value exchange crops.

Risk Buffering

In small-scale, independent farming systems, risk mitigation is a central consideration in production strategies. Along with storage, mobility, and exchange, diversification is a principal means to buffer risk due to environmental variability and uncertainty (Halstead and O'Shea 1989; O'Shea 1989). Diversified production as a risk mitigation strategy differs greatly from the diversification described above as its central motivation is not output maximization or increased production of high-value, low utility crops for exchange.

Small-scale, risk-adverse farming is characterized by high diversity within several key aspects of crop production in an attempt to minimize the chance catastrophic crop failure in years having adverse conditions (too wet, too dry, too cold, crop diseases, pests, etc.). There will be a greater diversity of staples being produced, especially those with different ecological parameters. This will include some hardy but less desirable species as well as fast-growing emergency or back-up crops. Different strains of the same crop or two complementary crops may be grown together as maslins (Jones and Halstead 1995). There also may be increased used of wild crop replacement species. In addition, variation in the species utilized, there may also be spatial and ecological variability in field systems. Plots may be dispersed throughout a fairly large area and may include a variety of ecozones.

Processing, Distribution, and Storage Systems

Centralized economies not only have increased influence on crop husbandry practices (directly or indirectly), but also have greater control over local (mobilization) and extra-local distribution systems, including those for foodstuffs. This affects the organization of crop processing, distribution, and food storage. In small-scale, non-centralized systems, crop processing will be done by all households as part of the agricultural cycle. In more centralized systems, not all households will be equally engaged in agricultural production, including the processing aspects. Elite households may receive all or a part of their food from the commoner producers through resource mobilization systems. Mobilized food is not only used to provision elites directly, but may be used by elites to support various specialists, supporters, and administrative institutions, to host feasts, or to be exchanged. The key here is that mobilized crops are unlikely to have been transferred in a completely unprocessed state given the costs of bulk transport. Provisioned populations will have a disproportionate amount of crops in more advanced processing stages and there will be less evidence for processing residue in elite areas.

Mobilization systems also create asymmetries in the amount and types of crops available to different households. Producers will have a portion of their crop appropriated by the local elite, cutting into the size of their household stores. This difference may be exacerbated if the elites are also producing their own crops, as they will have access to larger plots of land, more fields, more expensive technologies, and additional labor (through debt obligations, corvée labor, compensated labor, or larger families). As a result, they may be able to accumulate greater crop stores through household production in addition to mobilized resources. Elites will have larger and greater numbers of storage facilities. Some of these storage facilities may represent centralized administrative stores, not necessarily associated with specific elite households. There should also be differences in crop types as mobilized resources are unlikely to target low-value species. Elites have greater access to luxury or specialty crops and may directly influence their production (see above).

Test Expectations

Intensification Proper

There has been much attention placed on intensification in the archaeological literature, especially though *landesque capital* improvements. Unfortunately, these are largely absent in prehistoric temperate Europe. Instead we must look at other types of intensification dealing with crop husbandry practices such as frequency of cropping cycles and labor/resource investment. More intensive agricultural systems are often associated with a reduction in fallow period length (Boserup 1965). This can be seen in the composition of weeds with more biennials and perennials in crops grown on plots with longer fallow cycles as they have a greater undisturbed period in which to establish themselves (Bogaard 2004b). In systems with shorter or no fallow periods, the weeds will be dominated by annuals, especially those that tolerate disturbance. Double cropping may also be practiced. In this case, wheat must be sown in the fall in order to harvest at an earlier date. This allows the planting of a secondary, fast-growing crop. Season of planting can be identified through the weed assemblage associated with wheat, with fall sown crops having a higher proportion of *Secalinetea* (fall) weeds over those in the *Polygono-Chenopodietalia* (spring) weed association (Bogaard 2004b; Jones, et al. 1999). There would also be higher proportion of short growing-season crops, such as millet.

More intensive cultivation methods are characterized by increased energy and resource investment in field preparation and crop maintenance. These include seed bed preparation, transplanting, tilling, weeding, and manuring (Morrison 1994), which affects weed composition. For winter crops, this favors the increased proportion of spring weeds. For all crops, this also favors species that can withstand frequent disturbance and promotes the growth of nitrophilous taxa (Jones, et al. 1999). Harvested crops (at similar processing stages) would also have a lower weed to crop seed ratio than in crops that were less intensively maintained.

Table 7.7: Expectations for crop production in intensive versus less intensive systems

Strategy	Variable	Practice	Indicator
small-scale independent farming (risk minimization)	location of fields	dispersed fields	higher variability weed species of different habitats
	crop rotation	longer fallow period	more biennials/perennials
	frequency of cropping	single	fewer short growing period crops
	crop selection	diversified (risk buffering)	higher diversity and evenness more hardy species (barley, millet) mixed maslin crops
	planting schedule	staggered crop planting	mixed winter/spring weeds in wheat
	labor/resource investment	lower maintenance no manuring	higher ratio weeds:crops lower frequency nitrophilous weeds
	producer population	household production	uniform distribution agricultural implements
intensification	crop rotation	shorter fallow period	fewer biennials/perennials
	frequency of cropping	double	more short growing period crops wheat fall planted
	labor/resource investment	high maintenance manuring	lower ratio weeds:crops higher frequency nitrophilous weeds
extensification	labor efficient technologies	plow cultivation	more traction cattle lower proportion disturbance tolerant weeds higher proportion biennials/ perennials
	labor/resource investment	lower maintenance no manuring	higher ratio weeds:crops lower frequency nitrophilous weeds
diversification	location of fields	dispersed fields	higher variability weed species of different habitats lower utility land in production
	crop selection	diversified export production	higher diversity more high value/low utility crops
	labor/resource investment	variable	variable
specialization	crop selection	specialized production	single crop dominant higher value crop(s)
general	producing population	producing and non-producing groups	uneven distribution agricultural implements

Manuring should be considered in more detail as it in a critical means to increase crop yield per unit area as it can boost output by up to twice the normal rate. Manuring is associated with intensive animal husbandry systems that keep livestock in enclosures close the settlements so that it is easier to obtain large and concentrated quantities of dung (see also below). It is also typically requires bulk transport technologies (e.g., ox carts) if practiced at a larger scale. Soil studies can be used to identify manuring through higher phosphorous levels and through the increased presence of fecal spherulites (Canti 1999).

Extensification

Extensification is often more difficult to identify archaeologically than intensification as the botanical indicators are also found in other strategies and extensive methods are often combined with more intensive ones in diversified systems. The most oft cited marker of extensification is the adoption of plows and bulk transport. The use of these technologies has been established since at least the Copper Age in the study region (Bogucki 1993; Bóna 1960; Milisauskas and Kruk 1991; Sherratt 1981, 1997). These implements are largely made from perishable materials that are rarely found archaeologically, so it is challenging to document an increase in their use directly. However, the importance of traction animals can be identified zooarchaeologically through an increase in the proportion of older cattle, especially oxen, and an increased incidence of traction pathologies, as discussed in a subsequent section (Bartosiewicz, et al. 1997; Miller 2003).

Increased land clearance (assuming significant wooded areas) can be seen by an increase in charcoal in sediment cores. Land clearance is associated with simple expansion as well (see below) so it is not only indicative of more extensive farming methods. It is also problematic, as Bogaard (2004b) and others have argued, as the period of land clearance is only a short-term phenomenon and can be of limited visibility. Increased land clearance may be associated with other activities, including collection of wood and charcoal production, related instead to craft intensification (e.g., metallurgy) or large scale construction activities (Willis, et al. 1998). It will be far less visible in areas dominated by grasslands, as in most parts of the study area, although changes in the specific taxa represented may be present. In sum, land clearance is not a good indicator for this region.

Extensive methods can be better identified through weed assemblages, but these can overlap with other systems, so these must be evaluated in conjunction with other lines of evidence. Extensive field systems typically have very low maintenance after initial planting, with little weeding or fertilizing.[55] As a result, there will be comparatively high proportion of

[55] Note that plow agriculture is not mutually exclusive of more intensive practices, as plowed fields can also be manured or otherwise fertilized/maintained, especially those closer to the settlement. This section refers to the far end of the cultivation spectrum (holding labor as constant) in which energy is placed into bringing more area into production rather than into more intensive practices on existing fields.

weeds, fewer nitrophilous species, and weeds that are more directly associated with season of planting (e.g., fewer *Polygono-Chenopodietalia* in winter sown cereals). In addition, as the ground is less frequently disturbed during the growing season, there will be a greater number weeds species that do not tolerate disturbance well, including more biennials/perennials. In the initial period of implementation, there will also be a higher incidence of species endemic to the pre-clearance habitat (Bogaard 2004b)

Expansion

Expansion is the most difficult method to identify archaeologically as it does not involve a change in cultivation practices. Rather, it is simply a matter of bringing more land into production with existing methods, with no advantage in crop yield per unit area or labor efficiency. In some cases, where fields are marked or walled, the expansion of arable land can be traced. Unfortunately, this is not done in the study area. Without these, more indirect methods must be used. This is essentially limited to markers of land clearance, which have been discussed above. Given issues of equifinality and low visibility, expansion is not considered in my study.

Diversification

Diversification entails bringing more types of crops into production, using a greater variety of planting methods, and/or bringing a wider range of areas into production, especially those requiring alterations to extant production strategies. Diversification related to risk mitigation can be easily distinguished and is considered below. Diversification associated with more centralized economic systems can reflect a response to pressures to increase crop yields by expanding fields into a greater range of land with varying environmental parameters, especially those that are lower yield. This can be seen through an increase in the diversity of weed species with different habitat preferences. There may also be evidence for multiple forms of production strategies, which may be apparent in different areas of settlements.

A more direct cause for diversification is increased elite demand for prestige foods (rare, exotic, spices, oil plants, other non-staple foods), crops associated with craft production (fiber crops, dyes), or other specialized species (ritual, medicinal, ornamental) (Morrison 1996; Morrison 2002; Morrison 2006, 2007). These are often species that are meant for export or used in the production of export goods (e.g., “cash crops”). These species are far less likely to be major crops in small-scale subsistence farming due to their low general utility or high labor/resource demands. This form of diversification can be readily identified by the range and specific composition of crop plants. In this region and time period, this is most likely to be seen in oil and fiber plants like flax (oil and fiber), gold-of-pleasure (oil), and perhaps poppies (oil). This form of diversification is likely to correlate with an increase in regional exchange and intensification of local craft production, especially for textiles.

Specialization

Specialization can be identified through the range (very low diversity) and type (high value) of crop species. It is unlikely that highly specialized crop production will be found in Bronze Age temperate Europe, especially at the settlement scale. However, specialization may occur within particular households or residential areas, and may be documented through associated crop-processing debris. Specialization of high value, low utility species by only a few households will mirror diversification at the level of the settlement.

Risk Buffering

To identify a shift to intensified agricultural systems, it is necessary to understand the organization of small-scale, risk-adverse systems from which they develop. A diversified subsistence economy is a hallmark of self-sufficient, household farming systems (Halstead and O'Shea 1989). There will be a greater range of staples being produced, especially those with different ecological parameters as well as hardy and fast-growing emergency or back-up crops. In the study region, it is expected that risk-adverse systems will have larger proportions of barley and millet compared to wheat as these are more tolerant species. There may be use of “maslin” crops, which are fields which two or more crops are deliberately grown together. These are typically different types of cereals or legumes, ranging from 50%-50% to 80%-20% mixtures (Jones and Halstead 1995).[56] There also may be greater exploitation of wild resources, especially crop replacement species like white goosefoot (*Chenopodium album*) (Gyulai 2010).

Diversification may also be seen through land use and planting strategies. Fields may be dispersed and situated in a variety of habitat types, particularly between floodplains and dry loess

[56] 90% or greater dominance of one species is considered a monocrop.

grassland areas, but also may include some use of wet meadows. In this case, there will be a greater diversity in weed species having different ecological parameters. Crops may also be planted at different times of the year. This includes not only staggering, which is common to most systems, but also planting wheat in both the fall and spring. This seasonal displacement can be identified through associated weeds (see above).

Producers versus Consumers

In increasingly complex societies, there will be a greater distinction between segments of the population, including those based on status, wealth, and power. There will also be an increase in the number of non-farming groups such as administrators, ritual specialists, military personnel, and (full-time) craft specialists. Not only does this growing non-producing population need to be sustained, creating increased pressure for surplus production, but there will be a spatial segregation between these groups that can be identified archaeologically. The density and spatial distribution of agricultural implements (e.g., sickle blades, heavy-duty antler tools, stone axes) can be used to identify divisions between elite consumers and commoner producers. Methods used for assessing nucleation of craft production are utilized.

Crop Processing, Distribution, and Storage

Centralized political economies are characterized by mobilization, which affects the organization of crop processing, distribution, and storage. Here, crop processing and storage are the major foci as they are more readily identifiable in the archaeological record and can be used as proxy measures for distribution systems (Table 7.9). In non-centralized systems with household production, there will be little spatial variation in crop processing residues and processing tools. However, in centralized systems these will be unevenly distributed as not all of the population will be equally engaged in agricultural activities.

Households (or larger residential groups) that are less directly involved, or not involved at all, in crop production and processing are expected to have a higher proportion of late-stage processed or completely cleaned crop seeds if they are being provisioned through mobilized resources. Processing, especially early-stage processing, is more likely to be done closer to the producing populations' residences (or unprocessed harvest storage areas). There should also be fewer weed seeds overall. If elites are receiving grains that still require late-stage processing, the weed seed composition will be different from early-stage processing. In the course of threshing, coarse sieving, flinging,[57] winnowing, and fine sieving, not only are more weed seeds removed from the crops, but the size of the remaining weed seeds increases (Engelmark 1989; Hillman 1983, 1985; Jones 1983). Smaller seeds are differentially lost during sieving and winnowing, with larger weed seeds, especially those approaching the size of the grain, only being removed by hand in final stages (if at all). Consequently, in provisioned areas, there will be fewer small sized weed seeds in comparison to larger ones, depending on how well the crop was cleaned. There will also be a greater density and diversity of processing tools in the processing areas, given adequate preservation.

Table 7.8: Expectations for crop processing, distribution, and storage in centralized versus non-centralized systems

	Less Centralized		**More Centralized**	
	Practice	**Indicator**	**Practice**	**Indicator***
crop processing	all households processing	higher ratio of chaff: crop seeds	processing and non-processing groups	lower ratio of chaff: seeds
		higher ratio of weeds: crop seeds		lower ratio of weeds: crop seeds
		higher ratio small: large weed seeds		lower ratio small: large weed seeds
		higher density of processing tools		lower density of processing tools
crop distribution and storage	more equal access to crops	lower density of crop seeds	less equal access to crops	higher density of crop seeds
		fewer prestige or specialty crops		more prestige or specialty crops
		smaller storage pits		larger storage pits
		fewer storage pits		more storage pits
		fewer storage vessels		more storage vessels
		less elaborate storage vessels		more elaborate storage vessels

*For non-producing groups only. Producing groups have the same expectations as for less centralized systems.

The presence of mobilization systems exacerbates differential access to food between elites and non-elites. There are several ways to measure this asymmetry. In elite sectors, we would expect a higher density of crop seeds per unit volume of soil. There would also be larger and greater numbers of storage facilities, including pits, ceramic vessels, and granaries. These may be more elaborate as well, to publicly display staple wealth. The types of food remains would also differ between areas. Elites would have greater access to high value or specialty

[57] Flinging is done indoors in temperate climates during cold weather (Engelmark 1989).

crops like oil and fiber seeds and may directly influence their production. Provisioned stores are less likely to contain wild, gathered plants and lower ranked crops like millet. In non-centralized systems, there will be far less variability in the size of food stores or the types of crops utilized.

Animal Economy

General Patterns

Intensification Proper

Intensification of the animal production systems is not easy to define, let alone document archaeologically. The traditional definition of intensification, more output per unit of land (through increased input), only applies in part to animals (Table 7.10). There is a less direct relationship between the number of animals being kept and labor/energy requirements. Increasing the number of animals in a given herd can be done with a non-proportional increase in labor demands. Further, intensification may be as simple as putting more animals in any given pasture (Thurston 2006), which would not be readily identifiable archaeologically. However, if animals are being kept in pens or stables, then there may be an increase in these structures' density and size. In addition, adding more animals to a specific area can only be done up to a point without other measures needing to be taken. Specifically, there would be an increased need for foddering. This can be seen in the archaeobotanical record by an increase in fodder plants, whether crops or harvested wild hay.

Intensification can also be viewed as increasing the output per unit animal. This can be done through genetic innovations *sensu* Kirch (1994), for example, by adopting new breeds that are more productive (larger, fattier, more secondary products). Except for secondary products (which are discussed further below), these do not require additional labor or resources so are not intensification proper. Nonetheless they do result in an increase in output per animal. But there are other ways to maximize energy output per animal based on management strategies, but at the cost of herd security and additional resource input (Redding 1981). Specific patterns of intensified production will vary between species and the range of products being maximized. Maximization of a single product will be discussed below under specialization. Intensified production is associated with culling patterns that increase the amount of resources obtained per animal, which is typically seen as a reduction of juvenile off-take, being delayed until approaching maximum body size. For animals producing multiple resources, cull age may be weighted to maximize average production rates. This requires additional maintenance costs as a larger proportion of the herd is being kept for a longer period of time. For fast maturing species with high reproductive rates, such as pigs, a rapid turnover system may be employed and double farrowing may be encouraged.

Table 7.9: Animal production strategies

Strategy	Principles	Features of Animal Production
small-scale independent herding	risk buffering self sufficiency energy conservation	diversified species low risk species diversified resource types culling favoring herd security
intensification	increase output per unit area increase output per unit animal increase energy input	more animals per unit area more, larger housing facilities foddering resource maximizing off-take rapid turnover systems
extensification	increase area of pasturage decrease energy input per unit area decrease energy input per unit animal	long distance herding mobile species lower utility pastures
expansion	increase area of pasturage no change in input per unit area	land clearance no change in methods
specialization	decrease in the # of components targeted production (exchange)	low species diversity higher value animals maximize single resource type
diversification	increase in the # of components targeted production (exchange)	multiple strategies

Extensification

Extensive herding practices entail keeping herds at a greater distance from the settlement, generally between two to twelve hours from the settlement (Gamble 1982). Of course, with transhumant[58] or nomadic pastoralism, this distance will greatly increase as herders travel with their flocks and may cover very large areas, up to hundreds of kilometers, typically being away from settlements for long periods of time. Extensive herding is often used as a way to bring otherwise low utility areas into production, and given the distances involved, does not compete with farming (but does not benefit it either through manuring, traction, grazing of unripe crops, etc.) (Bogaard 2004a). There is also a decrease in labor and resource investment as distant herds

[58] Note that transhumant pastoralism is embedded within more intensive agricultural systems whereas in nomadic pastoral production is primary.

are not maintained with special housing or foddered. Because herding is an economy of scale, low maintenance extensive herding can support very large numbers of animals with little additional labor investment, increasing overall output. At the same time, the output per animal is reduced, given the often lower quality and quantity of graze and extensive movement. These animals generally have a lower meat weight, are less fatty, produce less milk, and have lower quality wool. Milk is generally not a significant component of extensive systems given the low productivity rates, high labor costs, and difficulty of transporting this highly perishable product to the settlement.

Extensification is not easy to document archaeologically. However, given the distances involved, it is generally restricted to herd animals that can be easily moved over long distances on the hoof. The proportion of this class of animals is expected to increase with more extensive practices being adopted. Meat and/or fiber would be the primary resources obtained, which will be evident in herd demography (see below).

Expansion

For animals, expansion is simply increasing the area used for pasturage using the same herding strategies. As with crop production, expansion of grazing land is finite in any given catchment and at a point of diminishing returns, more intensive or extensive methods will be employed. This may be impossible to see archaeologically unless this involves significant land clearance, which may be apparent in archaeobotanical and pollen records (see above).

Specialization

Specialized animal production systems have been comparatively well studied, both methodologically and theoretically (Bartosiewicz, et al. 1997; Bogucki 1993; Bökönyi 1988; Crabtree, et al. 2010; Greenfield 1988; Marom and Bar-Oz 2009; Payne 1973; Sherratt 1981; Vigne and Helmer 2007; Zeder 1991). Specialized animal production occurs in two ways. It can be a focus on one or a small range of animals at the expense of other species or for a single product within a particular taxon. Specialized production is generally viewed in terms of secondary products, resources from animals that do not require their death, but for animals that produce multiple resources, meat production itself may be specialized, a notion that is commonly overlooked when searching for "specialized" production systems archaeologically. Greater attention must also be paid to specialized production of livestock for exchange rather than just their locally consumed products.

In sedentary, mixed-farming societies, highly specialized animal production systems are generally only found in centralized economic systems. Specialization, especially for secondary products, usually requires a market system and of some form of elite/state sponsorship, given the high risk involved and the loss of subsistence autonomy. There also needs to be an infrastructure to coordinate production and distribution as well as sufficient demand. This demand is typically generated by elites, either through tribute/tax obligations, elite food preferences, or for animals/animal products that will be exchanged or used in craft production, especially fiber. Specialized production for meat, secondary products, and animal export can be readily identified through taxon composition and demographic profiles, the specifics of which are presented in the following section.

Diversification

Diversification is considered last since, along with expansion, it is challenging to identify archaeologically. As with crops, diversified animal production involves the addition of more components, takes a variety of forms, and occurs under disparate conditions. Diversification associated with risk buffering in smaller-scale herding systems is discussed below. Diversification related to increased centralization entails the addition of different herding strategies within a larger system. For example, more specialized, extensive, or specialized systems under centralized control mayoperate alongside household husbandry systems. Again, this may reflect the need to increase overall output by bringing under-utilized lands into production with alternative herding strategies, or it may reflect targeted production to increase exchange goods. Scale is critical here as these additions will not be uniform. It is necessary to examine animal husbandry practices in different parts of a settlement as households will be using different strategies, some of which may directly controlled by elites. The adoption of new species, an increase in high-cost animals, or specialized production within some species may indicate the addition of production for export. The adoption of extensified or intensified systems within some herding sectors may reflect a need to increase overall production, likely related to mobilization demands.

Risk Buffering

In small-scale, independent, household production systems, herd security is more important than resource maximization, especially when there are limited resources available for livestock maintenance. A diverse range of livestock will be kept to reduce catastrophic loss of a single species. However, there will be a greater focus on less resource intensive, hardy, and more rapidly maturing and reproducing species, especially smaller livestock. The specific composition of herds will vary based on ecological parameters, being tailored to species that are best suited to local conditions. To lower upkeep costs and to maintain a stable herd size, there will be a relatively large number of juveniles culled before reaching physical maturity (Redding 1981). Adult animal off-take may balance various resources, including both primary and secondary products.

Distribution Systems

A hallmark of centralized economies is greater elite control over distribution systems. One effect is the increased importance of indirect procurement (Zeder 1991). In these systems, a segment of the population obtains part of or all of its meat from other producers. This is in contrast to direct procurement systems, in which the producers and consumers are the same, essentially self-producing farmers. Indirect procurement systems take a variety of forms, not all of which are directly related to centralization. For example, independent exchange of livestock can be done at the household level through barter or markets. In these cases, production and distribution decisions are made by the herder. Mobilization systems are also important types of indirect procurement, in which animals are funneled to governing institutions via tribute or tax payments. A specific set of criteria may be established for these payments in terms of the species, sex, or age of the animal, which influences herding decisions of the producer. A more extreme form of indirect procurement and mobilization is provisioning, which involves government (or equivalent non-state leadership) organization of both the production and distribution of meat/animals to support non-producers. Mobilized animals and animal products are important means of elite finance that are used to compensate individuals or groups for labor or other services.

Provisioning is associated with a specific set of criteria for animal production and distribution, which has been discussed in detail by Zeder (1991) for state-level societies.

However, the fundamental principles equally apply for provisioning in pre-state societies. Detailed consideration of zooarchaeological correlates are presented in the following section. Here I will outline the basic concepts. Provisioning involves centralized intervention in production systems and fosters increased standardization, as there is a need for a predictable supply of specific products at specific times. Provisioning systems almost always rely on livestock husbandry as wild resources are far less predictable and manageable. If the animals have to be moved over long distances, this requires herd animals that travel easily on the hoof (Redding 1991, 1992). Animals with larger body size are also favored to increase the meat obtained per animal (Zeder 1991), although this does vary by the status of the group being provisioned (see below). Another prominent feature of provisioning is standardization in culling by age class and time of year. Animals are raised in a meat maximization system where culling is delayed until full body weight is achieved (prime aged). If the provisioning involves meat itself rather than whole animals, which is more likely when producers and consumers are in the same settlement, then there will be a difference in the utility values of meat cuts. Meaty, fatty, and tender elements are more likely to be provisioned with lower quality elements kept by the producers.

In systems where direct procurement is dominant, with households primarily producing their own meat, a wider diversity of animals is likely to have been eaten, both domestic and wild, especially easy to obtain and lower ranked wild species, and more focus is placed on species that reproduce rapidly and are hardy over body size or meat quality. Livestock off-take will not be as tightly scheduled, with animals taken as needed by the family. There will also be a wider range of ages present, including both very young animals as well as prime aged and mature. Most of the skeleton will be represented, with perhaps the exception of primary butchery debris, as the household consumes the entire animal (Zeder 1991).

Status-Related Consumption Patterns

Meat consumption represents the endpoint of animal distribution systems, whether direct or indirect. In increasingly complex societies there will be pronounced differences in access to meat between elites and commoners, both in terms of quality and quantity. These are the result of differences in productive capabilities and position within exchange and mobilization systems.

Elites obtain animals (or meat and other animal products) through a variety of mechanisms. They may maintain their own stocks of animals and will have the resources available to focus on high cost animals. They may mobilize animals through tribute or taxation. There may be more formalized provisioning systems that support both elites and other specialist groups. They may trade with herders informally for animals when needed. Whether these animals are being obtained directly or indirectly, through formal or informal distribution and exchange systems, elite consumption preferences will be apparent.

There is an extensive literature on elite consumption of animal products and archaeological correlates are well documented (Crabtree 1990; Crabtree, et al. 2010; deFrance 2009; Emery 2003; Ervynck, et al. 2003; Gumerman 1997; Hayden 2001; Jackson and Scott 2003; Kirch and O'Day 2003; Redding 2010; van der Veen 2003). Elite consumption will favor higher value animals and meat cuts. These can be defined in various ways but are typically associated with species that have more meat per animal, higher quality meat (tenderness, fat content), higher production costs, or “wasteful” (very young animals). For wild animals this also includes greater procurement costs (labor intensive, dangerous) and relative rarity (Crabtree 1990; deFrance 2009; Ervynck, et al. 2003; van der Veen 2003). These can be identified archaeologically through taxon composition, age profiles, and body part representation, which again are discussed in more detail below.

Test Expectations

Intensification Proper

Increasing the animal yield per unit area can be done through placing more animals in a given area, and generally requires food supplementation through foddering. Theoretically, the addition or expansion of animal facilities, like pens or stables, can be a good archaeological indicator of intensified production, as can the increase in fodder plants. However, several problems are encountered when using these variables in the study area. First, unlike other regions in Europe, there is no clear evidence for formal animal housing facilities in this period, suggesting that ephemeral pens or corrals were used. Second, since excavations historically target central habitation areas, if there were in fact pens or corrals in the areas peripheral to the settlement, ephemeral or otherwise, they will not be found. This underscores the need to conduct more archaeological research away from the densest habitation areas. It is possible, however, that even if livestock were kept some distance from principal habitation areas, some fodder plants may have made their way to central occupation, either incidentally or perhaps through dung, especially if dung is used as fuel. Given that there are no specialized fodder crops in the Bronze Age, it will be difficult to identify foddering. At this time foddering would entail the collection of wild plants (hay) or crop processing byproducts, which are normally present in and around the settlement. Instead, it is more productive to examine the animal remains themselves.

Intensification may entail adopting methods to increase the output per animal, principally meat or a combination of meat/dairy. Redding's (1981) study of sheep and goat husbandry in the Middle East highlights a few important trends. It should be kept in mind, as Redding points out, that his figures are based on a set of conditions that are specific to his study and may not be applicable elsewhere, especially under different environmental conditions, which is the case for temperate Europe. In addition, goats are kept in very low numbers compared to sheep in my study region, differing greatly from his study parameters. Despite the expected deviations from the specific cull rate figures, general patterns and their underlying rationales should be applicable.

In short, systems that are maximizing energy output (as measured by protein, utilizing both meat and milk) cull fewer animals in their first year (which are primarily males) than in risk mitigation strategies (see below, Table 7.11). Instead, more animals are maintained until their growth rate approaches zero (i.e., "prime-aged"). At this point, diminishing returns in meat weight are gained for the amount of energy invested (labor, food, etc.). Energy maximizing systems may focus on species that produce the most output per animal, including larger body size and those with secondary products, especially milk. Pigs can be encouraged to breed twice a year (double farrowing), as part of a rapid-turnover system in which more animals are culled at a younger age, but more animals are produced overall given the higher breeding rate. Pigs also mature more rapidly than other species, so a younger cull would not result in as great of a loss of meat per animal. Given sufficient dental samples, double farrowing can be identified in age profiles (Ervynck 1997).

Extensification

In the study region, goats and especially sheep are favored in extensive herding systems. The tendency for sheep to graze in "clumps" makes them easier to herd in large numbers (Gamble 1982). In addition, the greater distance from the settlement and low number of herders present per animal makes it less likely that higher value animals, like cattle and especially horses, would be kept using extensive methods given risk of raiding and theft. A shift to more extensive systems therefore can be seen as an increase in ovicaprids in particular, especially compared to pigs.

Extensive sheep husbandry usually involves a mixed meat-wool or specialized wool system. Cattle may also be herded for meat extensively if dairy production is not important. Both meat and wool herding strategies can be readily identified in culling patterns. The expectations for these are described in the specialized production section in more detail, but in short, meat production has peak culls that are centered on prime-aged individuals while wool maintains more animals into adulthood. There will also be greater numbers of males (castrates) in wool systems. In extensive herding systems, there will be narrower age ranges for culling periods than if animals were kept intensively nearby the settlement given seasonal herd movements. In addition, as these herds would be kept at some distance from the settlement, animals lost to predation or natural deaths outside of the scheduled culling period would not be visible within assemblages at the home community. This causes an under-representation of the most vulnerable age classes, particularly very young and old animals.

Specialization

Any discussion of specialization must begin with secondary products. Secondary products have a long history in Europe, with dairy being used since the Earliest Neolithic (Craig, et al. 2005) and both plows and wool sheep by the Copper Age (Bogucki 1993; Bökönyi 1988; Sherratt 1981, 1997). As discussed above, once secondary products are available, meat can be a specialized resource as well. The regional exchange of livestock is also often not considered, especially compared to the importance placed on secondary products in specialization literature. Live animals would have been valuable resources themselves and were likely traded on the hoof in various exchange networks, from those at the intra-settlement (e.g., provisioning, local markets) to regional scales (long distance exchange, regional markets). For Bronze Age groups in lowland areas away from metal and other mineral sources, the surplus production of livestock for export may have been very important in animal management systems, providing an important means for local production systems to articulate with regional networks.

Specialized animal production systems have been well studied and numerous demographic models have been developed (Bartosiewicz, et al. 1997; Bogucki 1993; Bökönyi 1988; Crabtree, et al. 2010; Greenfield 1988; Marom and Bar-Oz 2009; Payne 1973; Sherratt 1981; Vigne and Helmer 2007; Zeder 1991). The clearest demographic profile is associated with wool production (Payne 1973). In systems where maximizing wool output is stressed, most animals will be kept into old age, until the quality of fleece output falls off. This includes animals of both sexes and castrates Increased wool production may also be associated with a higher density of textile production implements and facilities (see craft production above) as well as a sheep dominated faunal assemblage. Wool production is often combined with extensive animal husbandry as the animals do not need to be kept near the settlement for most of the year.

Specialized dairy production profiles have been much criticized in their applicability (or lack thereof) for pre-market societies as well as the (potential) inability of primitive breeds to produce enough milk to support a specialized system in the first place (Crabtree, et al. 2010; McCormick 1991; Redding 1981). In modern systems, dairy specialization entails the cull of the vast majority of juveniles before their first year to maximize the amount of milk available to humans (Payne 1973; Vigne and Helmer 2007). As a result, dairy specialization is usually paired with veal and lamb production. Several dairy models have been proposed that differ in their off-take patterns. Payne's and Vigne and Helmer's "Type A" dairy models both show extremely intense off-take off animals before their 2nd month (53% and 78%, respectively). These strategies differ primarily in that Vigne and Helmer's Type A model only 4% of animals are kept beyond their first year. This is an extremely specialized and rapid-turnover system that is unlikely to be seen prehistorically. Vigne and Helmer's "Type B" dairy profile differs substantially as infants are not immediately killed, but rather separated until reaching a greater meat weight. In this case the primary juvenile cull is delayed to between 2-6 months, with substantial numbers being kept until their second year. This system is more likely to be found in the Bronze Age as it balances dairy and meat production. All of these dairy profiles would appear to be female dominated as the majority of males are culled before developing diagnostic secondary and tertiary sex characters. Specialized dairy production results in a focus on cattle and/or ovicaprids. Dairy processing implements would also be more common. For Bronze Age Europe, this is usually associated with strainers (Bogucki 1986).[59]

Specialized meat production is characterized by large culls of prime aged animals, for the same reasons as outlined in the intensification section above (energy maximization), with varying degrees of juvenile off-take. The primary goal is to produce the most amount of meat per animal before reaching diminishing returns. In contrast to overall energy maximizing systems, specialized meat production does not take into account dairy output. The primary difference is a greater off-take of juveniles, especially between 2-6 months, in a meat-only system than in Redding's meat-dairy maximizing model. In Payne's specialized meat system, there are large culls of animals less than 6 months and between 1-3 years. In Vigne and Hemler's "Type A" meat model, the peak is between 2-6 months, and in "Type B," between 6 months to one year. These latter two are extremely specialized modern systems that are more focused on rapid production than maximizing the amount of meat per animal and may have only limited applicability to the Bronze Age, except for pigs. Like most husbandry systems, the sex ratio will appear to be female dominated. The number of archaeologically visible males is related to the age where the peak cull falls, with older males being preferentially identifiable to sex.

Specialized production of export livestock in many ways follows the logic for meat maximization herding strategies. Animals are typically raised until prime-age, reaching peak value, especially if the animal will be slaughtered for meat in the short term. If not, then the age at transfer may be younger (but after weaning and when they can travel over distances). If the animal is for traction or transportation, then the age of transfer will be after the training is complete (e.g., typically four years for horses). As discussed in the distribution section below, while the logic of herd management is similar, the resulting demographic profile will differ greatly from a specialized meat profile because of animal export. The producing site will have exported the target animals and would be left with primarily the breeding population, which is dominated by reproducing females and their young offspring. Very few males will be visible.

There are also expectations for taxon composition, depending on the importing population's requirements and the nature of the distribution system. Livestock have different

[59] Although there is some debate about the function of strainers, as they may also be used for the production of fermented beverages (Sherratt 1997).

values, some of which are undoubtedly culturally specific, but others can be more directly measured based on reproduction and maturation rates, quantity of meat, quality of meat (fat content, tenderness), maintenance costs (fodder, labor, shelter, supplements), value of secondary products, and for traction and transportation animals, training costs. Pigs and ovicaprids would lie at the low end of the value scale while cattle, and especially horses, would lie at the other.[60] Higher value animals are more likely to enter regional exchange networks because their value offsets the resources expended in transport (the point of diminishing returns is higher). In addition, longer distance exchange would favor animals that can move on the hoof over species like pigs (Redding 1991, 1992). There are fewer constraints within local networks.

Horses would have been the most valuable and widely exchanged animal during the Bronze Age. Given the ubiquitous local breeding of other livestock species (see Chapter 13), it is unlikely that exchange would be visible through demography, except in highly specialized and high volume systems. However, horses are relatively rare animals at this time, occurring at very low frequencies at most sites and often they are often completely absent. In such a situation, horses could have been very important commodities for the communities that could breed them in sufficient numbers and quality. Horse breeding, and especially training for riding and chariotry, would have required specialized knowledge, allowing some degree of elite restriction. This also applies to the manufacture of horse gear and chariots (see craft production).

Tracing livestock movement directly is challenging, especially when there is not a strong asymmetry between producer and consumer sites. For horses, there may be visible differences in demography between producer and consumer settlements in the study region, with the latter lacking very young animals, including fetal and neonatal individuals. Isotopic analyses using strontium may also be valuable. Currently, the author is part of an international collaborative project that is undertaking an isotopic study in the Carpathian Basin to trace the movement of people and animals in the Bronze Age.

Diversification

Diversification in animal production systems, like crop husbandry, falls into three main types depending on whether the diversification is adopted for reasons of risk mitigation, for increasing output over varied landscapes, or for targeted export production. The first is

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[60] Refer to previous sections for explanation of taxon value assessments.

discussed in the following subsection. In diversified systems in which export production is important, there will be increased focus placed on high value and rare livestock (cattle and especially horses) and the demographic profiles for these species will approach that for specialized export production. This may also include increased wool production.. Adoption of diversified strategies to maximize resources within varying ecological zones and distances will entail the addition of intensive or extensive methods within particular husbandry sectors. This may be difficult to distinguish archaeologically in the absence of fine-grained data from multiple spatial scales.

Herd Security

Risk mitigation can take a variety of forms and may include culling patterns geared to herd security as well as more diversification in both animal resource use and the range of animals utilized. All livestock types will be raised but there will be a greater emphasis on hardy, fast reproducing and maturing, and less energy intensive species like ovicaprids and pigs. The specific taxon composition will also be tailored to produce species that are best adapted to the local environment and will be site specific. For example, at settlements where there are more dry grasslands, ovicaprids will be more frequent, while in areas where there are extensive forests or wetlands, pigs will be dominant. There will also be greater use of wild resources, especially abundant and often low-ranked taxa that easy to obtain (smaller game, fish, shellfish).

Culling strategies that favor herd security over resource maximization are characteristic of small-scale husbandry practices, especially when there are limited resources available for livestock upkeep. In this system, a larger proportion of yearlings will be culled to conserve resources and maintain a stable herd size (Redding 1981). Because of the larger number of juveniles culled in this system (primarily males), the overall sex ratio will appear to have fewer males than in energy maximization systems as fewer individuals will have developed diagnostic sex characters. In addition, there are more likely to be mixed herding strategies in which a wide range of animal products are utilized, resulting in adult demographic profiles that fall between specialized systems. For example, a typical meat profile may be skewed towards older adults if secondary products are important. There will also be less standardization in culling periods, which can be identified as greater diversity in off-take ages.

Table 7.10: Expectations for faunal assemblage composition under different production strategies[61]

		Production Strategy							
				Specialized Production					
		Intensification	Extensification	Meat	Dairy	Wool	Traction/ Transport	Animal Export	Risk Buffering
Zooarchaeological Variable	**Dominant Species (taxon abundance)**	larger livestock (cattle) fecund (pig) species with multiple resources (cattle, ovicaprids)	ovicaprids, cattle	livestock (general)	cattle, ovicaprids	sheep	cattle, horses	high value livestock (horses)	hardy, low risk livestock (pigs, ovicaprids) diverse wild fauna, including low ranked
	Culling Strategy (peak age class represented)	prime aged (general) more juveniles (pig double farrowing)	prime aged (general) mature (sheep: wool, mixed meat-wool)	prime aged	very young	mature	mature	very young, mature (breeding population)	more juveniles (general) older adults (mixed production strategy)
	Sex Composition*	female dominated	female dominated (general) mixed sex (sheep: meat/wool)	female dominated	female dominated very few males	mixed sex, castrates	mixed sex, castrates	female dominated very few males	female dominated

*as visible archaeologically

Distribution (Direct versus Indirect Procurement)

The ability to identify production systems is affected by the degree to which direct or indirect procurement systems are operating. In direct procurement systems, where the producers and consumers are the same, the demographic profiles will directly reflect production strategies. Indirect procurement, where animals are not produced by the consumer, animal demography will more likely reflect specialized meat production and export profiles. These can be distinguished in a number of ways and require adequate samples from producing and consuming populations (Table 7.11).

Faunal assemblages will differ in specific ways between producing and consuming groups, both of which share features less likely to be seen in direct procurement systems. Provisioning, in particular, involves direct centralized intervention in production systems and are more likely to be standardized, relying on a predictable supply of specific products at specific times. There will not be as tight scheduling in independent exchange of livestock.

Indirect systems almost always rely on livestock husbandry. Depending on the distance between producers and consumers, there will be a larger or smaller range of species involved. If the animals have to be moved over long distances, pigs are unlikely to be utilized since they do

[61] Note that this table represents the archaeological (or death) assemblage, not the living herd profile. General patterns and expectations for specific sub-types are presented. See text for further explanation.

not travel easily on the hoof (Redding 1991, 1992). The most prominent feature of provisioning is standardization in culling. Animals are raised in a meat maximization system (see above) in which they are kept until reaching a plateau in body weight increase and then exported. Producing sites will be characterized by the remnant breeding population, in which there are greater numbers of very young (including neonates), representing primarily infant mortality, and sexually mature females. Consuming sites will be dominated by prime-aged males. If the provisioning involves meat itself rather than whole animals, which is more likely when producers and consumers are in the same settlement, then there will be a difference in the body part utility values. As discussed above, meaty elements are more likely to be provisioned with less meaty elements kept by the producers (see Chapter 8 for specific utility values per element).

In systems where direct procurement is dominant, with households primarily producing their own meat, a wider diversity of animals is likely to have been eaten, both domestic and wild (especially lower ranked wild species), and more focus placed on species that reproduce rapidly, are lower risk, and require less resources. Livestock off-take will not be as tightly scheduled, and a result, there will be a wider range of ages present, including both very young animals as well as prime-aged and mature. Most of the skeleton will be represented, including both higher and lower utility elements.

Consumption Patterns

The third layer of the animal economy that overlies (and acts in concert with) production and distribution systems is differential consumption practices. This includes status based differences in access to meat as well as specialized consumption events like feasting.

There will be pronounced differences in access to meat between elites and commoners, both in terms of quality and quantity. Elite consumption runs parallel with indirect procurement, although there are additional considerations. Elite consumption will favor higher quality meat as determined by species, age, and element (Table 7.12 and Chapter 8). In the study region, higher ranked species include larger livestock like cattle, horses, and potentially pigs (fattened or suckling), and large game like red deer, wild boar, and aurochs.

There will be a relatively narrow range of age classes represented in elite contexts, centered on prime aged and juvenile animals. The consumption of very young animals is inefficient and can be seen as conspicuous consumption (e.g., suckling pigs, veal). In cases where meat is asymmetrically distributed, in addition to the animals themselves, there will also be a distinction in the body parts represented. Elite areas will have a greater proportion of high utility elements, those that are meaty, tender, and fatty. This includes trunk elements and upper limbs.

Feasting deposits largely mirror elite consumption patterns, with an emphasis on large quantity and high quality of meats (and other foods) (deFrance 2009). However, there will be additional features present as well. There may be increased standardization of the animals (and parts thereof) involved, especially if there is a religious component. This form of this standardization will be culturally/ritually specific, but will differ from typical food refuse. There also may be special deposition of the food remains, either in a unique midden or refuse area or as a commemorative deposit, including associated bone groups (Morris 2010). Feasting refuse will also be linked with other specialized paraphernalia, including large and high quality serving vessels. There may also be special preparation facilities. Feasting areas will be segregated (Hayden 1995, 2001) and require spatial analysis to be properly identified, as well as strong integration with analysis of other artifacts and features.

Table 7.11: Expectations for centralized influence on animal distribution systems and consumption patterns

	Zooarchaeological Variable				
	Dominant Taxa	**Peak Cull**	**Sex Composition**	**Body Part Representation***	**Standardization**
Procurement Systems					
indirect-- producers	livestock (mobile)	very young, mature	female (very few males)	(lower quality)	moderate
indirect-- consumers	livestock (mobile)	prime aged	male dominated	(higher quality)	high
direct	livestock (mix), wild	variable	female (some males)	(all)	low
Consumption Patterns					
elite consumption	higher value species	prime aged, juvenile	male dominated	higher utility elements	high
non-elite consumption	lower value species	mature	female (very few males)	lower utility elements	low
ritual feasting	higher value species	prime aged, juvenile	variable (ritual dependent)	higher utility elements	very high

*effects most strongly seen in local distribution systems

CHAPTER 8: METHODOLOGY

In this chapter, I describe methods for analyzing specific artifact classes that are used in this thesis to assess economic organization. Primary analysis of faunal remains and bone tools was completed by the author for all settlements except for Százhalombatta. For Pecica, I also conducted preliminary assessments of off-tell ceramics, chipped stone, ground stone, and miscellaneous artifact classes. Other materials from Pecica were examined by specialists associated with the larger project, including the on-tell ceramics, plant remains, and metallurgical items. For the comparative settlements, specialist analyses are documented in their respective sections. All secondary analyses, including spatial distribution, densities, and other measures used in hypothesis testing (Chapters 3 and 7) were completed by the author.

FAUNAL ANALYSIS

Faunal analysis, as a means to identify the degree and form of centralization within the local economy, is the core of this study. While faunal reports from systematically excavated Bronze Age sites are becoming more widespread, especially in Hungary, there is still a general lack of integration of the pastoral economy with other facets of local production. Little attention has been paid to specialization or intensification within the animal economy, even though livestock production is a key arena in which these larger processes are manifested. As outlined in Chapter 7, changes in the production, distribution, and consumption of animals related to the development of political economies can be readily identified in zooarchaeological remains by using appropriate frameworks. These include specific alterations in taxon composition, culling patterns, butchery practices, and food processing and presentation. In this section, I present the methods used for assessing these variables. Comparison of animal economies is possible for all sites, except Semlac, used in this study as the faunal remains were analyzed by the author or by other analysts using comparable methods.

Identification

The first step in faunal analysis is to inventory the animal remains. The basic information recorded includes: catalog number, context, taxon, element, portion, side, quantity, age, sex, pre- and post-depositional modification, pathology, and standardized measurements (Appendix 7.1). In addition, weights are taken of each lot of bone which, along with bone counts, is used to calculate fragmentation rates and the density of bone per unit volume of soil.

Specimen documentation was largely completed during the field seasons. Problematic specimens were brought to the University of Michigan for further analysis. Taxon identification was aided through the use of comparative collections from the University of Michigan Museum of Anthropology and Museum of Zoology, along with specimens I collected. Some species require more detailed means of identification, particularly those that are closely related. These taxa include aurochs (*Bos primiginius*) versus domestic cattle (*B. taurus*), wild boar (*Sus scrofa ferus*) versus domestic pig (*S. scrofa domesticus*), and sheep (*Ovis aries*) versus goat (*Capra hircus*). The first two pairs can be separated through size distinctions, with baseline measurements available for wild versus domestic cattle (Grigson 1969, 1974, 1975, 1976; Rowley-Conwy 1995; Stampfli 1963; van Vuure 2005) and pigs (Albarella, et al. 2005; Albarella and Payne 2005; Payne and Bull 1988; Rowley-Conwy 1995).[62] Certain elements of sheep and goats can be distinguished qualitatively and quantitatively (Boessneck 1969; Buitenhuis 1995; Halstead, et al. 2002; Payne 1968; Prummel and Frisch 1986; Rowley-Conwy 1998). Freshwater mollusks are identified using Welter-Schultes (2012).

Skeletal element recording follows standard anatomical nomenclature. Specific portions of individual bones are described using a set of element segments and/or diagnostic features that aid in the determination of Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) (see Quantification). For long bones, portions include: proximal epiphysis, proximal shaft, mid-shaft, distal shaft, and distal epiphysis. In addition, any element-specific landmarks, other than those already incorporated into major bone sections, are recorded. These are particularly important for shaft fragments, as these are notoriously difficult to quantify in terms of MNE/MNI. MNE values are strongly affected by carnivore gnawing, which is common at Pecica, reducing the preservation of diagnostic epiphyses. As a result, shaft quantification is

[62] There are areas of overlap for wild female and domestic male cattle, so care must be taken to examine size distributions carefully.

especially important for assessing the degree of this taphonomic bias and providing accurate bone quantification (Bartram 1993; Marean and Spencer 1991). Relevant markers include major foramina, muscle attachments, and the proximal origin of the ulnar grove on the radius. Irregular and flat bones have element-specific quantification segments.

Quantification

The methods used to quantify animal remains and their relative contribution to past diets have been the subject of numerous studies (Binford 1978; Grayson 1979, 1984; Klein and Cruz-Uribe 1984; Lyman 1994; Marean and Spencer 1991; Marshall and Pilgram 1993; Ringrose 1993; Rogers 2000a). The most commonly used measures are Number of Identifiable Specimens (NISP),[63] Minimum Number of Elements (MNE), Minimum Number of Individuals (MNI), and meat weights. Each of these methods has advantages and drawbacks, as they respond differently to various taphonomic effects.

NISP is a raw count of the number of bone fragments belonging to a specific category. It provides the maximal number of bones present, considering each specimen as an individual element. From NISP, several other measures can be calculated. MNE estimates the minimum number of skeletal elements represented by the bone fragment assemblage. It tallies the number of discrete, non-redundant bone portions, accounting for side, age, and size. MNI is the minimum number of individual animals that are represented by the MNE.[64] Meat weights are calculated by multiplying the MNI by the weight of meat provided by that species.

A number of important taphonomic and cultural processes affect these measures and their reliability, especially carnivore gnawing and fragmentation rates. Carnivore gnawing tends to differentially destroy longbone epiphyses, which are the most diagnostic portions and primarily used for MNE/MNI calculations. Documentation of discrete shaft portions is stressed in this study to reduce this problem. Fragmentation rates also strongly affect quantification methods. As fragmentation increases, so too does NISP, resulting in over-representation of elements due to interdependence.[65] However, because of a decreasing ability to identify small fragments to element and taxon, NISP counts tend to reflect actual bone proportions when fragmentation is very high. MNE/MNI measures, because they rely on the ability to identify specific diagnostic

[63] Also known as Number of Individual Specimens
[64] For example, three humeri (2 left, 1 right) produces a MNI of two individuals (given the same age/size class).
[65] One bone may be fragmented into ten identifiable pieces, which NISP would consider ten individual specimens.

features, have a nearly linear inverse relationship between fragmentation and counts, causing element/taxon under-representation in highly fragmented assemblages (Marshall and Pilgram 1993). In addition, MNI tends to over-represent rare taxa[66] and is strongly affected by sample aggregation methods[67] (Grayson 1979, 1984). Problems with MNI follow directly into meat-weight measures.

Because of the above limitations, each of these measures was used for different purposes. MNI, based on MNE values, is calculated at the largest possible assemblage aggregation within contemporary deposits. This includes all contexts within major chronological phases (see Chapter 6) in order to minimize the effects of aggregation bias and rare taxon over-representation. NISP is presented along with MNI to establish maximum and minimum estimates for bone/species counts. The differences in relative abundance between NISP and MNI measures can be used to determine the degree to which fragmentation and other taphonomic processes have affected the assemblage. These figures are supplemented with direct measures of fragmentation and post-depositional alterations that were documented as part of taphonomic assessment. Very strong taphonomic effects may not only affect the relative abundance of individual taxa, but also may result in statistically significant differences in taxon rank order, as measured through Mann-Whitney tests. In this case, NISP will be considered the more reliable measure (Grayson 1984; Marshall and Pilgram 1993). Further, statistical analyses require minimum sample sizes (Zar 1999) that may not be met with MNI counts, including chi-square, which is used for assessment of nominal data. As a result, most of the diachronic and synchronic comparisons of relative taxon abundance, a critical component for assessing herd management, utilize NISP. MNI is used for demographic aspects of herd composition.

Body part representation is used to infer butchery, distribution, and consumption patterns. Like taxon abundance, both NISP and MNE values are used with the same caveats. Before making interpretations about human practices, it is necessary to take into account the degree of density-mediated attrition[68] and other taphonomic effects that bias skeletal element

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[66] For example, if an assemblage has 100 cattle and two fox bones (NISP), but the element distribution results in MNIs of three cattle and two foxes, it would suggest that foxes are nearly as important as cattle.
[67] The more an assemblage is subdivided and MNIs calculated separately for each context, the more individuals will be represented overall, even if there is no overlap in element distribution. For example, a single sheep carcass may have been deposited in five different refuse pits. If MNI is calculated for each pit separately, then the result would be five sheep, rather than the one sheep that is actually represented.
[68] Density-mediated attrition refers to differential destruction of bones based on their density. In other words, less dense elements are more likely to be destroyed or rendered unidentifiable than denser elements.

representation. Butchery and consumption patterns are largely based on the relative abundance of specific bones ranked according to their food value. There is a large literature on skeletal element utility curves for various taxa (Bartram 1993; Binford 1978, 1984; Bunn 1993; Bunn, et al. 1988; Friesen 2001; Lyman 1994; Marshall 1993; Marshall and Pilgram 1991; Rogers and Broughton 2001), primarily focused on hunter-gather assemblages. While body part representation can be assessed by individual element or element portions, given the vagaries of differential bone destruction, it is often more useful to lump together elements with similar utility values. In this study, classes were based on natural breaks in general utility values, using Binford (1978) for artiodactyls (sheep modified general utility index/MGUI) and Outram and Rowley-Conwy (1998) for horses (standardized food utility index/SFUI), using the maximum value per element (Tables 8.1 and 8.2). The skeleton is divided into very high, high, medium, low, and very low portions, which can then be lumped into more general higher (very high through medium) versus lower (low through very low) utility element classes. Using NISP values, these combined categories produce sample sizes adequate for chi-square analysis. Because of the differences in the number of elements, bone densities, and utility values among taxa, temporal and spatial comparisons are only made within individual species.

Table 8.1: Utility categories for artiodactyls (derived from Binford 1978)

Utility Class	MGUI	Element	Utility Class	MGUI	Element
very high	100-80	rib	medium	30-20	radius
		costal cartilage			ulna
		sternebra			astragalus
		pelvis			calcaneus
		sacrum			naviculocuboid
		femur	low	20-10	cranium
		patella			atlas
high	55-30	mandible (with tongue)			axis
		hyoid			carpals
		cervical vertebra (no C1/2)			metacarpals
		thoracic vertebra			tarsals
		lumbar vertebra			metatarsals
		vertebra (gen)			caudal vertebra
		scapula	very low	<10	1 phalanx
		humerus			2 phalanx
		tibia			3 phalanx
		fibula			sesamoids
					horn core
					antler

Table 8.2: Utility categories for horse (derived from Outram and Rowley-Conwy 1998)

Utility Class	SFUI	Element	Utility Class	SFUI	Element
very high	100-45	cervical vertebra (C3-7)	medium	10-7	radius
		thoracic vertebra			ulna
		rib			astragalus
		costal cartilage			calcaneus
		sternebra			tarsals
		pelvis	low/very low	<5	carpals
		sacrum			metacarpals
		femur			metatarsals
		patella			1 phalanx
high	25-15	cranium			2 phalanx
		lumbar vertebrae			3 phalanx
		scapula			sesamoids
		humerus			
		tibia			
		fibula			

Mortality Profiles

Age and sex determination are necessary to create mortality profiles that are used to evaluate herding strategies, as outlined in the previous chapter (Dahl and Hjort 1976; Deniz and Payne 1982; Greenfield 1988; Kunst 2000; Marom and Bar-Oz 2009; Payne 1973; Redding 1981, 1991, 1992; Russell 2004; Vigne and Helmer 2007; Zeder 1991). Age determination primarily uses a combination of element size, epiphyseal fusion, and dental eruption/wear stages. Size measures are used for very young animals, particularly fetal and neonatal individuals maturation rates presented in the literature for individual species (Bull and Payne 1982; Bullock and Rackham 1982; Grigson 1982a; Schmid 1972; Silver 1969; Wilson, et al. 1982). Dental eruption and wear stages for ovicaprids, pigs, and cattle follow Grant (1982), which are then translated into specific age ranges for each taxon (Albarella, et al. 2005; Albarella and Payne 2005; Andrews 1982; Bull and Payne 1982; Bullock and Rackham 1982; Deniz and Payne 1982; Grant 1982; Greenfield and Arnold 2008; Grigson 1982a; Hamilton 1982; Jones 2006; Levitan 1982; Payne 1973; Zeder 2006). Armitage (1982) provides methods for aging cattle by horn cores. Horse dental aging uses Levine (1982) and Cirelli (2008). Red and roe deer aging follows methods presented by Klein *et al.* (1981) and Carter (2006). Magnell (2006) is used for wild boar.

Sex determination is done principally through size measurements, canine tooth presence/form, and pelvic morphology (Bartosiewicz 1987; Bull and Payne 1982; Greenfield 2006; Grigson 1982a; Rogers 1999; Sisson, et al. 1975; Thomas 1988; Wilson, et al. 1982). Cattle horn cores (Armitage 1982; Armitage and Clutton-Brock 1976; Grigson 1982b) can also be used and a number of ovicaprid bones have unique sexual morphology (Prummel and Frisch 1986; Ruscillo 2003). Various carnivores can be sexed through the presence of baculi, and dog humeri (Ruscillo 2003, 2006) also can be assigned to sex. Antlers are only found on male red and roe deer.

Taphonomy

Understanding the taphonomy, including both pre- and post-depositional factors, is essential for properly interpreting the composition of faunal assemblages. This study includes assessment of the degree of bone loss/fragmentation due to density-mediated attrition and animal consumption, as well as butchery, cooking, and disposal practices. Any significant differences in taphonomic patterns between periods and contexts were assessed prior to any comparative analyses. Taphonomy has received a great deal of attention in zooarchaeological literature, primarily with respect to Paleolithic assemblages. This is particularly the case for density-mediated attrition and carnivore destruction (Beaver 2004; Brain 1981; Bunn, et al. 1988; Hedges 2002; Lam, et al. 1998; Lam, et al. 2003; Lyman 1984, 1993, 1994, 2002; Marean 1991; Marean and Spencer 1991; Robinson, et al. 2003; Rogers 2000b; Stiner 2002; Symmons 2004).

In this study, bone fragmentation rates and bone modification are documented. Fragmentation rates are calculated by individual lot and by larger aggregate contexts through the average weight of bone fragments (NISP/lot weight). Bone-surface modifications, including butchery marks, animal gnawing/digestion, burning, and weathering, are recorded with descriptions of their form, degree, and location (Blumenschine, et al. 1996; Fisher Jr. 1995; Marean 1991; Munson and Garniewicz 2003).

Pathology

Any traces of pathology or trauma will be recorded when encountered. Common osteological problems will be described following veterinary literature (Jubb, et al. 1985). Certain pathologies have particular importance, particularly those resulting from traction.

Osteoarthritis occurrences increase significantly in livestock when used for pulling ards, plows, and especially heavy-wheeled vehicles. These degenerative changes will be documented following methods outlined by Bartosiewicz *et al.* (1997) and Miller (2003). The use of horse bits also leaves diagnostic traces on their teeth and will be described using the systems presented by Anthony and Brown (1989), Bendrey (2007), and Rogers and Rogers (1988).

Standardized Measurements

Bone measurements are important for distinguishing between closely related species (see above), aging fetal/juvenile remains (see above), sexing (see above), and identifying breeds (Bartosiewicz 2006; Bökönyi 1988; Lyublyanovics 2006). Standardized osteological and dental measurements follow von den Driesch (von den Driesch 1976), with supplemental measurements taken from the aforementioned references as needed.

CERAMIC ANALYSIS

Detailed analyses of Maros ceramics have been conducted previously by Fischl (1997, 1998), Michelaki (1999, 2008), and O'Shea (1996; 2012), and current analysis of Pecica's on-tell ceramics is being undertaken by O'Shea and Howey. Fischl's work is largely descriptive, focusing on space-time systematics. Michelaki examines manufacturing techniques and organization of production. O'Shea examines formal and functional differences in ceramics that, in addition to identifying chronological and spatial variability, relate to status and display. This study will follow the methodology of O'Shea for two reasons. First, it is important to employ a consistent coding system to ensure the comparability of ceramics within and between Maros sites. O'Shea's system is used for the on-tell Pecica material and Maros mortuary sites, and is compatible with Michelaki's work at Klárafalva and Kiszombor. Second, by highlighting key differences in pottery related to socioeconomic factors, O'Shea's methods allow for closer examination of practices differentiating various segments of Maros society.

In-depth examination of manufacturing techniques and stylistic attributes are beyond the scope of this current study. It will be noted here, however, that in Maros pottery grog is used exclusively for temper, primarily from burnished fine ware ceramics. Size and sorting methods for the grog vary by vessel element, site, and time period. A variety of vessel construction methods are used, which are largely size dependent. Smaller vessels are made through pinching techniques while larger vessels tend to use coiling and/or slab-building (Michelaki 2008).

Ceramic analysis was completed in the field. Ceramics were collected from all contexts using general artifact collection and sampling procedures (see Chapter 6). Materials from hand-collected lots and flotation samples were sorted by material type, with a subdivision into diagnostic and non-diagnostic ceramics. Rims, handles, bases, and decorated body sherds are considered diagnostic. Both diagnostic and non-diagnostic sherds were counted and weighed. Only diagnostic materials were used for more detailed analysis. These were all photographed and ceramics from Bronze Age contexts were coded. A sample attribute list and coding form is provided in Appendices 8.2 and 8.3. Screen materials were not analyzed for this study, but are available for future work.

In my study, primary data from the analysis of the off-tell settlement ceramics at Pecica is presented. These data include variables describing vessel ware, form, and size, which together highlight important assemblage characteristics such as the proportion of fine versus coarse ware, frequency of imported ceramics, and prevalence of cooking, serving vessels, and storage vessels. Assemblage composition will be compared against contemporary material recovered from the on-tell occupation. The nature and degree of assemblage distinctions, if present, will be used to assess differences in the socioeconomic organization between these social segments. In addition to social distinctions, certain ceramics can be used to document specific activity areas. Craft production can be identified by the presence of spindle whorls, looms, and crucibles. Strainers are tied to making cheese or fermented drinks, although residue analysis would have to differentiate between the two. Lastly, cart models, figurines, and similar items indicate ritual areas or deposits.

Ware

One of the major distinctions within Maros ceramics is ware. Following O'Shea's methods, variables describing ware include: internal/external color and surface treatment, handle form and treatment, and decoration. Together, these can be used to separate coarse and fine wares. Fine wares come in a variety of colors but typically are very dark, are burnished or polished, have more ornate handles, including the high arched or kantharos styles of loop handles, and are frequently decorated. Coarse wares are generally lighter in color, ranging from orange to tan to brown. The surface treatment is often plain, but vessels may have smoothing, coarse burnishing, or rustication.[69] Handles are simpler and typically are thick loops, tabs, lugs, or variations thereof. Decoration, which is usually absent, is usually limited to pinched fillets. A complete list of ware attributes, including decorative motifs, is presented in Appendix 8.2.

Vessel Form

Along with ware, shape is a primary indicator of vessel function. Variables related to form include: lip shape, rim orientation, base cross-section, and base profile. Because Maros vessels have standardized forms, these attributes, when combined with size and ware, often can be used to distinguish cups, jars, pitchers/jugs, bowls, cooking pots, and storage vessels. One of the most important characters for formal identification is rim orientation: one class of Maros bowls has inverted rims, cooking pots and large storage vessels have straight rims, and the remainder has everted rims. The other traits describe vessel shape in more detail and also can be used to identify chronological changes and the range of formal variability.

Vessel Size

Size is important for two reasons. First, it is used to separate vessel types that have the same general shape but have different modal sizes. Size is particularly important for distinguishing between jars (smaller) and pitchers/jugs (larger). Miniatures are another obvious example. Second, vessel size can also be useful for identifying socioeconomic differences. Households with more resources are expected to have relatively larger storage vessels. Higher status groups are also associated with wealth display through feasting. Larger displays would require larger cooking and serving vessels. Variables measuring size include: rim thickness, lip thickness, rim diameter, handle width, and base diameter.

Specialty Classes

Other ceramic objects can be readily identified through their unique shapes that are not coded in the same manner as vessels. These include strainers (which have holes), braziers (large portable ovens), and “fish plates” (low, flat-bottomed oval vessels, likely related to metallurgy).

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[69] Note that rustication is generally limited to Early Bronze Age vessels and is a horizon marker throughout the study region.

There is also a series of flat, circular forms that must be fairly complete to separate, particularly their central portions. These are lids (often decorated and having small peripheral holes for lashing), model cart wheels (raised around central hole, sometimes spoked, burnished), and spindle whorls (flat around central hole, often coarse ware), although the latter also come in ovoid forms.

OTHER ANALYSES

Plant Remains

Plant husbandry is the second component used in understanding strategies for local agro-pastoral production. Botanical materials were primarily obtained from light fraction flotation samples, but special or large deposits were collected independently as special samples. Seeds and other herbaceous plant elements, such as glume bases and spikelet forks, are currently being identified by Dr. Laura Motta (Museum of Anthropology, University of Michigan) and her team of student researchers. This includes taxon and element identification. Wood charcoal is being analyzed by J. A. Scott (University of Michigan). The composition of plant remains from these studies is used to create the abundance, diversity, and density measures used to test expectations presented in Chapter 7.

Craft Production

The local manufacture of crafts is an important component of both the domestic economy and the production of prestige goods for long-distance exchange. Identification of crafting areas entails qualitative and quantitative assessment, including the range, relative density, and spatial distribution manufacturing material, as outlined in detail in the previous chapter. The type of crafts made in a particular context is documented through the nature of raw materials, tools, facilities, and by-products present (Table 8.2). The intensity of production is assessed by the density of these items per unit volume, which is a standardized measure that can be compared within and between sites. Similarly, the diversity of crafts produced is calculated by the number of craft types represented per unit sediment volume. Spatial analysis of crafting areas within sites will identify the context of production. At Pecica, this is established through precise 3-D Total Station mapping of individual artifacts as well as densities of items per grid unit or discrete feature. Distribution maps are created using ArcGIS 10. Standardization of production is assessed only in artifacts types with large sample sizes (n>50). Specific methods are described below for each artifact class. Given the high level of detail required to evaluate the organization of craft production, this study focuses on Pecica, with limited comparisons with Tarhos, Klárafalva, and Kiszombor.

Table 8.3: Materials and facilities associated with specific crafts

Craft	Raw Materials	Tools*	By-Products*	Facilities*
Potting	clay, pots (grog), wood	mortar/pestile (stone, antler), scrapers (shell, stone, bone), burnishers (pebbles, bone/antler, sherds), decoration tools (bone/antler, chipped stone), wasters	wasters	ovens, kilns, firing pits, open fires
Bone working	bone, antler, teeth	soaking containers (ceramic), cutting and engraving tools (chipped stone, metal), polishers (abrasives)	bone/antler debitage	
Weaving	fiber (linen, wool, bast, reeds), dye	shuttles (bone/antler), needles (bone/antler, metal), loom wieghts (ceramic), spindle whorls (ceramic)		loom (loom wights, post molds)
Hide working	animal skins, tanning agents, dye	skinning/cutting tools (chipped stone, metal), scraping tools (bone/antler, stone), tanning containers (ceramic), perferators/sewing implements (bone/antler, metal)	animal bone	drying/stretching racks (post molds)
Woodworking	wood	axes/adzes (antler, stone, metal), wedges (antler), carving/engraving tools (chipped stone, metal), smoothing tools (sandstone, other abrasives)		
Stoneworking	stone	knapping tools (hammerstone, antler), grinding tools (sandstone, other abrasives)	stone debitage	
Metalurgy	ore, recycled metal, flux, wood	molds (stone, ceramic), crucibles (ceramic, stone), tuyeres (ceramic), hammers (antler, stone), tongs (metal), anvils (stone, metal), polishers (abrasives), engravers (chipped stone, metal)	slag	kilns, furnaces

*exludes organic items that would not preserve

Worked bone, antler, horn, teeth, and shell

Some of the most common crafted items, aside from pottery, are worked bone, antler, teeth, horn, and shell (all considered here as "worked bone"). Worked bone includes utilitarian tools like scrapers, burnishers, needles, and hammers that are used in a variety of domestic activities and in the production of other crafts. There is also a range of finely crafted bone objects like beads, hilts, decorated containers, and horse gear. Terminology for both finished tools and manufacturing debris largely follows the typology established by Choyke for the Carpathian Basin Bronze Age to maintain inter-site comparability (Choyke 1982, 1983, 1984a, b, 1987, 1997, 1999, 2000, 2001; Choyke and Schibler 2007). Variables documented include: element, portion, and taxon of raw material, form of the tool's working and butt ends, hafting form, manufacturing marks, use wear, and tool-specific measurements. These data allow the assessment of production stages as well as the formal types of items being crafted. The distribution of debitage is compared against tools that are likely used in their manufacture, including chipped stone and metal cutting and drilling implements and abraders. Standardization of production is difficult to assess in the worked bone assemblage given the wide range of types and generally small number of artifacts within each class. Where possible, standardization is evaluated using variability in the raw material types (species, element, and portion). Formal characteristics of the artifacts, both qualitative and quantitative, are also used, such as form and size

Stone working

Stone working, including chipped stone and ground stone technologies, has been the focus of a large number of studies within the Carpathian Region. Although most of the work has focused on the Paleolithic through Neolithic periods (Bácskay and Biró 2003; Biró 1993, 1998, 2002; Biró 2003a, b; Crandell 2008; Šarić 2002), there are some notable publications for the Bronze Age as well (Biró 2000, forthcoming; Horváth 2005; Horváth, et al. 2000; Pető, et al. 2002). Sourcing of the obsidian found on-tell was completed by Rosiana and Baker (2009). Additional lithic sourcing is being undertaken by K. Biró (Hungarian National Museum) and formal analysis by L. Draşovean (Berlin). Preliminary documentation of raw material, form, and measurements was done by the author and K. Gillikan (UM undergraduate volunteer). Raw material type can be evaluated with varying degrees of precision. Obsidian is readily identifiable. Non-obsidian materials, primarily chert and related stones, are more difficult to distinguish in the absence of a comparative collection. Basic types can be sorted by color (recorded as Munsell values), luster, inclusions, and cortex. These characters are compared against databases (Biró 2009, 2011; Crandell 2009) and descriptive literature (Biró 2002; Crandell 2008) to identify sourcing, where possible. Standard lithic measurements from Andrefsky (1998) are used where applicable. For special forms, such as the denticulates, length (working edge and base), width (each side), thickness, and weight are recorded. The degree of production standardization is described using basic statistical measures of variance and central tendency in these values.

Stone working areas are identified through debitage and tools. For chipped stone, debitage morphology is used to assess production stages present on site, a well understood process (Andrefsky 1998; Odell 2000, 2001). An important consideration of this analysis includes the degree of primary versus secondary or retouching debitage. Since stone is largely imported, the relative proportions of these classes, as well as the proportion of formal versus expedient tools (utilized flakes), can help to determine in what form the materials were obtained, for example, as raw nodules, cores, pre-forms, or finished items (e.g., blades, sickles, saws/denticulates, borers, points). These classes can also be used to assess the degree of conservation, curation, and remodeling, which tend to be high when raw material supply is limited. Tools used for chipped stone manufacture are also documented, including hammerstones, antler billets, antler pressure-flakers, and abraders.

Identification of groundstone production is a more difficult task as it does not produce the same type of debitage as chipped stone manufacture. However, unfinished broken fragments may be found in working areas, along with grinding tools like pestles, sandstone abraders/polishers, and other abrasives. Groundstone objects include querns, axes, whetstones, metallurgical molds, and ornamental objects like beads and pendants.

Ceramics production

In addition to formal analysis of the Pecica ceramics (see above), identification of ceramic production areas is also considered. Pottery manufacture entails four primary steps: raw material collection, forming, finishing, and firing (Michelaki 2008). Focus will be placed here on the latter two, as these are more likely to leave archaeological traces within or close to the settlement. Note that for Maros ceramics, a range of specific non-perishable items used in ceramic manufacture has been found in "potter's graves," including modified mussel shells, burnishing stones, and worked bone scrapers (Michelaki 2008; O'Shea 1996).

Raw material collection could be identified through borrow pits in clay producing areas, be these are likely to be located away from the settlement and not represented in our excavation areas. Mortars and pestles were used for crushing pottery in grog production, but these items have a wide variety of uses. Most stages of the forming process will not necessarily leave any traces other than on the pots themselves. However, shells of freshwater mussels (*Unio spp*.) and perhaps other bone tools are thought to be used for scrapping excess clay during vessel shaping.

The finishing stage employs a variety of tools used in surface treatments, including smoothing, burnishing, brushing/rustication, channeling, and incising (Michelaki 1999, 2008; O'Shea 1996). Smoothing tools are generally soft (including hands) and are unlikely to preserve. Burnishing tools include river pebbles, wide-tipped bone/antler tools, and even smoothed sherds. Plant materials, like twigs or straw, have been suggested for brushing tools, but it is possible that catfish (*Siluris glanis*) or carp (Cyprinidae) spines, which are denticulated, may have been used as well. Engraving and channeling are some of the most common decorative styles used on Maros ceramics. Channeling is likely done with a wide-tipped bone or antler implement. Engraving can use a variety of sharp, narrow-tipped items, including sticks, fish spines, bone awls, stone, or even metal tools.

The firing stage for Maros ceramics demands well-controlled temperatures, in this case less than 800 C, to maintain the glossy finish burnishing produces. The dark color also favored in these fine wares is created through smudging, which requires smoke-producing materials, like green branches or manure, to be added to a low-temperature fire at the proper time. While little is known about firing facilities, based on thermal color variation and cracking patterns, it appears that Maros pots were fired in pits or open fires rather than formal ovens or kilns (Michelaki 2008). This was probably done away from central habitation areas to avoid settlement conflagration. If this pattern is maintained at Pecica, we will not be able to identify firing areas in the current excavations, but future off-tell magnetometry work may be able to shed light on the issue. However, possible firing pits (those with burned edges, abundant charcoal) and kilns (larger ovens with evidence of high temperatures, but not exceeding 800 C) will be investigated.

Hide working

Fur and leather products themselves are rare, but the tools used in their manufacture are widespread. These include the myriad forms of bone/antler scrapers, beamers, and perforators found at Bronze Age settlements, with the most common forms made from cattle/large mammal ribs and ovicaprid tibiae and ulnae (Choyke and Schibler 2007). Stone scrapers are rare. Attention will also be paid to the distribution of bones of carnivores and other small fur-bearing mammals, as their presence on sites is directly related to pelt production. Traces of skinning cut marks on skeletal material will be documented. Stone and metal tools (or fragments thereof) associated with primary butchery and skinning may also be present. Processing requires soaking the pelts in a tanning agent and containers may be present if ceramics are used. Drying/stretching racks can only be observed as post molds.

Weaving

Prehistoric textiles have been preserved at waterlogged sites throughout Europe (Choyke and Schibler 2007; Kristiansen and Larsson 2005). From these finds, it is known that linen and wool were commonly used for Bronze Age fabrics, along with other plant fibers and reeds. Direct evidence of textiles is rare at archaeological sites in the Carpathian Basin, but indirect evidence of the materials used is found through the presence of flax seeds (and perhaps dye species) and wool-production mortality profiles of sheep (Gyulai 2010; Vretemark and Sten 2005). While fabrics themselves are rare, tools associated with weaving are more common. These include ceramic loom weights and spindle whorls and bone/antler shuttles and needles. The looms themselves are created from wood and do not preserve, but small post holes associated with them have been found elsewhere in the Basin. The spatial distribution of these items will be documented to identify areas of textile production.

Woodworking

Woodworking must have played an important role in Bronze Age societies, from shaping large timbers for house construction to creating finely carved objects. Little work has been done on the subject unfortunately, no doubt related to the general rarity of preserved wood in the Carpathian Region. However, architectural wood, including beams, posts, wattle, and planking, have been recovered from a number of Bronze Age sites, including Pecica, where burning or anaerobic conditions have preserved them (Csányi and Tárnoki 2003; O'Shea, et al. 2012). Charcoal from off-tell contexts is being analyzed by J. A. Scott (UM). While debris from woodworking is unlikely to be present, various tools may be present, such as axes, adzes, wedges, engravers, and abraders.

Metallurgy

In theory, metal working should be one of the most identifiable crafts given the multitude of raw materials and tools needed in its production, the abundance and durability of by-products, and highly visible smelting facilities. However, only a few *formal* metal workshops have been found in the Carpathian Region to date, including one at the Middle Bronze Age Vatya settlement of Lovasberény-Mihályvár (Kovács 1977). Due to the danger of the fire and toxic fumes, larger-scale metal working was likely done away from the primary settlement, as is seen at Lovasberény, and therefore rarely encountered in excavations that target the central portions of the settlement. However, these facilities can be found using various remote sensing techniques.

On-site metallurgical production areas can be identified through the presence of raw material fragments, specialized tools and equipment, slags and other by-products, and smelting facilities. It is important to note that furnaces may be quite small, on the order of 30 cm in diameter, which is roughly the size of a household oven (Papalas 2008). This is why careful and systematic recovery strategies, including flotation, are required to identify small ore and slag remnants associated with metal production. At Pecica, these are being analyzed by C. Papalas to determine sourcing and smelting techniques, the preliminary results of which are used in this study. Other equipment and tools include tuyères (bellows nozzles), molds, cubicles, tongs, hammers, anvils, and whetstones. It should also be kept in mind that while the actual furnaces may be located on the site periphery, materials (including ores and specialized equipment) used in manufacturing high-quality metalwork may be kept within households controlling production. Associations of these items within particular residences or settlement sectors will be noted.

Long-Distance Exchange

The spatial distribution of imported items, both of raw materials and finished products, is important for understanding the organization of long-distance trade networks as manifested within specific settlements. Quantifying the relative abundance and distribution of import goods is a challenging task given their relative rarity at settlements and the lack of systematic recovery strategies at most sites in the region. While there have been voluminous works on Bronze Age long-distance trade networks (Clark 1952; Frank 1993; Kristiansen 1987, 1991; Kristiansen and Larsson 2005; O'Shea 2011; Pare 2000; Pearce 2004; Price 1993; Renfrew 1969; Shennan 1986, 1993; Sherratt 1993; Voutsaki 2001), most analyses rely on simple presence/absence measures. In most situations this is the only possibility. However, in other cases, where comparable modern excavation techniques were used, including screening, flotation, volumetric measurements, and three-dimensional mapping techniques, a more standardized assessment of the frequency and spatial distribution of foreign goods is possible. The relative abundance and range of imported materials are calculated by density (number of items or types/kL), which can be compared between some settlements in this study. Basic diversity measures can also be compared (# types/kL). Spatial distribution of import items follows the same methodology as for craft production, but given their low density, greater emphasis is placed on piece-plotted data. At other settlements, published maps and context descriptions are used. This analysis requires substantial areal excavations and volumetric recording, so it is confined to intra-site examination of Pecica and inter-site comparisons with Klárafalva and Tarhos.

Raw Materials

As discussed above, the two major classes of imported raw materials are stone for chipped and groundstone manufacture and ores for metal production. The sourcing of stone resources is being conducted by Biró and the metals (via ores and slags) by Papalas. Salt was likely to have been an important import material, but one that lacks known archaeological traces at consumer sites. Timber also may have been brought down from the highlands along the Maros, along with various mineral resources. Great quantities of wood would have been required for extensive metallurgical production, and trees may have been of limited availability once local gallery forests and steppe-oak stands were exhausted. Imported charcoal or timber can be identified archaeologically through the presence of species that inhabit highland regions, particularly aspen, birch, and the conifers. Again, the off-tell wood charcoal sample is being analyzed by J. Scott.

Currently, it is not known to what degree materials like amber and sea shells were being worked locally or imported as finished goods. Evidence for on-site manufacture will be examined, including any debitage and unworked pieces. Amber can be chemically sourced through various non-destructive mass spectrometry methods (Heck 1999; Teodor, et al. 2010) and may be sent for analysis. This is important for establishing whether only Baltic amber was being imported or if Romanian sources were exploited in the Early and Middle Bronze Age, as they were in later periods. Sea shells, such as *Spondylus, Glycymeris, Dentalium, Cardium*, and *Columbella,* were also used for decorative purposes in the Bronze Age, despite a great decrease in their importance from the preceding Neolithic (Veropoulidou 2011). Some shells can be specifically sourced through taxon identification, most of which are from the Aegean or Adriatic (Hladilova 2011). However, others are found in multiple regions (e.g., both the Mediterranean and Black Seas), as well as in fossiliferous deposits, and sources may be difficult to distinguish without isotopic analysis (Dimitrijević 2010; Hladilova 2011; Siklósi and Csengeri 2011). Shells will be identified as specifically as possible to taxon and source using European shell guides

(Costello, et al. 2001; Poppe and Goto 1991). If necessary, strontium isotope analysis can be completed in the future.

Finished Goods

Finished goods are largely treated in the same manner as raw materials; their diversity, abundance, and intra-site spatial distributions are documented and sourcing will be done where possible. Note that chemical sourcing of finished metal items is problematic as metals from multiple ore sources may be used, as well as recycled metal objects. However, stylistic attributes can be used to identify source regions. This also applies to other artifact classes, including fine ware ceramics, beads, etc.

Statistics

The majority of data used in this study are nominal. Chi-square statistics are used for quantitative comparisons of nominal data between samples from different settlements, occupation periods, and, for Pecica, settlement areas. Chi-square tables are presented within each chapter's respective appendices. I use $\alpha=0.05$. For ratio data, basic measures of central tendency are provided, including mean, median, and standard deviation.

CHAPTER 9: THE ANIMAL ECONOMY AT PECICA ŞANŢUL MARE

This chapter provides a comprehensive analysis of the faunal remains at Pecica Şanţul Mare. A primary goal is to identify diachronic changes in animal production systems reflecting the development (and potential collapse) of a centralized political economy (see Chapters 3 and 7). In order to address this issue, a multifaceted approach must be used in the analysis of Pecica's faunal assemblage. This includes an evaluation of taphonomy, taxon representation, livestock mortality profiles, and body part representation for the three major occupation phases (Chapter 6). Specific methods used for these analyses are presented in Chapter 8.

This chapter is divided into four parts. The first is a brief summary of Pecica's faunal assemblage as a whole, including collection and sampling strategies. Next, descriptions of the animal economies for each of the major occupation phases are presented, including the Early, Florescent, and Late Periods. The third section takes a diachronic perspective, highlighting important changes between these periods. Lastly, synchronic variability is examined, comparing animal production and consumption between inhabitants of the central tell versus the peripheral occupation. The resulting data are used to assess the models of economic centralization within the agro-pastoral sector, presented in the summary discussion of Pecica's political economy in Chapter 12.

THE ASSEMBLAGE

The faunal assemblage at Pecica Şanţul Mare is one of the largest systematically collected and analyzed samples in the Carpathian Basin Bronze Age. Over 17,000 specimens have been examined to date by the author. This study represents the first comprehensive evaluation of animal economies within the Middle Maros culture and the first to explicitly examine both diachronic and synchronic variability in Bronze Age animal production systems in the region.

Animal remains were collected in the course of excavations, following the standardized procedures outlined in Chapter 6. The majority of the examined fauna comes from hand-collected materials. A stratified random sample[70] of screen and flotation samples was analyzed previously to assess the degree of collection bias in the hand excavated assemblage. A particular concern was that hand collection was missing a substantial amount of fish bone, as these were being found infrequently at Pecica but were known to be more common at contemporary settlements in the Lower Maros region (Nicodemus 2010). As expected, there was a considerable amount of animal remains in the screened and floated materials. However, these were overwhelmingly small fragments of mammal bone that are rarely identifiable to element or species. While there was proportionally more fish bone (primarily in the flotation samples),[71] these too were almost exclusively non-identifiable, being predominately very small spine and flat bone fragments. Because the various measures used in this study require precise taxon and element attribution, the exclusion of screened and flotation fauna does not significantly affect the results. Additionally, the use of only hand collected materials allows comparison with fauna from other settlements in the region as flotation and screened fauna are rarely (if ever) included in analyses.

The trench, block, and test unit excavations from 2005-2011 produced a vast collection of faunal remains, more than could be analyzed by a single researcher in a reasonable time frame. As a result, I developed a sampling strategy at the beginning of the project to reduce the overall amount of material to study while maintaining representivity. For the large 10 x 10 m excavation block, a 50% area sample was used, which includes all general fill layer lots from units within a checkerboard pattern of selected 2 x 2 m squares (Appendix 9.1). For features and structures, a random 50% sample of lots was selected from each internal layer. All Bronze Age lots were studied from trench and test unit contexts given their comparatively small volumes and faunal assemblages. Lots from contexts with significant disturbances or questionable phase

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[70] A random 10% sample of lots (using a random number generator) was chosen from each stratigraphic layer and feature class (e.g., pits, house floors, middens, hearths, etc.) to ensure examination of the full range of contexts.
[71] For the samples included in the comparative study (vertebrates only), fish are significantly more frequent in the >4mm flotation samples (6%, χ^2=97.7324, df=2, p<0.001) and <4mm flots (25% χ^2=938.5504, df=2, p<0.001) than in the hand collected samples (2%), but are predominantly non-identifiable to either genus/species or unique element. In addition, given the much greater number of bones per individual in fish versus mammals (especially spines, vertebrae, cranial bones), the large amount of small fish bone fragments in the flots is not likely to affect MNI counts. Other non-mammalian species are only statistically more frequent in the <4mm flotation sample, primarily due to the presence of small amphibian bones, which are likely modern as they all derive from the most shallow deposits. While the absolute differences are very small, the screen samples do have significantly more fish (3%) than their corresponding lots (1%), but fewer mollusks (10% vs. 13%, χ^2=17.5512, df=2, p<0.001). Note that only three additional taxa were identified from non-lot samples: toads (Anura spp.—flotations, likely intrusive), hedgehog (*Erinaceus concolor*—screen, likely intrusive), and dace (*Leuciscus* spp.—screen). A full treatment of the screen and flotationfauna is beyond the scope of this thesis.

attributions were omitted. The Iron Age material has been published elsewhere (Nicodemus 2012) and the Medieval fauna has not yet been examined in any detail.

A summary of analyzed contexts by phase is presented in Table 9.1. There are six major occupation layers, Phases 1-6+, which are grouped into three larger chronological units. The earliest occupation period examined is Phase 6+, found in deposits from the base of Trenches 1 and 2, dating to before 2000 BC (Early Period). The Florescent Period (c. 2000-1700 BC) is represented by Phases 3-5. This period shows dense habitation, intensive metallurgy, public architecture, and ritual deposits. The Late Period (c. 1700-1500 BC) contains Phases 1 and 2, which show lower occupation intensity and the eventual abandonment of the settlement. A more detailed review of site chronology and major features is presented in Chapter 6. A complete taxon inventory (NISP) by phase is presented in Table 9.2. Summary taxon and taphonomic measures for on-tell phases are found in Tables 9.3 and 9.4, respectively. Off-tell summaries are all provided within section three. Chi-square tables are located in Appendix 9.2 for taphonomy, 9.3-9.7 for taxon representation, 9.8 for demography, and 9.9-9.13 for body part representation. In text references to statistically significant differences reflect the results of these tests (α=0.05).

Table 9.1: Primary contexts by phase (on-tell)

Phase	Date	Context	Description	Phase	Date	Context	Description
1	post 1600	B1-1	fill	(3)		Platform	
		B1-2	fill	4	1850-1750	E (upper)	fill
		B1-3	fill			Str 3	structure
		Str 0 (upper)	structure			Str 4 (lower)	structure
		F35	floor (Str 0)			F160	pit (str 4)
		F16	pit			F159	post
		F40	pit/ditch			F163	architectural
2	1700-1600	C1/C1a	fill			F164	bone pile
		C2/C2a	fill			F165	post
		C3/C3a	fill			F167	bone pile
		Str 0 (lower)	structure			F168	bone pile
		F80	architectural (Str 0)			F169	bone pile
		F82	hearth (Str 0)			F170	bone pile
		Str 1 (upper)	structure			F171	bone pile
		F125	hearth (Str 1)			F172	midden
		F127	hearth (Str 1)			F176	bone pile
		F30	hearth	5	2000-1850	E (lower)	fill
		F54	pit			Str 5	structure
		F72	pit			Str 6	structure
		F73	architectural			Str 7	structure
3	1750-1700	C4	fill			Str 8	structure
		C5	fill			F180	bone pile
		Str 1 (lower)	structure			F181	bone pile
		Str 2	structure			F182	bone pile
		F129	hearth (Str 2)				
		Str 4 (upper)	structure				
		F153	hearth (Str 4)				
		F161	hearth (Str 4)				

Table 9.2: NISP fauna by phase/context

		Early Period	Florescent Period								Late Period		Bronze Age
Taxon	**Common Name**	**6+**	**5**	**4/5**	**4**	**B***	**3/4**	**P****	**3**	**A***	**2**	**1**	**Total**
Ovicapridae	sheep/goat	369	79	46	210	10	15	174	139	17	506	142	**1707**
Ovis aries	sheep		5		19	1	2	9	13	4	16	11	**80**
Capra hircus	goat		2		2		2	4	6	1	6		**23**
Sus scrofa	pig	149	51	34	186	6	9	140	138	13	346	148	**1220**
Bos taurus	cattle	104	39	10	143	3	7	122	74	6	231	79	**818**
Equus caballus	horse	15	31	12	223	2	8	71	68	2	65	19	**516**
Canis familiaris	dog	6	3	1	15	1		7	4	1	27	22	**87**
Domesticates		**643**	**210**	**103**	**798**	**23**	**43**	**527**	**442**	**44**	**1197**	**421**	**4451**
Cervus elaphus	red deer	39	18	11	90	3	6	72	69	9	210	81	**608**
Capreolus capreolus	roe deer	6			4	7	1	8	2	4	41	6	**79**
Sus scrofa ferus	wild boar	8	1		5			3	5		10	3	**35**
Castor fiber	beaver		1		2						9	3	**15**
Bos primigenius	aurochs	1			1				5		7	1	**15**
Lepus europaeus	brown hare					1	1	1		1	2	3	**9**
Meles meles	badger				1						8		**9**
Vulpes vulpes	red fox							1			5	3	**9**
Canis lupus	wolf										3	1	**4**
Cervidae	deer (indet)	2	2										**4**
Carnivora (sm)	small carnivore				3				1				**4**
Mustelidae	mustelid (indet)					2							**2**
Mustela putorius	polecat										1		**1**
Wild Mammal		**56**	**22**	**11**	**106**	**13**	**8**	**85**	**82**	**14**	**296**	**101**	**794**
Muridae	mouse/rat										4		**4**
Rodentia	small rodent				2	1					2		**5**
Rodent					**2**	**1**					**6**		**9**
Homo sapiens*	human								**2**		**3**	**14**	**19**
Mammalia (lg)	large mammal	262	185	70	1017	21	52	857	480	19	1211	629	**4803**
Mammalia (med)	medium mammal	267	111	53	548	44	74	513	338	51	1399	612	**4010**
Mammalia (sm)	small mammal	3	1	1	19		1	9	4	1	19	2	**60**
Mammalia	mammal	7	6	8	102	2	80	208	61	14	202	55	**745**
Indeterminate Mammal		**539**	**303**	**132**	**1686**	**67**	**207**	**1587**	**883**	**85**	**2831**	**1298**	**9618**
Cyprinus carpio	common carp	6			10			1		2	32	17	**68**
Cyprinidae	carp (indet)		1		21	9	5		4	3	8	4	**55**
Siluris glanis	wels catfish	1			2					1	12	4	**20**
Esox lucius	northern pike										1	1	**2**
Pisces	fish (indet)	1			11	1			2	6	25	11	**57**
Fish		**8**	**1**		**44**	**10**	**5**	**1**	**6**	**12**	**78**	**37**	**202**
Aves (md)	medium bird	1	2		2			1			2		**8**
Aves (lg)	large bird				3	1		1			1		**6**
Bird		**1**	**2**		**5**	**1**		**2**			**3**		**14**
Emys orbicularis	European pond terrapin					1					7	1	9
Reptile						**1**					**7**	**1**	**9**
Unio spp.	river mussel		28	1	248	77	22	312	161	62	724	249	**1884**
Cepaea vindobonensis	Viennese banded snail				43	1		30	6	12	22	17	**131**
Helix pomatia	edible snail							3		2			**5**
Helicidae	helicid snail									2	36	8	**46**
Planorbidae	planorbid snail				1								**1**
Mollusk			**28**	**1**	**292**	**78**	**22**	**345**	**167**	**78**	**782**	**274**	**2067**
Grand Total		**1247**	**566**	**247**	**2933**	**194**	**285**	**2547**	**1582**	**233**	**5203**	**2146**	**17183**

*Off-tell deposits, A=Phase 3, B=Phase 4 ** Platform ***intrusive from Medieval period

Table 9.3: Summary taxon measures by phase, on-tell contexts (% NISP)

	Early Period†	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	On-Tell Total
Mammal*	**99.3**	94.5	89.7	87.5	89.4	**89.6**	84.2	86.4	**84.8**	**88.3**
Mollusk	**0.0**	4.9	8.6	12.4	10.2	**9.6**	14.1	11.8	**13.4**	**10.5**
Fish	**0.6**	0.2	1.5	0.0	0.4	**0.7**	1.5	1.8	**1.6**	**1.1**
Bird	**0.1**	0.4	0.2	0.1	0.0	**0.1**	0.1	0.0	**0.0**	**0.1**
Turtle	**0.0**	0.0	0.0	0.0	0.0	**0.0**	0.1	0.0	**0.1**	**0.0**
Domestic	**90.9**	79.8	67.1	56.9	64.2	**65.1**	52.5	52.8	**52.6**	**62.2**
Wild Fauna (incl. mollusks)	**9.1**	20.2	32.9	43.1	35.8	**34.9**	47.5	47.2	**47.4**	**37.8**
Domestic	**90.9**	89.4	84.7	85.7	83.7	**85.3**	76.9	76.7	**76.9**	**82.7**
Wild Mammal	**7.9**	9.4	11.3	13.8	15.5	**12.6**	19.0	18.4	**18.9**	**14.5**
Other Wild Vertebrates	**1.1**	1.3	4.0	0.5	0.8	**2.1**	4.0	4.9	**4.3**	**3.1**
Red Deer	**69.6**	81.8	84.9	84.7	84.1	**84.7**	70.9	80.2	**73.3**	**76.6**
Other Large Game	**30.4**	13.6	9.4	12.9	14.6	**11.8**	19.6	9.9	**17.1**	**16.8**
Other Small Game	**0.0**	4.5	5.7	2.4	1.2	**3.5**	9.5	9.9	**9.6**	**2.8**
Ovicaprid	**57.9**	41.5	29.5	36.0	36.1	**34.7**	45.1	38.3	**43.4**	**41.3**
Pig	**23.4**	24.6	23.8	26.9	31.5	**26.7**	29.6	37.1	**31.5**	**27.9**
Cattle	**16.3**	18.8	18.3	23.5	16.9	**18.9**	19.7	19.8	**19.8**	**18.8**
Horse	**2.4**	15.0	28.5	13.7	15.5	**19.7**	5.6	4.8	**5.4**	**11.9**
Large Mammal*	**35.0**	52.0	59.4	56.5	52.1	**55.5**	42.1	46.0	**43.2**	**48.5**
Medium Mammal	**64.8**	47.6	39.5	42.9	47.5	**43.8**	56.9	53.4	**55.8**	**50.8**
Small Mammal	**0.2**	0.4	1.0	0.6	0.4	**0.7**	1.1	0.6	**0.9**	**0.7**
High Value	**23.9**	34.5	39.4	29.1	32.3	**33.9**	23.3	23.7	**23.4**	**28.3**
Medium Value	**75.3**	54.3	37.0	36.7	43.7	**40.9**	42.6	41.3	**42.3**	**45.0**
Low Value	**0.9**	11.2	23.7	34.1	24.0	**25.2**	34.1	35.0	**34.3**	**26.7**

†Not collected systematically

*All measures except these use only specimens identifiable to genus or better

Table 9.4: Summary taphonomic measures by phase, on-tell contexts (% NISP)

	Early Period†	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	Total On Tell
Fragmentation (avg g/bone)		19.0	16.6	9.4	11.7	**12.9**	12.5		**12.5**	**12.7**
Fragmentation (avg g/shell)		4.8	4.2	3.4	4.8	**4.1**	5.8		**5.8**	**4.8**
Identifiable*	**56.5%**	45.6%	41.1%	37.6%	43.7%	**40.4%**	44.1%	38.4%	**42.4%**	**42.5%**
Intrusive Taxa**	**0.0%**	0.0%	1.6%	1.3%	0.5%	**1.1%**	1.3%	1.8%	**1.4%**	**1.2%**
Weathered	**1.0%**	1.9%	0.3%	0.0%	0.1%	**0.3%**	0.0%	0.3%	**0.1%**	**0.2%**
Animal Modification***	**4.8%**	12.4%	16.7%	3.9%	13.1%	**11.2%**	6.2%	1.9%	**4.9%**	**8.0%**
Burned	**1.0%**	3.7%	4.3%	29.1%	4.5%	**12.5%**	1.8%	0.6%	**1.4%**	**6.8%**
Calcined	**0.0%**	1.8%	3.2%	45.7%	0.9%	**15.8%**	0.6%	0.2%	**0.5%**	**7.9%**
Butchery Marks	**2.1%**	1.1%	0.6%	0.2%	0.9%	**0.6%**	0.3%	0.5%	**0.3%**	**0.6%**
Worked	**0.0%**	0.2%	0.4%	0.2%	0.6%	**0.4%**	0.4%	0.0%	**0.3%**	**0.3%**
Total Modified Bone	**8.8%**	**21.0%**	**25.6%**	**79.1%**	**20.1%**	**40.7%**	**9.3%**	**3.4%**	**7.6%**	**23.8%**

†Not collected systematically

*Identifiable to genus or better

**Intrusive taxa are burrowing rodents/invertebrates and Medival human remains

***Inlcudes carnvivore gnawing, rodent gnawing, and digested bone

EARLY PERIOD

The Early Period has not yet been examined in detail at Pecica Şanţul Mare. Deposits of this age were only encountered in the two stratigraphic test trenches dug in 2005 and various deep cores by S. Sherwood (2005-2007).[72] These contexts are not well dated by radiocarbon samples, but fall sometime before 2000 BC and contain diagnostic EBA rusticated wares. These deposits were not systematically excavated or collected, as they were part of exploratory work, and can only be used for a portion of the analyses. The sample includes 1247 specimens (Table 9.2).

Taphonomy

Because the Phase 6+ assemblage was largely collected unsystematically, several basic taphonomic measures are not possible to analyze and bone modification may not be representative (Table 9.4). The frequency of intrusive taxa, those introduced from later contexts from sediment disturbance, is also unreliable given the strong bias against small species and elements in this assemblage, which accounts for the absence of small rodents and invertebrates. No weights were taken of sample lots so bone/shell fragmentation is not calculated.

There is a relatively low level of bone modification present (9%). The most common alteration is animal gnawing, which is found on 5% of the specimens. Other modification is infrequent: cuts and other butchery marks 2%, burning 1%, and weathering 1%. None of the specimens were calcined nor were there any worked bones found within the general faunal collection. Interestingly, 40% of the horse bones were weathered.. These bones represent two individuals, all found in the same context (Trench 2 center, Level 5). Weathered bones from cattle and red deer were also found in this level. It is unclear what caused this extensive weathering, but it is likely that this area was exposed for a considerable period of time prior to burial. This differs from the rest of known tell contexts which appear to have been buried quickly under rapidly accumulating sediments. 57% of the bones were identified to genus or species.

[72] Additional deposits were systematically excavated in 2013, but these have not yet been analyzed.

Taxon Representation

Relative taxon abundance is greatly affected by the unsystematic recovery strategies used for the majority of Phase 6+ contexts, resulting in strong under-representation of small-bodied taxa, particularly non-mammalian species. As a result, mammals comprise the overwhelming majority of the faunal remains (99%) (Table 9.3). Fish and birds make up less than 1% of the sample and there were no turtles or mollusks recovered. Carp and wels catfish are present in the small fish collection. For mammalian fauna, domesticates are far more abundant than wild game (90% versus 10%). 70% of the wild mammal bones are from red deer; wild boar and roe deer are present in roughly equal numbers and there is a single aurochs bone. Smaller game is not present, again, likely reflecting collection bias. Ovicaprids are the most abundant livestock, comprising 58% of the sample. They are followed by pig (23%), cattle (16%), and horse (2%). Collection methods do not appear to have strongly affected representation of medium-sized and larger animals, as the vast majority of livestock are the smaller species (sheep/goat and pig). As a consequence, livestock composition may be used tentatively in diachronic comparisons.

Demography

Ovicaprids

There are 66 ageable but no sexable elements from sheep and goats in Phase 6+. Only 30 bones were able to be assessed for fusion status, nearly all of which are from elements that fuse before two years. About 85% of bones are fused within this age range. There is one individual aged around 10 months and another between 1.5-2 years, but the majority of elements belong to adults. There is no evidence of fetal or neonatal animals. There is a relatively large sample of ageable mandibular dentitions, with 36 specimens belonging to at least 23 individuals. The dental data largely mirror the bone fusion data (Figure 9.1), although there are somewhat more juveniles represented by teeth, which is expected given the differential destruction of young animal bones. According to the dentition, about 18% of the ovicaprids were slaughtered before one year of age. More than half were adult (>3 years) and a substantial number were between 4-6 years (or older). This suggests that secondary products were important in husbandry systems, part of a mixed meat-dairy-wool production strategy.

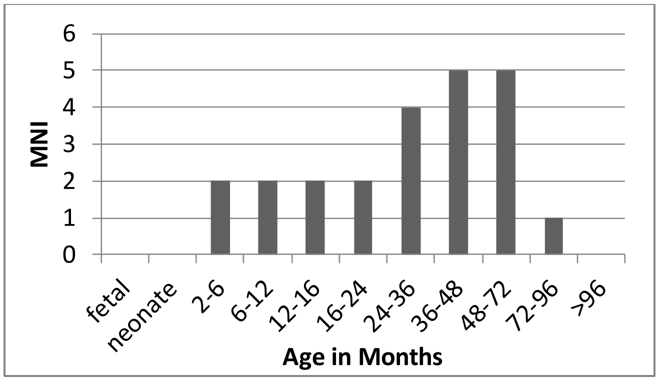
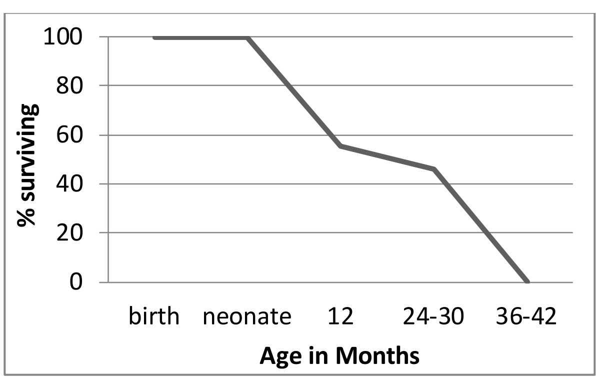


Figure 9.1: Ovicaprid dental age in months, Phase 6+ (MNI)

Pig

There are 48 ageable elements from pigs, about half of which are dentition. There is only one sexable specimen, a canine from juvenile male. While the bone fusion data are not abundant (only 26 specimens), a substantial portion of the bones are from very young individuals (Figure 9.2). 44% of elements are from animals less than one year old and none are from animals greater than 3-3.5 years. No fetal or neonatal pigs are represented. The dentition differs somewhat from the fusion data. There are a minimum of 13 individuals present. These show a relatively narrow age range, predominantly prime aged animals (85%), with only 15% younger than one year. No physically mature pigs are evident. The large discrepancy in the frequency of juveniles between the two datasets may be due to small sample sizes (see also below). Nonetheless, both show a lack of older animals, which is a typical culling pattern for pigs which mature early, have high fecundity rates, and lack secondary products. Interestingly, no individuals represent expected deaths within a local breeding population (no fetal/neonatal animals). However, the sample is limited and probably does not reflect the full range of demographic variability.



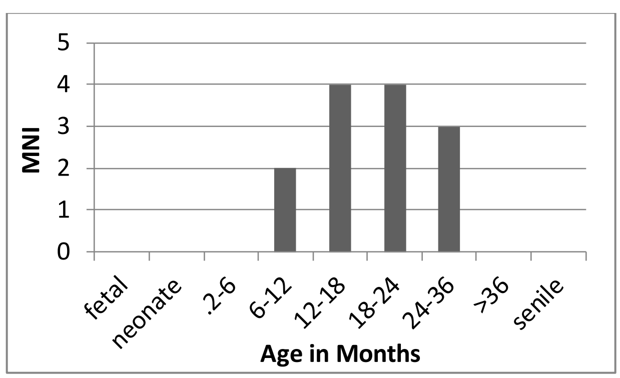


Figure 9.2: Pig age in months, Phases 6+. Left: epiphyseal fusion (NISP), right: dentition (MNI).

Cattle

There are 42 ageable cattle elements, allowing only a tentative demographic profile for this species. However, a few basic observations can be made. For bones (NISP=34), there are no unfused elements from animals less than two years old present (Figure 9.3). Bones that fuse after three years are rare in the sample (NISP=4), but both subadults and adults are present (50%). At least one animal was aged between 4-4.5 years, represented by a distal femur that was in the process of fusing. There is also a small, porous horn core from a young individual. The dental sample is small but agrees with the fusion data. There are eight elements representing a minimum of six individuals. Two animals are subadults (1.5-2 and 3-4 years old) and the rest are very old individuals (senile) (Figure 9.3). There is only a single element that could be sexed, a large first phalanx from a male that also has arthritic growths consistent with a traction pathology. While the dataset is not large, the available sample does suggest that both meat and secondary products, especially traction, were important since prime-aged subadults and older adults are the dominant (and only) age classes represented.

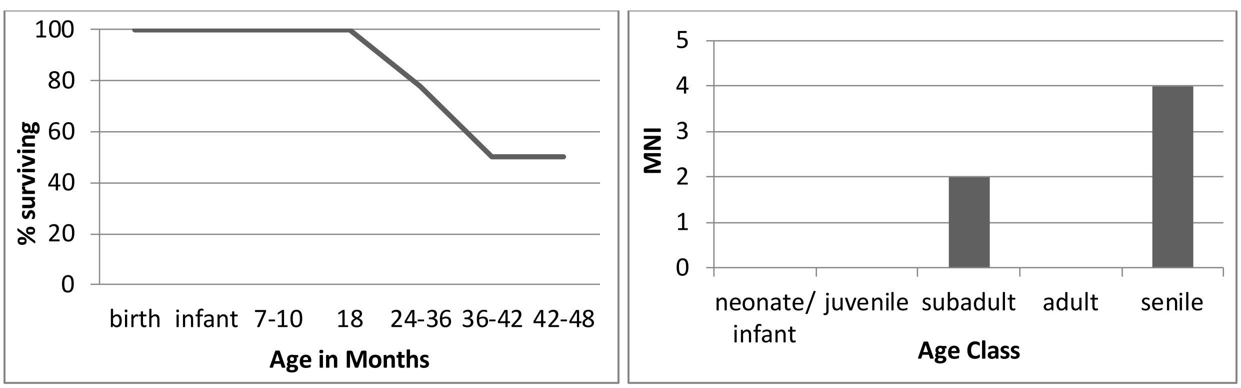


Figure 9.3: Cattle age, Phases 6+. Left: epiphyseal fusion in months (NISP), right: dental age classes (MNI).

Horse

Out of the 15 horse bones recovered from Phase 6+ deposits, 10 of them were ageable, none of which were teeth. There are also no sexable elements. This sample is far too small to reconstruct a demographic profile. However, all of the horse bones are fused, coming from adult animals.

Body Part Representation

Summary tables for body part representation by anatomical region and utility are presented in the third section of this chapter, the diachronic study (Tables 9.5-9). Statistical tests assessing differences in element representation between periods and taxa are listed in Appendix 9.9. For the combined mammal sample, the highest number of bone fragments is from meaty upper limbs (36%), followed closely by cranial elements (31%). Lower limb and axial bones comprise 15% and 14% of the assemblage, respectively. There are few foot bones (4%). The majority of bones are from high food value elements with few from very low utility parts.[73] This indicates that the primary butchery took place away from the central habitation area and meat-poor elements like feet were generally disposed of elsewhere.

For the individual livestock species, there are interesting similarities and differences in body part representation, which are related to differences in anatomy (e.g. number and range of individual elements), attrition rates (bone density), and identifiability of fragmented remains.[74] For most taxa, cranial elements are frequent, primarily due to the large number of teeth in the samples (Tables 9.6-9). This is an expected pattern given their high density/low attrition rates and the ease of their identification, even in a highly fragmented state. Axial elements are universally infrequent due to high fragmentation rates in these friable bones (e.g., vertebrae and especially ribs) and the difficulty of identifying them to specific taxon.

There are very different patterns seen in limb representation between species, in part dependent on body size. For the smaller livestock (ovicaprids and pigs), upper limb bones are most common, with substantially fewer lower limb fragments and very few foot bones (Tables 9.6 and 9.7). This is strongly influenced by the utility of these elements, with the meatiest parts being most common and the lower quality portions under-represented. Foot bones are particularly uncommon for two reasons: 1) they are very low utility and were likely disposed of with primary butchery debris and 2) because they are small and dense, they do not fragment greatly, reducing their relative NISP compared to long bones. In general, higher utility elements[75] are far more common than lower utility elements (72% for ovicaprids and 76% for pigs). This indicates that either animals were butchered outside the central habitation area with

[73] See Chapter 8 for further explanation of utility classes.
[74] For these reasons, statistical comparisons of body part representation are not done between taxa with the exception of general higher versus lower utility elements.
[75] "Higher utility" includes elements that fall within the "very high," "high," and "medium" utility classes. "Lower utility" includes "low" and "very low" elements. Teeth are excluded from the utility measures.

edible portions brought to households or that animals were butchered centrally with waste products disposed of elsewhere. The frequency of higher versus lower utility elements does not differ statistically between ovicaprids and pigs in the Early Period and they were likely butchered, cooked, consumed, and disposed of in a similar manner.

For cattle, the various limb portions are more equally represented, differing substantially from the general mammalian pattern (which includes all identifiable mammalian taxa and elements attributed only to mammal size class) and from smaller-bodied livestock (Table 9.8). This is influenced by taphonomic and analytical issues. Phalanges of larger animals tend to be more fragmented than those of smaller species and therefore have relatively higher NISP representation. Highly fragmented remains of large mammal long bones are also much more difficult to assign to specific taxon than in smaller-bodied animals, which lowers NISP for upper and lower limbs. Differences in anatomical representation affect the frequency of higher versus lower utility elements. Cattle have statistically fewer higher utility elements (54%) than do sheep/goats (72%) and pigs (76%).

The sample size for horse bones identifiable to specific element is too small for statistical comparison (NISP=19) and may not accurately represent the underlying population. The assemblage is dominated by upper limb bones and lacks any cranial or axial elements (Table 9.9). Most of the elements present derive from higher meat quality elements (87%) and the frequency of limb portions is directly related to their utility, following the general mammalian pattern. However, it should also be noted that horse utility indices (Outram and Rowley-Conwy 1998) differ substantially from those for artiodactyls (Binford 1978), with different numbers and types of elements within each utility class. As a result, horses are not directly comparable to the other livestock species.

Summary

In the Early Period (Phases 6+), livestock husbandry was the most important sector of the animal economy. Sheep and goat comprised the largest portion of the domesticates and their culling patterns indicate that secondary products were very important in addition to their meat. Pigs were also a significant meat source, followed by cattle, the latter of which were also used for their milk and labor. Few horses were present. Hunting, fishing, trapping, and shellfish collecting were practiced as well. Unfortunately, the relative contribution of small-bodied fauna cannot be assessed reliably given the unsystematic collection strategies which are biased against the collection of non-mammalian taxa. Primary butchery largely took place off site, with the more useful elements being cooked, consumed, and disposed of in the general habitation area. There is some suggestion that larger animals like cattle were utilized more thoroughly, with even lower utility elements being processed. However, taphonomic issues complicate the picture.

FLORESCENT PERIOD

The Florescent Period encompasses Phases 3 through 5. This also includes the central platform feature (layer D0/"Baxter") and the off-tell occupation areas, the latter of which are discussed in the final section on intra-site spatial variability. Basic features of the individual phases and the platform are presented where sample size allows. The Florescent Period on-tell assemblage totals 8160 specimens (Table 9.2). The Phase 5 sample is relatively small, with an NISP of 566. Major contexts within this phase include the lower levels of the E layer deposit, Structures 5-8, and several bone pile features. There are large collections from Phase 4 and the platform, numbering 2933 and 2547 specimens respectively. Phase 4 includes the upper E layer fill, Structures 3 and 4 (lower), a dense midden, and numerous bone pile features. While the platform was in use during Phase 3, it was constructed of sediments quarried from elsewhere on the site, dating from sometime within the later Florescent Period, based on the ceramic assemblage. Materials within it are considered separately since their exact chronological relationship to other deposits is not known. There are 1582 specimens from Phase 3, which include the lower C layer deposits (C4-5) and Structures 2 and 4 (upper). See Table 9.1 and Chapter 6 for the full list of contexts within each phase and associated radiocarbon dates.

Taphonomy

In the Florescent Period, 40% of the specimens could be identified to genus or better (Table 9.4), with little variability between phases (Appendix 9.2). Overall, less than 2% of the fauna belongs to species that are likely to be intrusive (e.g., burrowing rodents and invertebrates). This low number reflects the greater depth of these deposits below the modern ground surface than in subsequent phases and the lack of historic and modern disturbances. Fragmentation rates vary considerably between phases and contexts. The highest on-tell fragmentation rate is found in materials from the platform, with the average bone specimen weighing 9.4 g versus the 12.9 g for the Florescent Period as a whole. This is due to the intense burning of these sediments, which caused the majority of bones to be calcined and highly friable. High fragmentation rates are also found within the structures due to a combination of trampling and floor cleaning, which removes most large debris from within houses.

Bone modification is frequent in the Florescent Period assemblage (41%), but this value varies greatly between contexts due largely to the extreme burning in the platform. In the platform, 29% of the specimens are burned and another 46% are calcined, often to the point of reaching a blue/green color. In sharp contrast, burning in other contexts varies between 3.7%-4.5% and only 0.9%-3.2% are calcined. The highest rates are in Phase 4, particularly for calcination. Some of these burned bones may have been introduced from the overlying platform via bioturbation. However, the E layer fill also contains very large amounts of charcoal, so Phase 4 may be characterized by more burning activities, perhaps associated with smelting.

Animal modification (predominantly carnivore gnawing, but also rodent gnawing and digestion), generally occurs at high rates in the Florescent Period as well (11%). This also varies by context. Gnawing (along with other types of modification) is uncommon in the platform materials, where they have been largely obscured by intense burning. For this reason, the platform is excluded from statistical analyses. Phase 4 has the most animal gnawed specimens, which may be related to the comparatively larger dog population at this time. Other types of modification, including weathering, butchery marks, and working are present in very low frequencies (all less than 2%). Despite the very small absolute differences, Phase 5 has more weathered bone, nearly all of which derives from bone pile features (F180 and F181). In these, portions of the vertically oriented bones were projecting above ground, causing partial weathering.

Taxon Representation

The Florescent Period assemblage is dominated by mammals (88%), although there are significant numbers of mollusks (11%), primarily freshwater bivalves (Tables 9.2 and 9.3). Fish, birds, and turtles are rare (<1%). The fish are primarily members of the carp family, but wels catfish is also present. Wild fauna makes up a considerable portion of the assemblage that could be identified to genus or better, 38% when including mollusks. 13% of the mammals are wild. Red deer is by far the most common hunted animal (82%), but there is a wide range of other game present, ranging from aurochs to hare. Ovicaprids are the most abundant livestock species (35%), followed by pigs (27%), cattle (19%), and horse (19%).

There are striking similarities and differences within the Florescent Period fauna (Figure 9.4, Appendix 9.3). In all phases, mammals are by far the most common class of animals and livestock provided the bulk of the meat. However, the majority of relative taxon abundance measures presented in Table 9.3 differ statistically through time. The platform has significantly more wild fauna than in other contexts, which primarily reflects the large number of river mussels in this deposit. The opposite pattern is found in Phase 5, where they are less than half as common. Fish are most frequent in Phase 4; despite the small absolute differences, there are four to nine times as many fish bones during this occupation period compared to other phases.[76] When excluding the mollusks, there is no statistical difference in the overall representation of wild versus domestic resources (84-89% domestic by phase).

The greatest contrasts are found in the relative abundance of livestock species, particularly horses. In Phase 4, horses are twice as common as in other contexts. At the same time, sheep and goats are strongly under-represented. While pigs and cattle do not differ greatly in absolute terms between phases, pig are significantly more numerous in Phase 3 (by 20-30%) and there are 20-40% more cattle in the platform assemblage. There is important variation in the proportion of higher versus lower value species through time as well. Phase 4 has significantly more bones from the highest value taxa, 10-30% more than other phases, largely reflecting the sizable horse population in this period. The platform has the most low value species, but this is strongly influenced by the abundance of shells. When these are removed, the platform does not have significantly more low value taxa.

[76] This excludes the platform since fish and other friable bones are under-represented due to taphonomic issues (extreme burning).

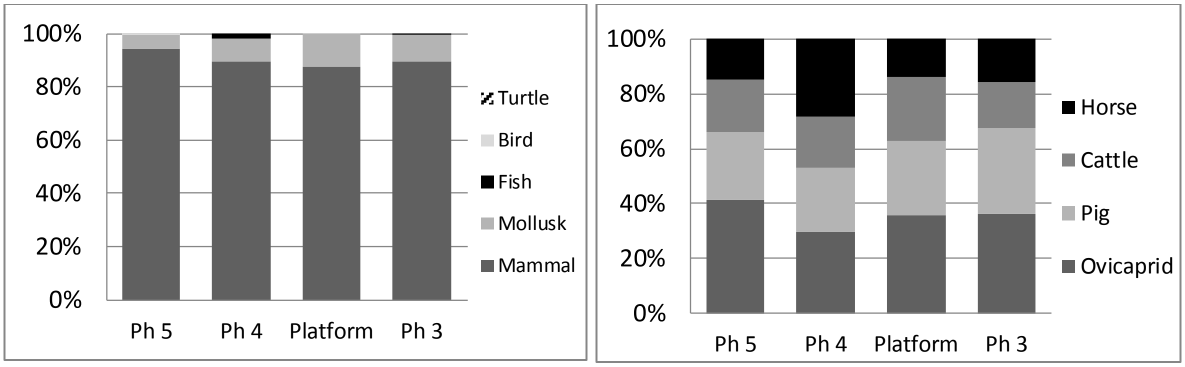


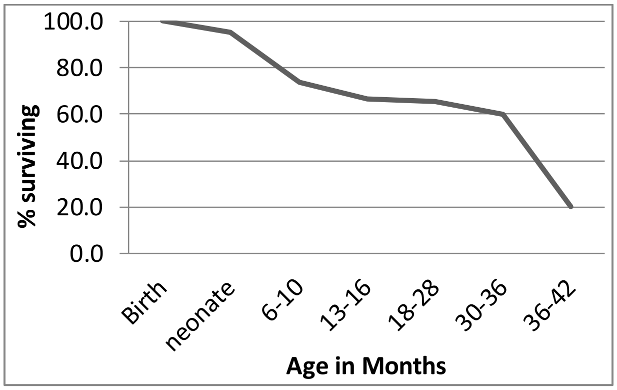
Figure 9.4: Florescent Period (Phases 3-5) taxon abundance (%NISP). Left: faunal class, right: livestock.

Demography

Ovicaprids

The sample of ageable bones and teeth per phase is too small for individual evaluation so the materials are combined for the whole Florescent Period. There are 62 elements for which fusion status could be assessed. The age profile illustrates two major off-take periods (Figure 9.5), one of juvenile animals less than 6-10 months (21%) and the other of prime-aged subadults around three years old (40%). Only 20% of the sheep and goats were kept into adulthood. The dental data show a similar mortality pattern for major age classes, although there is some disagreement as to the peak cull age within the subadult period. There are a minimum of 23 individuals represented in the ageable dentition sample. These show a highly structured off-take system with a large cull of animals around 6 and especially 18 months, corresponding to fall slaughters. The majority of sheep and goats were eaten as subadults (54%), but note that the 18 month peak subadult cull seen in the dental sample is at least a full year younger than indicated by the fusion data. Nonetheless, both datasets show that the majority of ovicaprids were consumed as subadults, demonstrating a clear meat-centered production strategy. The strongly bimodal age distribution also indicates a regular and highly organized culling schedule.

There are six sexable elements (four pelves and two astragali) in the Florescent Period sample, all of which are from adult females (MNI=4). While the sample size is not large, the under-representation of males does argue against wool production being a primary goal of sheep husbandry as a more equal ratio of males to female would be expected in a specialized wool production system (Payne 1973). Rather, the majority of males were most likely culled within their first year, probably representing most of the 6 month cull (unsexable), a pattern which is consistent with a more focused meat or mixed meat-dairy strategy.



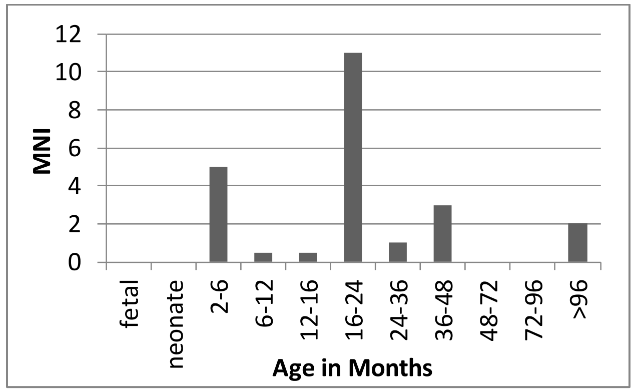


Figure 9.5: Ovicaprid age in months, Phases 3-5. Left: epiphyseal fusion (NISP), right: dentition (MNI).

Pig

There is a large sample of ageable pig bones (NISP=83) and teeth (MNI=40) in the Phase 3-5 sample.[77] Given that pigs are reared for meat and reproduce rapidly, a mortality pattern that shows intense off-take of juvenile and subadult animals is expected. Both datasets show that about half of the animals were slaughtered before their first year and only about 5-10% were kept into adulthood (Figure 9.6). A small number of neonates are also present, pointing to local breeding. The dentitions that could be aged more precisely show that there does not appear to be as tight of off-take scheduling for pigs as there is for ovicaprids. Rather, pigs appear to have been slaughtered throughout the year as the need arose.[78]

There are 12 sexable elements in the Florescent Period sample, two pelves and ten canines, representing a minimum of eight individuals. The ratio of females to males is 2:1 NISP and 5:3 MNI, both measures showing a majority of females (67% versus 63%, respectively). Males were likely culled as infants and juveniles, with more females being maintained for breeding purposes. This is consistent with standard pig/meat husbandry systems.

[77] Note that there is very little variability in age profiles between individual phases in the Florescent Period.
[78] There is also a possibility of double farrowing, which would also increase the variability in off-take ages/seasons.

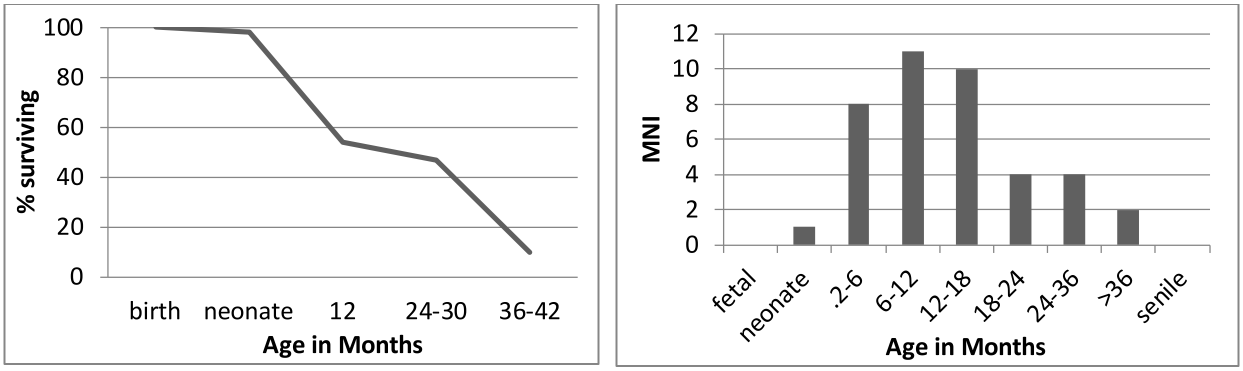


Figure 9.6: Pig age in months, Phases 3-5. Left: epiphyseal fusion (NISP), right: dentition (MNI).

Cattle

The combined sample for Florescent Period contexts contains 99 bones with epiphyseal fusion data (Figure 9.7). These show a low cull rate for animals less than 2-3 years old (23%). Half of the cattle were kept after reaching physical maturity at four years. The dental data suggest a somewhat different age distribution, particularly for mature animals. There are a minimum of 26 individuals represented in Phases 3-5 and the platform. There are no neonates or fetal cattle present. 25% of the animals were culled as juveniles, half of these within their first six months. 48% of the individuals were prime-aged subadults and there is no evidence of any standardized off-take within this age class (even age distribution between 1.5 through 4 years). 27% of the cattle were kept past achieving physical maturity, nearly all of which were maintained to a very old age. The mortality profile indicates that meat production was the primary focus of the husbandry system, but secondary products, both dairy and traction, were also important resources. The available sex and pathology data strongly support this interpretation. There are ten sexable elements (five pelves and five horn cores) belonging to at least eight individuals. The ratio of females to males is 2:3 NISP (40% female) and 1:1 MNI (50% female), showing a nearly equal or slightly male biased population. Note that most of the male horn cores came from mature adults, two of which are identified as oxen (castrates), underscoring the importance of cattle traction. In addition, two of the three female pelves show arthritic lipping consistent with heavy load bearing, showing that traction was not limited to males.

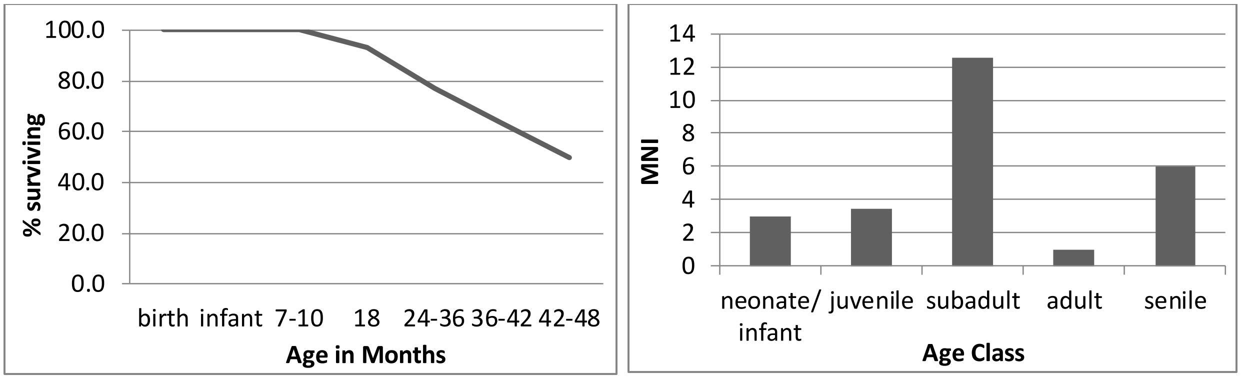


Figure 9.7: Cattle age, Phases 3-5. Left: epiphyseal fusion in months (NISP), right: dental age classes (MNI).

Horse

In the Florescent Period assemblage, there are 101 horse bones with fusion data. There is little evidence of juveniles, at least from animals less than 3-3.5 years (Figure 9.8). 95% of the specimens are from individuals older than this age class. Nonetheless, there are a few bones that can be aged more specifically given their state of partial fusion. These demonstrate that there are horses aged around 1.5 years, 2 years, and 3-3.5 years present in the sample. For animals less than 3-3.5 years, it appears that that largest rate of death (~5% of the total population) occurred between six months and 1.5 years, likely reflecting natural infant mortality.

There is a substantial amount of dental ageing data from the combined Phase 3-5 sample, representing at least 49 individuals, 21 of which are from Phase 4. There is no statistical difference in age classes between phases (Appendix 9.8). The teeth show a much higher proportion of juveniles than do the fusion data. One third of the horses are less than five years old, the vast majority of which are less than three years old (88%). This large discrepancy is in part due to differential destruction of juvenile bones, but there may other factors at play as well given the degree of this difference.[79] The high frequency of very young animals in the dental sample, including neonates, indicates a local breeding population. Also of note is the unusual abundance of prime-aged animals between 5-10 years old (25%), indicating a relatively intensive off-take of this most valuable age class.[80] This pattern is particularly striking when comparing discrete contexts. The "vertical bone pile" features contain almost entirely prime-aged

[79] This may include the differential treatment of young horse carcasses. A large proportion of elements that fuse before 20 months are from the meat-poor lower limbs and feet. These elements may have been utilized more intensely in adult animals, perhaps for marrow extraction (especially the metapodials).
[80] This age class is especially valuable as they: 1) are sexually mature, 2) have reached maximum body size and strength, 3) have been fully trained , and 4) have not degenerated or acquired the pathologies of older animals.

individuals, a statistically significant difference from contemporary deposits. These features are likely associated with high status feasting and will be discussed further in Chapter 12.

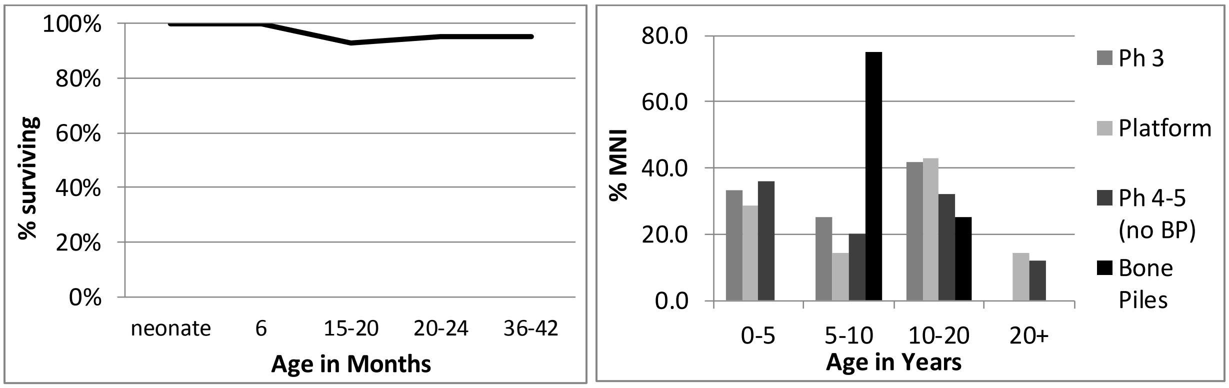


Figure 9.8: Horse age, Phases 3-5. Left: epiphyseal fusion in months (NISP), phases combined; right: dental age in years (%MNI) by individual context.

From the presence/absence and morphology of canines, there are 3 males and 3 females.[81] While in the entire Florescent Period sample, there is an equal proportion of males and females, females were only recovered from the earlier Phases 4 and 5, where there is a male to female ratio of 1:3. Interestingly, all of the females and none of the males were recovered from the bone pile features, which seems to underscore the unusual demography of individuals in these contexts. Again, it appears that the most valuable animals, in this case reproductive females, were disproportionally selected for consumption. However, the sample sizes are very small and these suggestions must be treated with caution. Future work is planned to develop more reliable methods for horse pelvis sexing which will greatly clarify the demographic models, as there is a relatively large sample of horse pelves (NISP=15).

Body Part Representation

Mammalian body part representation, by both anatomic region and utility, does not differ greatly between phases in the Florescent Period (Table 9.5, Appendices 9.9-10). The majority of elements are from the head, although the very large number of loose teeth present over-represents the relative frequency of cranial elements. These are followed closely by meaty parts from the upper limbs (28%) and axial skeleton (27%). Lower limb (11%) and foot bones (4%)

[81] Interestingly, two of the three females have small, vestigial canines. This is a relatively high rate and may be a characteristic of this local population.

are less common. While none of these categories differ greatly in absolute values, there are some statistical differences, which are in part influenced by fragmentation rates (Table 9.4). Contexts with higher fragmentation, especially the highly burned platform, tend to have relatively more axial elements represented (compared to long bones) as these fragile bones are more easily broken, increasing NISP. For this reason, the platform is excluded from statistical comparison. Phase 5 has significantly more cranial and fewer axial and foot elements than the later phases.[82] Anatomic regions no not differ between Phases 3 and 4. There are also no statistical differences between phases for elements by utility. The meatiest parts of animals are most frequent and there is little primary butchery debris present.

Body part representation for sheep and goats is generally similar between phases in this period (Table 9.6).   The distribution of bone fragments resembles the general mammalian pattern with the exception of axial elements for reasons discussed previously. Cranial elements are most common, followed closely by upper and lower limbs. There are very few foot bones. There is no statistical difference in element distribution by anatomic region between phases (platform excluded). By utility, there are statistically more medium utility portions (14%) in Phase 3.   There does not appear to be any significant changes in the processing and consumption of sheep and goats through time during the Florescent Period.

The pattern of pig element distribution generally parallels that of ovicaprids (Table 9.7), although there are comparatively more cranial and foot bones and fewer lower limbs, which is likely linked to anatomical differences, given the greater number of teeth and podials in pigs. Excluding the platform, there are no significant differences in element representation by anatomic region or utility between phases. The frequency of higher versus lower utility portions is statistically similar to that seen in ovicaprids (pigs 70%, ovicaprids 67%).

For cattle, cranial and upper limbs are the most frequent (Table 9.8), as seen in other taxa, but there are more fragments of foot bones present (see also discussion in the Early Period section). This translates into statistically fewer high utility elements compared to smaller bodied livestock. While there is some level of variability between contexts, especially in Phase 5 where there are about half the number of the lowest utility elements (especially feet), none of the differences are statistically significant.

[82] There are up to a 30% difference in the frequency of cranial and axial elements. The foot bones differ more strongly—they occur at only ½ to 1/3 the rate as in Phases 4 and 5, respectively.

Horse element distribution by anatomic region is very similar to the cattle pattern, with the exception of the large number of upper limbs in Phases 5 and especially 4, which derive predominately from the bone pile features. For the Florescent Period as whole, cranial elements (especially teeth), are most common, followed closely by upper and lower limbs. Like cattle, horse lower limbs and feet are more frequent than in the smaller livestock, due in part to taphonomy, but it is also possible that larger mammals were more completely utilized. There are 50% more cranial and twice as many foot bones in Phase 3 versus Phase 4, but 70% more lower limbs in the latter. Small sample size prevents statistical analysis of Phase 5 element representation by anatomic region.

There are significant differences in horse bone representation by utility between phases. Much greater frequencies of high utility elements are found in Phases 4 and 5, reflecting the large number of meaty upper limbs from the bone pile features constructed in these occupation layers. Higher utility elements comprise 96% of the bones in Phase 5 and 85% in Phase 4, contrasting sharply with Phase 3 (65%) and the platform (58%), which more closely resembles the cattle pattern. Despite the variably within the Florescent Period, it is apparent that cattle and horses were being treated differently, especially in Phases 4 and 5, when significantly more high quality horse meat was being consumed.

Summary

The Florescent Period animal economy is marked by both its reliance on domesticates and the relatively high proportion of large-bodied livestock, particularly horses. Horses are especially abundant in Phase 4, where, along with ovicaprids, they are the most common domesticate. Horses also show an unusually high proportion of prime-aged animals, which is not typical for this species as they are usually kept primarily for traction/transportation, and therefore maintained well into maturity, rather than food. This will be discussed further in subsequent chapters. Meat production was the central goal of livestock husbandry, although secondary products were obtained as well. Cattle labor was used extensively and large numbers of old animals were kept for this purpose. Hunting contributed a significant amount of meat to the diet, especially large bodied game like red deer. Fishing was not important in this period, but there was a large number of river mussels collected. It is not clear whether these were used as food or as smelting flux (or both).

Primary butchery was generally done away from the central living area, but there may be some difference in the degree to which lower food quality elements were utilized between larger and smaller bodied livestock. Throughout the Florescent Period, most animals were processed similarly, but in the earlier part there are an unusually high number of meaty upper limbs from horses. Many, if not most, of these originate from the bone pile features and are related to feasting.

LATE PERIOD

The Late Period sample is comprised of Phases 1 and 2. Phase 1 contains fill layers B1-2 though B1-3 and the upper-most portion of Structure 0. Phase 2 includes layers C1-3, Structure 0 and Structure 1. Layer C3 and Structure 0 directly overlie the burned platform. Both phases have relatively sparse occupation compared to earlier deposits. However, they produced large faunal assemblages, deriving largely from their thick and rather undifferentiated fill layers (Phase 1 = 2164, Phase 2 = 5203).

Taphonomy

The identification rate (to genus or better) for Late Period fauna is 42% (Table 9.4). Fragmentation rates were not calculated for the 2006 materials, which includes most of Phase 1 and the uppermost portions of Phase 2. For Phase 2, the average weight per bone is 12.5 g, which is about the average for Bronze Age deposits at Pecica. Invasive taxa comprise less than 2% of the recovered fauna. Taken as a whole, there is a relatively low rate of bone modification in the Late Period assemblage (7.6%), with particularly low frequencies in Phase 1 (3.4%). The most common bone modification is animal gnawing, which is found on 5% of the specimens. 1.4% of the bone is burned and less than 1% show traces of weathering, calcination, butchery, or working. There are significantly more weathered bones in Phase 1 and more animal modified, burned/calcined, and worked bone in Phase 2 (Appendix 9.2). These patterns fit expectations for a decline in occupation intensity in Phase 1, immediately prior to settlement abandonment. During periods of less-intensive occupation, habitation debris accumulates more slowly so bones are more likely to be exposed for longer time periods prior to burial

Taxon Representation

The Late Period fauna is dominated by mammalian remains (85%), like other Bronze Age periods at Pecica (Tables 9.2 and 9.3). Mollusks make up 13% of the assemblage with low numbers of fish (2%), turtle (0.1%), and bird (<0.1%). In addition to the typical carp and wels in the fish collection, there is also northern pike. Considering only specimens identifiable to genus or better, wild animals (including invertebrates) comprise nearly half of the fauna (47%). For mammals, domesticates (77%) are far more abundant than game. The range of wild mammal species is similar to other phases. Ovicaprids are the most frequent livestock (43%). Pigs average 32%, cattle 20%, and horse 5%. In general, there are few differences between the faunal assemblages in Phases 1 and 2 (Figure 9.9). Only one of the taxonomic measures in Table 9.3 differs statistically (Appendix 9.4). There are significantly more large mammal bones (identifiable and non-identifiable combined) in Phase 1.

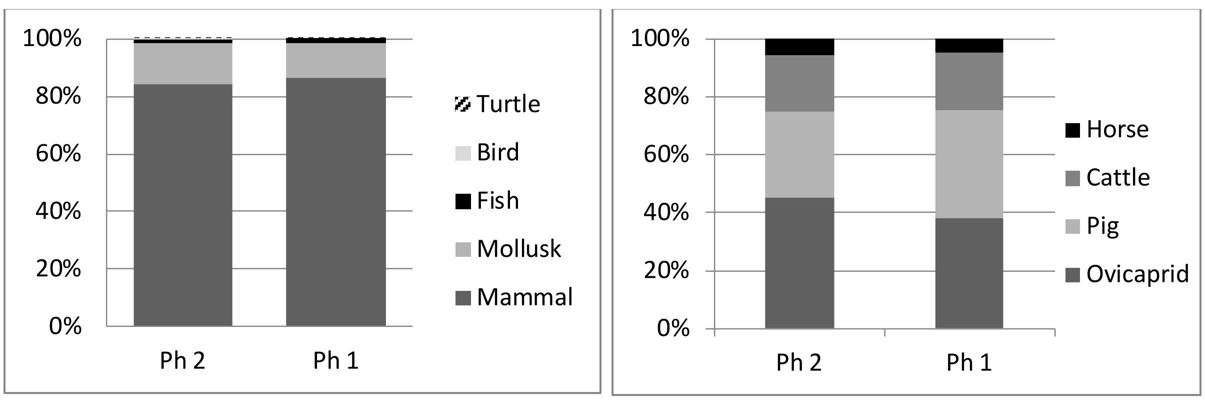


Figure 9.9: Late Period (Phases 1-2) taxon abundance (%NISP). Left: faunal class, right: livestock.

Demography

Ovicaprids

Epiphyseal fusion could be assessed for 22 bones in Phase 1 and 56 bones in Phase 2, which are combined in this study (Figure 9.10). Culling appears to have occurred primarily between 6-12 months and 2-3 years; only about 1/3 of animals were kept into adulthood. There are fetal/neonatal individuals present, indicating a local breeding population. The very large dental sample (Phase 1 MNI=14, Phase 2 MNI=38) largely agrees with the epiphyseal fusion data. About 1/3 of the animals are slaughtered before their first year, primarily in the fall, culling surplus animals at around six months of age. There is a second large off-take of animals between

1.5-2 years old. Only about 22% are maintained into adulthood. The largest age class of physically mature animals is very old, more than eight years, representing the off-take of animals that can no longer reliably produce secondary products or breed. This demographic pattern meets expectations for a meat centered production system, but the presence of mature and senile animals does indicate use of secondary products as well. Unfortunately, there are no sexable sheep/goat bones in this sample to further clarify husbandry practices.

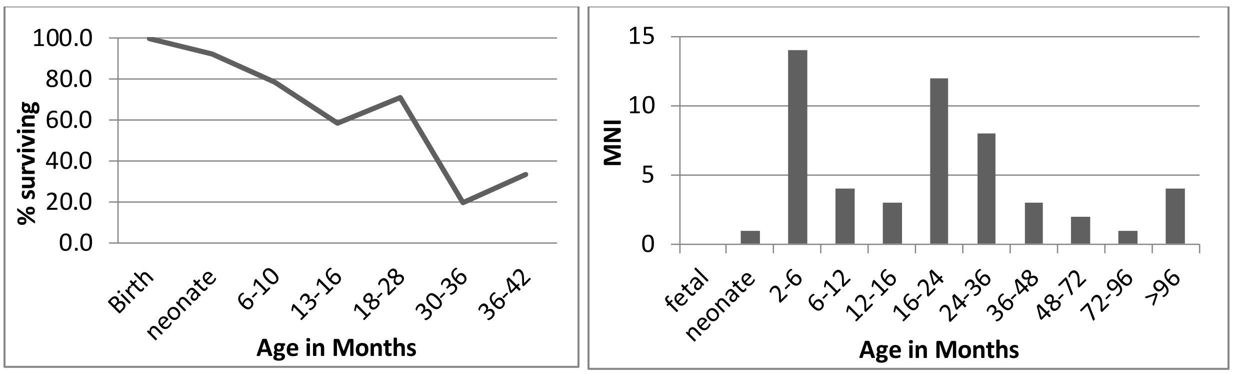


Figure 9.10: Ovicaprid age in months, Phases 1-2. Left: epiphyseal fusion (NISP), right: dentition (MNI).

Pig

There is a relatively large sample of ageable pig bones from Phase 1 (NISP=34) and Phase 2 (NISP=71). The age profiles are very similar between the two periods and the samples are combined for analysis. The bone fusion data show that there are neonatal animals present, indicating local breeding (Figure 9.11). There are very large culls of juvenile and subadult animals: about 40% were killed before their first year and another 20% by their second year. Less than 10% of pigs survived past 3-3.5 years. The dental data (MNI=36) show a similar pattern to the fusion profile, with a small number of neonates (6%), around half of the animals being culled in their first year (56%), another 28% between 1-1.5 years old, and only 5% kept beyond three years of age. There are twelve sexable canine teeth belonging to a minimum of seven individuals. A majority of females is present, with nearly identical ratios of female to males using NISP and MNI calculations: 7:5 NISP (58% female) and 4:3 MNI (57% female). These are typical rapid-turnover pig mortality profiles.

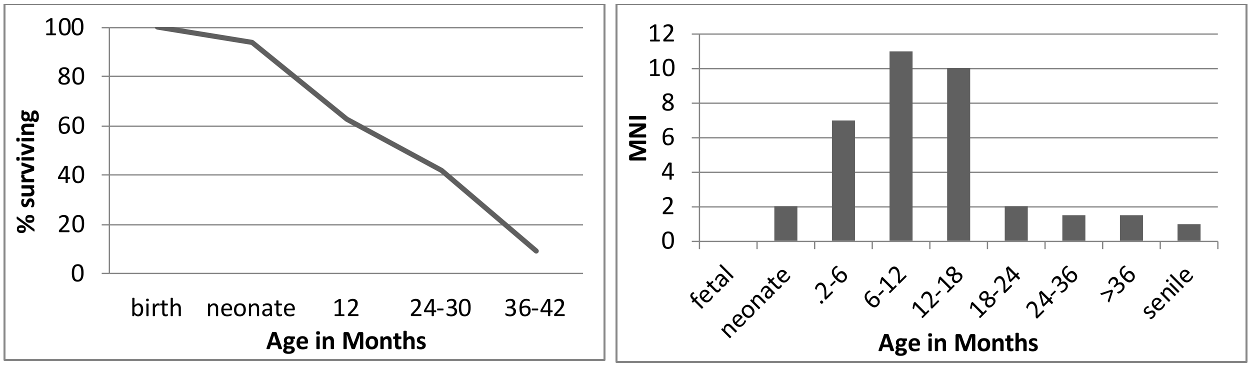


Figure 9.11: Pig age in months, Phases 1-2. Left: epiphyseal fusion (NISP), right: dentition (MNI).

Cattle

There are 22 ageable cattle bones in Phase 1 and 80 in Phase 2. The fusion data indicate that relatively few animals (20%) were culled prior to 1.5 years (juveniles), but most of these died between 6-12 months (Figure 9.12). Between 1.5 and 4.5 years, a significant number of animals were slaughtered, about 40%, with another 40% maintained into adulthood. The dental data from Phases 1 and 2 (MNI=13) mirror the fusion data. 23% of the animals were slaughtered as juveniles and the presence of neonates confirm the presence of a local breeding population. There are equal numbers of subadults and senile cattle (39% each) and no younger or middle adult animals are observed. There are six sexable elements from a minimum of four individuals. Both NISP and MNI show a female to male ratio of 1:1 (50% female). This age distribution represents a mixed meat/secondary products strategy, with the senile animals likely being kept for traction.

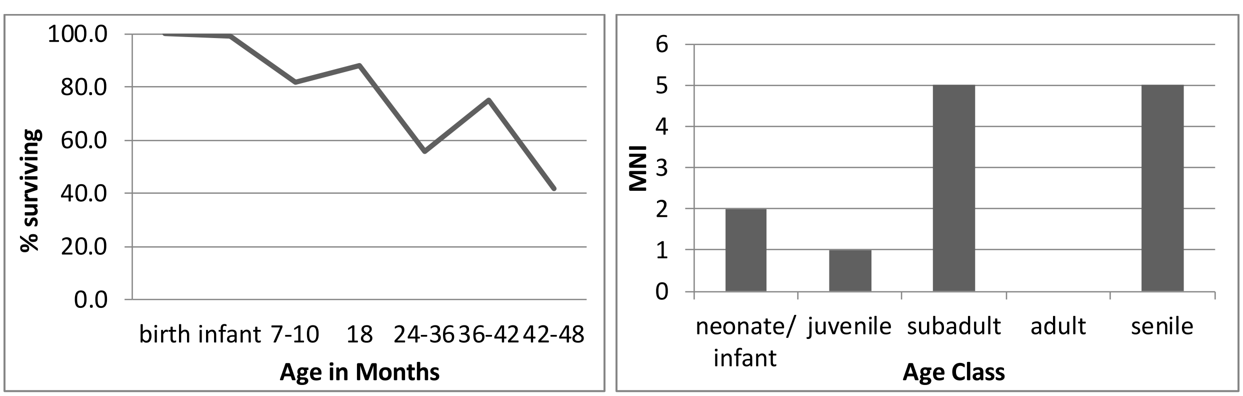


Figure 9.12: Cattle age, Phases 1-2. Left: epiphyseal fusion in months (NISP), right: dental age classes (MNI).

Horse

Epiphyseal fusion can only be assessed for 17 horse bones in the combined Phase 1 and 2 assemblages. This very small sample cannot be evaluated systematically. However, 88% of these are from animals aged over 3-3.5 years. There are also small dental samples, MNI Phase 1=3, Phase 2=7, which are combined in this analysis. Only eight of these can be placed within discrete age classes (Figure 9.13). Overall, there is considerable disagreement between the dental and epiphyseal fusion data, with the former showing many more juveniles, as in the Florescent Period sample. The horse age distribution reflects a breeding population with relatively large numbers of infants and older adults, including animals over 20 years old. There is likely some off-take for meat in addition to natural deaths. There is one male mandible present.

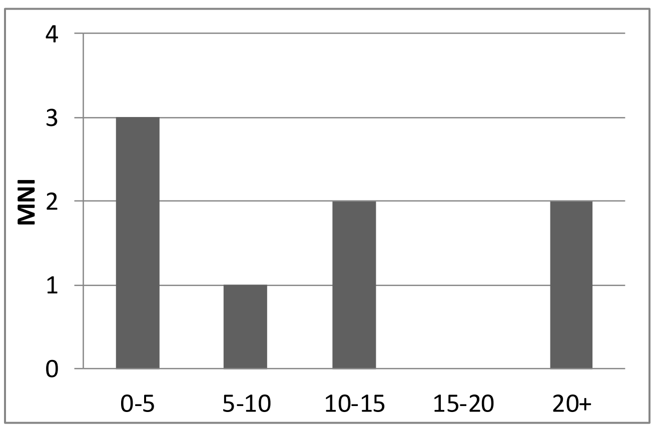


Figure 9.13: Horse dental age in years (MNI), Phases 1-2

Body Part Representation

The distribution of mammalian skeletal elements resembles other periods at Pecica. For the combined sample of Late Period fauna, body part representation by anatomical region is as follows: upper limb 33%, head 27%, axial 24%, lower limb 12%, and feet 4% (Table 9.5). These values are similar between periods, none of which differ greatly in absolute terms. However, there are statistically more cranial (20%) and fewer upper limb elements (30%) in the final Phase 1 occupation (Appendices 9.9, 9.11). Higher food value elements are dominant in the combined assemblage, and like other contexts, primary butchery debris was deposited elsewhere for the most part. Phase 1 material has significantly more low quality elements (20%)

due to the aforementioned differences in anatomical regions (more low quality cranial and fewer high quality upper limbs). This suggests a modest decline in meat quality consumption by tell inhabitants leading up to site abandonment.

For sheep and goats, there is some statistically significant variability in body part representation between phases (Table 9.6). In Phase 1, there are 50% fewer meaty upper limbs. There are also more than twice as many foot bones and nearly seven times the number of axial elements. These anatomic differences offset slightly, resulting in a small decrease in high utility elements in Phase 1 (20%). There is a similar trend in pig skeletal representation (Table 9.7), despite the inter-species difference in anatomy (discussed above). There are 25% more low utility elements present in Phase 1, particularly crania and feet. There is no statistical difference in utility between the two smaller bodied livestock, with both ovicaprids (62%) and pigs (66%) having mostly higher utility portions present in the Late Period.

There is little variability in cattle skeletal element representation between Phases 1 and 2, none of which are statistically significant (Table 9.8). The combined sample shows that the head and limbs are the most common elements and that higher and lower utility portions occur in roughly equal proportions. Compared to the smaller livestock, there are significantly more (50%) lower utility elements present, especially feet.

Horse body part representation by both anatomic region and utility is very similar to the cattle pattern, once again suggesting that larger bodied animals were treated similarly to each other and differently from smaller ones, although there are significant taphonomic issues to consider as well. There are few horse bones in Phase 1 (NISP=19), which limits statistical comparisons within the Late Period samples. However, at a general level, there is no statistical difference in the frequency of higher versus lower utility horse portions in Phases 1 and 2, despite the 30% decline in utility.

Summary

In general, the Late Period occupation shares many features with other periods. Livestock production is the focus of the animal economy. Ovicaprids are the most common domesticate, followed by pigs and cattle, while horses are rare. Meat was the primary product from animal husbandry, although secondary products, especially cattle and horse traction, were important as well. Wild animals were used to a lesser degree, particularly non-mammalian vertebrates, but there are significant numbers of river mussels present. Primary butchery debris is not common on the central tell and it appears that lower utility elements were processed more intensively for larger bodied livestock like cattle and horses. The relatively low rate of bone modification, particularly in Phase 1, supports a decline in occupation intensity through time.

PECICA ANIMAL ECONOMY: A DIACHRONIC PERSPECTIVE

This section examines significant changes in the animal economy at Pecica through the Bronze Age occupation. This includes a review of the analytic categories presented above for each major occupation period: taphonomy, taxon representation, demography, and body part representation. Phases that have biased assemblages are excluded where appropriate. It should be noted that given the large sample sizes for most measures, that statistical analyses often produce significant results due to high test power, despite very small absolute differences. Focus is placed on aspects of the animal economy that differ both statistically and in absolute values, which are more likely to represent meaningful, deliberate changes in production systems by the settlement's inhabitants.

Taphonomy

There are important similarities and differences in bone taphonomy between the three major occupation periods at Pecica (Table 9.4, Appendix 9.2). There is minimal variability in the degree of fragmentation, identification rates, and frequency of intrusive species, demonstrating that the samples are comparable. Other forms of pre- and post-depositional modification do contrast greatly through time and are statistically significant (Figure 9.14). Most striking is the very high frequency of burning and calcination in the Florescent Period. Much of this derives from the platform, where 75% of the material was thermally altered during this feature's construction. However, excluding the platform, the rate of burning is still nearly eight times that of the Early and Late Period periods, peaking in Phase 4. As discussed previously, while some of this material may have been introduced by bioturbation from the platform into the underlying E layer fill, increased burning activities are also suggested by the abundant charcoal and ash deposits in this period, perhaps related to more intense metallurgy.

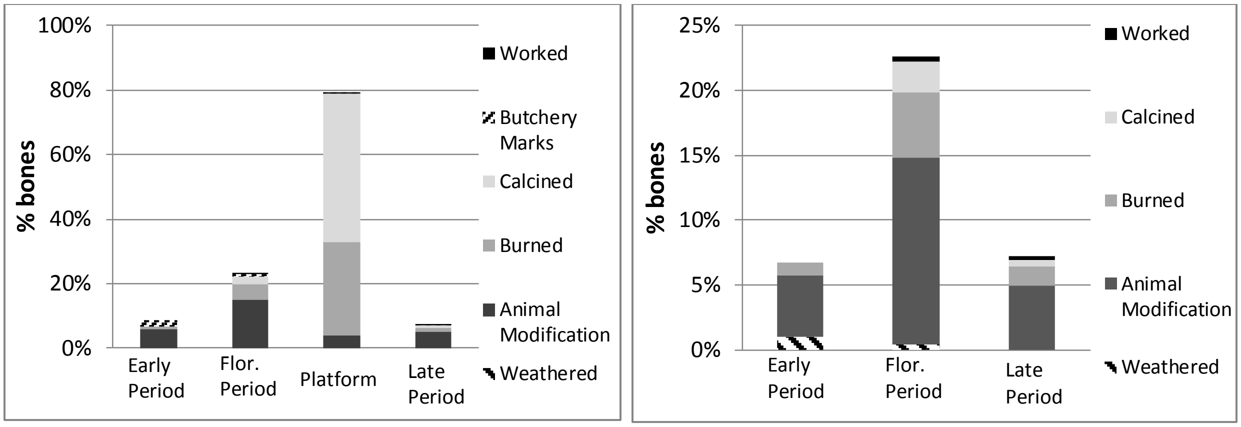


Figure 9.14: Bone modification (%NISP). Left: all periods, platform separate, right: platform excluded.

The Florescent Period is also characterized by particularly high levels of carnivore gnawing, with about three times the rate of animal modification than seen in other periods. While within the Florescent Period the proportion of dogs appears to be related to gnawing rates, this does not hold for the total occupation as the largest numbers of dogs are found within the Late Period. Despite the lower frequency of canine remains recovered from Florescent Period contexts, dogs appear to have had greater access to food remains in this period. It is possible that they were more abundant but that their carcasses were disposed of away from the dense central occupation area at this time. It should also be noted that the relatively high rates of carnivore gnawing in all periods contributes substantially to density-mediated attrition and epiphyseal destruction, resulting in under-representation of very young animal bones and of more friable (and typically higher utility) skeletal elements.

Importantly, there are few traces of butchery marks on bones during the Bronze Age (0.3%-2.1%), a figure which is influenced by two factors. First, the aforementioned high levels of carnivore gnawing and destruction of bone epiphyses tends to obscure and/or obliterate cut marks in these regions. Unfortunately, this is where much of the detachment of tendons and especially ligaments would occur during dismemberment and meat removal. The deleterious effect of gnawing is underscored by the fact that nearly half of the specimens with butchery marks in Phases 4 and 5 are found within the bone pile features, which differ greatly from other contexts in that elements are mostly complete and undamaged. However, the use of bronze implements may have affected butchery practices as well. In the later Dacian (and Medieval) occupation when iron implements were common, butchery marks are far more frequent and there are numerous examples of chopping through bones themselves, including halving a pig along the vertebral column with a heavy implement (Nicodemus 2012). The relative infrequency (and high value) of metal tools in the Bronze Age, as well as the comparative softness of bronze itself, may have fostered butchery practices that maintained their use life. For example, dismemberment may have been done predominantly by cutting between the joints rather than chopping through the bone or by extensive cutting along the bone surface through connective tissue.

Other types of bone modification occur in less than 1% of the specimens, but there are statistical differences between periods. Including butchery marks, there are significantly more weathered and butchered and fewer worked bones in the Early Period. However, given the largely unsystematic recovery strategies used in Early Period deposits, these results should be treated with caution. Excluding this phase, all modification classes except working occur more frequently in the Florescent versus Late Period faunal assemblages, again pointing to a decrease in occupation intensity though time.

Taxon Representation

Fundamental organizational features of Pecica's animal economy are maintained throughout the Bronze Age occupation at Pecica (Tables 9.2 and 9.3). This includes a reliance on mammals as the primary meat source, a strong focus on livestock production over hunting, and an emphasis on ovicaprid (primarily sheep) husbandry. However, the relative importance of various animal taxa changes significantly over time (Appendix 9.5). Statistical analyses use the three occupation periods (Early, Florescent, Late) as comparative units, providing a basic assessment of temporal changes in the animal economy. These patterns are further refined by examining trends between individual phases to clarify the longer-term patterns (see also previous sections). It must be restated that the Early Period sample is biased against small bones, especially those from non-mammalian species, due to collection strategies. Similar limitations hold for the platform assemblage, as extreme burning differentially destroyed small and friable elements, especially fish bone. These contexts are excluded where necessary.

Every measure of relative abundance presented in Table 9.3 differs statistically between the three major occupation periods. Figure 9.15 illustrates taxon contribution for faunal classes and livestock species. Interestingly, the temporal differences fall into two general patterns. One set shows relatively steady, unidirectional change through time. The other set shows more dynamic changes between phases, centered on the Florescent Period.

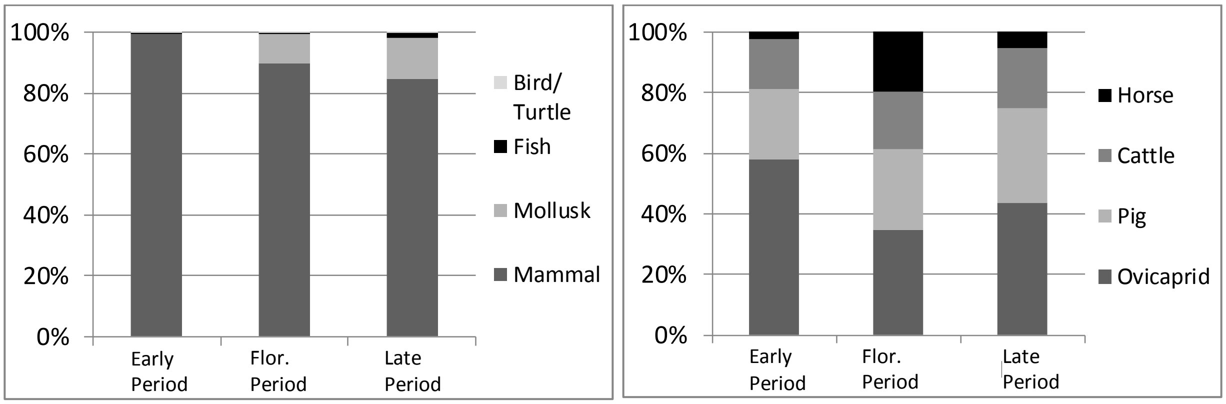


Figure 9.15: Pecica taxon abundance (%NISP) by period. Left: faunal class, right: livestock.

The frequency of wild resources belongs to the first group, with 40% more wild fauna in the Late versus the Florescent Period on average (Figure 9.16). This increase is particularly striking when comparing individual phases. From the beginning of the Florescent Period (Phase 5) through the Late Period, the frequency of wild mammals doubles. There is also a nearly threefold increase in freshwater bivalves and, although occurring in small numbers in all periods, there are ten times more fish. Turtles only occur in the Late Period assemblage. There is simultaneous 60% increase in the number of pigs[83] through time.

There is no straightforward explanation for this pattern of changes. Because the taxa that increase in frequency are overwhelmingly those that favor forested and/or wetland habitats, these changes may be related to a long-term environmental shift towards a cooler, more humid climate. Unfortunately, a more refined and localized environmental assessment is necessary to evaluate this hypothesis. However, Sherwood et al. (2013) have suggested that there is actually increased aridity though time, as documented through an increase in loess sedimentation rates. This is mirrored by an increase in warm/dry plant species in the weed assemblage between Florescent and Late Periods (Chapter 10). This would suggest that these faunal changes instead may be linked to socioeconomic reorganization, as they are predominantly lower value species.

[83] The relative frequency of pigs within the livestock assemblage includes Phase 6/Early Period.

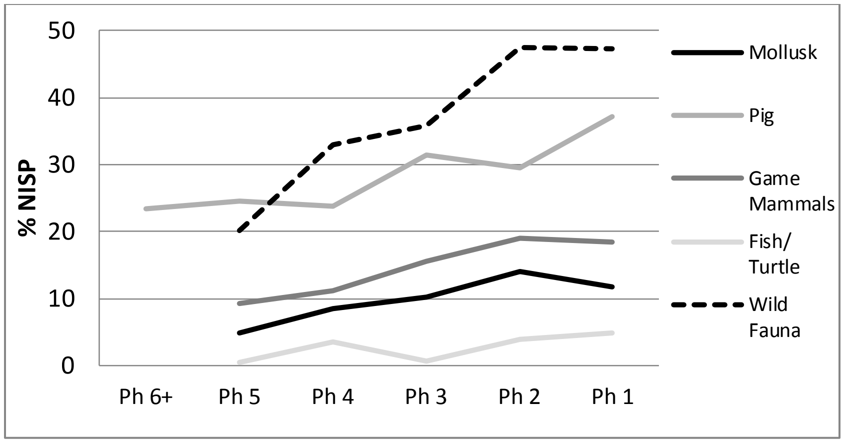


Figure 9.16: Unidirectional changes in faunal representation (% NISP, values from Table 9.3)[84]

The other set of changes shows a clear rise and fall in relative taxon abundance, peaking (or dipping) in the Florescent Period, and centered on Phase 4 (Figure 9.17). The most significant difference is found in the proportion of horses within the livestock assemblage. On average, horses are four times more common in the Florescent versus Late Period and eight times more common than in the Early Period. When comparing individual phases, the differences are even more dramatic: Phase 4 has six times more horses than the final occupation in Phase 1 and twelve times more than in Phase 6.[85] Major changes are also found within the game assemblage. There is more focus on red deer hunting over other wild mammals (especially smaller, lower-ranked species) during the Florescent Period, when they are 20% more frequent. Horse and red deer abundance contribute strongly to the significant increase in both larger-bodied species in general as well as the proportion of high value taxa, which are 40% more numerous in this period. Together, these changes indicate a shift in animal economies towards the production and consumption of more valuable taxa at the expense of lower ranked species during the Florescent Period occupation.

[84] Since most of these measures (except pig/livestock) include small bodied taxa, the platform and Phase 6 (Early Period) are excluded from this chart. The omitted values can be found in Table 9.3.
[85] Note also that ovicaprid representation is inversely proportional to horses and may in part reflect competition for large tracts of high quality (and defensible) pasture near the site.

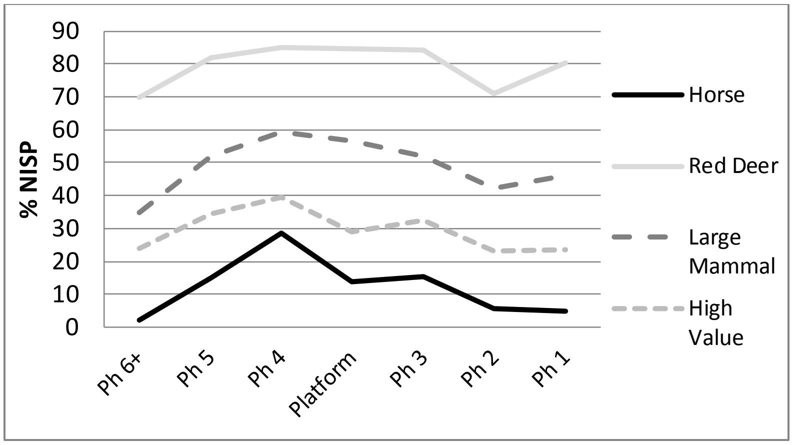


Figure 9.17: Changes in faunal representation centered on the Florescent Period (% NISP, values from Table 9.3)

Demography

Ovicaprids

Throughout the Bronze Age occupation at Pecica, ovicaprids (primarily sheep) were utilized for both their primary and secondary products. However, there is a very strong shift in in the relative importance of dairy and/or wool versus meat through time, which is clearly documented in their mortality profiles (Figure 9.18, Appendix 9.8).[86] In the Early Period, secondary products are very important, as demonstrated by the large proportion of mature animals (48%). In the Florescent Period, this changes significantly, with most animals being consumed as subadults (54%), indicating that meat was the principal resource.[87] There is also a very tight culling schedule in this period, a pattern that is expected in a highly organized production system. The low numbers of juveniles also indicates a concern for maximizing meat output. In the Late Period, meat is still the focus of ovicaprid husbandry with large numbers of subadults (44%). There is a larger cull of juveniles in this period (37% versus 24%), but this difference is not significant. Culling is also not as tightly scheduled in the Late Period, with a substantial number of animals being slaughtered outside of the typical fall off-takes of ovicaprids in their first and second years.

[86] Only the dental samples are used for phase comparisons as the age divisions are more narrowly defined and the data are more amenable to statistical analysis.

[87] It is possible that wool production may have still been very important in the Florescent and Late Period periods but with substantial differences in the age/quality of animals consumed between on- and off-tell inhabitants. For example, a number of juvenile and prime-aged animals may have been culled from the wool flocks to provision the on-tell population, with the off-tell people left to consume the poor quality meat of older animals. While the off-tell sample is not of sufficient size to test this hypothesis statistically (see section 3), the lack of males in the on-tell sample strongly suggests that the ovicaprid herds at Pecica were not kept for specialized wool production.

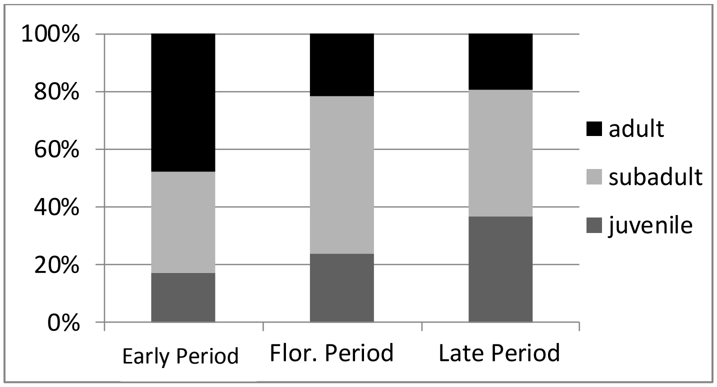


Figure 9.18: Ovicaprid dental age classes by period (% MNI)

Pig

Pig husbandry does not appear to have undergone any major changes at Pecica through time. The fusion age profiles are virtually identical between periods, all of which are consistent with rapid-turnover meat production systems that are typical for this species (Figure 9.19). There are two large culls, one of surplus animals in their first year (predominantly males) and the other of subadult animals approaching adult body weight (some males, mostly females). However, the picture is complicated when examining the dental data since the Early Period dental and bone fusion age profiles do not agree. This difference is likely due to small sample sizes and it not clear if the dental or fusion assemblage is more representative of the underlying population. The teeth suggest that there are significantly fewer juvenile animals consumed in the Early Period (15%) compared to the Florescent (50%) and Late Period periods (56%). It appears that maximizing the amount of meat per animal was more important in the Early Period. The abundance of very young animals (2 weeks to six months) in the Florescent (20%) and Late Period (19%) periods may also be related to gourmet/elite consumption of suckling pigs. There are no significant differences in fusion age, dental age, or sex profiles between the Florescent and Late Period occupations.

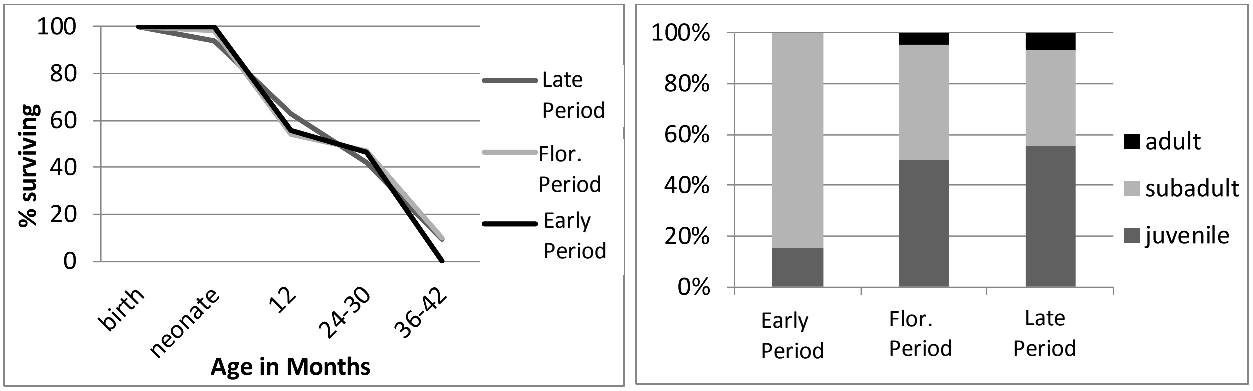


Figure 9.19: Pig age in months, all periods. Left: epiphyseal fusion (NISP), right: dentition (MNI).

Cattle

The cattle off-take patterns derived from epiphyseal fusion data show few differences between periods, especially when considering the relatively small assemblages for the Early Period sample and for elements that fuse at three or more years of age in all phases (Figure 9.20). Nonetheless, it appears that there was consistently little off-take of very young animals (<7 months), substantial culls of prime-aged subadults 1.5 to 4 years old (~40-50%), and maintenance of large numbers of mature animals (~40-50%). The dental data agree with the fusion profiles, showing predominantly subadults and very old animals. There may be a somewhat greater emphasis on meat production in the Florescent Period given the larger number of subadults, but the small samples, especially in the Early Period, limit reliable comparison. Despite the apparent variability in dental age classes, the differences are not statistically significant. There are roughly equal numbers of males and females present, at least in the Florescent and Late Period periods.

In all occupation phases, a mixed-husbandry strategy is documented. In addition to meat from prime aged animals, secondary resources were also very important, as roughly half of the cattle were kept past reaching physical maturity. Most these adult animals were slaughtered only in their old age, indicating that the use of cattle for their labor (i.e., pulling plows, carts, etc.) was a principal goal in management systems. This is supported by the balanced sex ratio and the occurrence of traction-related pathologies.

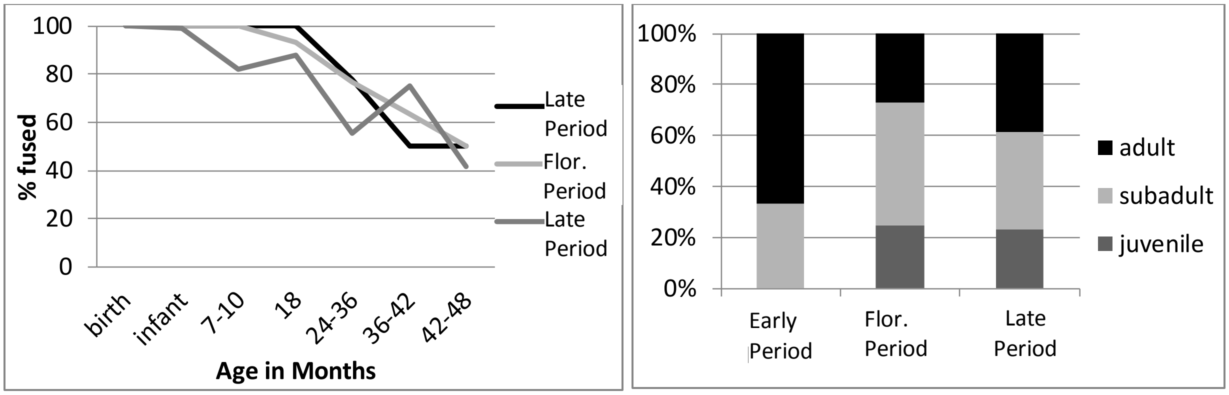


Figure 9.20: Cattle age, all periods. Left: epiphyseal fusion in months (NISP), right: dental age classes (MNI).

Horse

As with most of the other livestock, horse production strategies undergo changes between occupation phases.[88] While both Florescent and Late Periods show the presence of a local breeding population with large numbers of infants and juveniles, in the Florescent phase there are twice as many valuable prime aged animals and one third the number of very old adults being slaughtered (Figure 9.21). Unfortunately, the Late Period dental sample is too small to compare statistically. Nonetheless, there is some suggestion that the relatively intensive horse husbandry system in the Florescent Period (as documented by taxon abundance) produced a sufficient number of surplus animals that could be used as a high status meat source. It also appears that there was greater need to keep horses until senility in the Late Period, which is likely related to the sharp decline in local horse breeding.

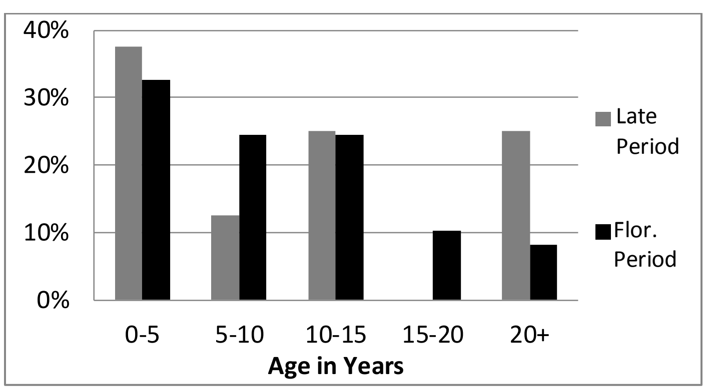


Figure 9.20: Horse dental age profile by period (% MNI), age in years

[88] The Early Period sample cannot be evaluated given small sample sizes.

Body Part Representation

Overall, there is a general similarity in mammalian body part representation between periods (Table 9.5, Appendix 9.12), as demonstrated by the small differences in absolute values. This results from shared site formation processes and butchery and disposal practices, as well as the physical properties of the bones themselves (e.g., size, shape, density). However, there are several notable differences between the on-tell occupation phases. Some of the differences reflect taphonomic issues and collection strategies. This is seen primarily in the Early Period assemblage (Phase 6+), where small and highly fragmented axial elements are under-represented, which produces the statistically lower frequency of very high-quality meat cuts. Excluding the Early Period material, there are still a few notable differences though time. There are significantly more cranial but fewer upper limb bones in the Florescent Period. In terms of meat quality, there are more very high and fewer medium-quality elements in this period. In short, there are more similarities than differences in body part representation for mammals in general between occupation phases. However, during the Florescent Period, people were consuming more of the highest-quality meat cuts available.

Despite the overall similarities in the combined mammal assemblages, there are some important differences in the processing, consumption, and disposal of individual livestock species. For ovicaprids, there are significant changes in both anatomic portion and utility through time, with the final occupation period, the Late Period, showing a clear decline in the quality of mutton consumed on the tell (Table 9.6).[89] In the Late Period, there are statistically more cranial and foot bones and fewer lower-limbs, resulting in relatively fewer (10-15%) high-quality meat portions.

A somewhat different pattern is seen in pigs (Table 9.7). By anatomical region, the Early Period contrasts most strongly, with significantly fewer cranial but more lower-limb bones. While there is a general trend for a decrease in higher-utility elements through time (again by 10-15%), the differences are not statistically significant. In terms of quality of pork consumption, there is not a clear distinction between periods.

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[89] Note that this pattern was also seen within Late Period sample, as meat quality declined for all taxa between Phases 2 and 1.

Table 9.5: Mammalian body part representation, all phases (% NISP)

	Early Period (Ph 6+)	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	Total On Tell
Anatomic Region										
Head	**31.0%**	39.3%	32.3%	30.3%	30.2%	**31.4%**	24.9%	30.9%	**26.5%**	29.3%
Axial	**13.9%**	19.6%	23.8%	31.2%	26.5%	**26.5%**	23.6%	25.4%	**24.1%**	24.2%
Upper Limb	**36.4%**	30.9%	29.2%	23.5%	28.8%	**27.8%**	35.6%	27.8%	**33.4%**	31.1%
Lower Limb	**15.0%**	8.6%	11.3%	11.1%	9.7%	**10.7%**	11.8%	11.6%	**11.7%**	11.6%
Foot	**3.7%**	1.6%	3.4%	3.8%	4.9%	**3.7%**	4.1%	4.4%	**4.2%**	3.9%
Utility										
Very High	**21.7%**	24.3%	27.2%	31.4%	27.8%	**28.4%**	25.9%	24.2%	**25.5%**	26.5%
High	**36.6%**	35.3%	31.1%	32.0%	33.4%	**32.3%**	34.6%	32.5%	**34.0%**	33.5%
Medium	**9.5%**	9.6%	9.0%	8.5%	9.2%	**9.1%**	11.7%	10.1%	**11.3%**	10.1%
Low	**26.9%**	26.3%	27.4%	22.7%	22.9%	**24.7%**	21.7%	26.6%	**23.0%**	24.2%
Very Low	**5.4%**	4.5%	5.3%	5.4%	6.6%	**5.5%**	6.1%	6.5%	**6.3%**	5.8%
Higher	**67.8%**	69.2%	67.3%	71.9%	70.4%	**69.8%**	72.2%	66.9%	**70.7%**	70.0%
Lower	**32.2%**	30.8%	32.7%	28.1%	29.6%	**30.2%**	27.8%	33.1%	**29.3%**	30.0%

*Based on Binford's (1978) GMUI for sheep, maximum value per element

Table 9.6: Ovicaprid body part representation, all phases (% NISP)

	Early Period (Ph 6+)	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	Total On Tell
Anatomic Region										
Head	**28.5%**	30.2%	23.8%	40.6%	24.1%	**29.4%**	34.8%	36.6%	**35.2%**	31.5%
Axial	**0.3%**	0.0%	1.3%	0.0%	0.0%	**0.6%**	0.4%	2.6%	**0.9%**	0.6%
Upper Limb	**48.8%**	51.2%	46.3%	35.8%	53.8%	**45.3%**	39.6%	26.8%	**36.7%**	42.7%
Lower Limb	**21.7%**	17.4%	27.3%	23.0%	21.5%	**23.8%**	23.7%	30.1%	**25.1%**	23.9%
Foot	**0.8%**	1.2%	1.3%	0.5%	0.6%	**1.0%**	1.5%	3.9%	**2.1%**	1.4%
Utility										
Very High	**14.1%**	11.4%	11.8%	11.5%	12.1%	**11.7%**	7.3%	6.1%	**7.0%**	10.5%
High	**45.3%**	48.1%	42.4%	43.2%	36.9%	**41.3%**	36.4%	26.1%	**34.2%**	39.5%
Medium	**12.2%**	12.7%	8.4%	10.8%	22.0%	**13.6%**	20.9%	20.9%	**20.9%**	16.0%
Low	**27.3%**	25.3%	35.0%	33.1%	28.4%	**31.7%**	32.7%	40.0%	**34.2%**	31.7%
Very Low	**1.0%**	2.5%	2.5%	1.4%	0.7%	**1.8%**	2.7%	7.0%	**3.6%**	2.3%
Higher	**71.7%**	72.2%	62.6%	65.5%	70.9%	**66.6%**	64.5%	53.0%	**62.2%**	66.0%
Lower	**28.3%**	27.8%	37.4%	34.5%	29.1%	**33.4%**	35.5%	47.0%	**37.8%**	34.0%

*Based on Binford's (1978) GMUI for sheep, maximum value per element

Table 9.7: Pig body part representation, all phases (% NISP)

	Early Period (Ph 6+)	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	Total On Tell
Anatomic Region										
Head	**28.4%**	44.9%	46.2%	45.3%	44.5%	**44.5%**	33.5%	49.3%	**38.2%**	40.0%
Axial	**2.1%**	2.0%	6.0%	0.0%	5.1%	**3.6%**	1.4%	0.0%	**1.0%**	2.4%
Upper Limb	**54.6%**	44.9%	35.9%	43.9%	35.8%	**40.5%**	48.6%	30.8%	**43.3%**	43.4%
Lower Limb	**12.1%**	6.1%	9.2%	7.2%	7.3%	**7.5%**	11.8%	11.0%	**11.6%**	9.7%
Foot	**2.8%**	2.0%	2.7%	3.6%	7.3%	**3.8%**	4.6%	8.9%	**5.9%**	4.6%
Utility										
Very High	**13.7%**	15.0%	16.9%	8.7%	16.4%	**14.7%**	13.6%	3.1%	**10.5%**	12.8%
High	**48.1%**	42.5%	36.3%	54.0%	38.8%	**44.2%**	42.6%	43.8%	**43.0%**	44.2%
Medium	**13.7%**	12.5%	10.0%	11.9%	12.9%	**10.9%**	13.6%	8.5%	**12.1%**	11.8%
Low	**21.4%**	27.5%	33.8%	21.4%	23.3%	**25.8%**	25.2%	34.6%	**28.0%**	26.2%
Very Low	**3.1%**	2.5%	3.1%	4.0%	8.6%	**4.4%**	5.0%	10.0%	**6.5%**	5.1%
Higher	**75.6%**	70.0%	63.1%	74.6%	68.1%	**69.8%**	69.7%	55.4%	**65.5%**	68.7%
Lower	**24.4%**	30.0%	36.9%	25.4%	31.9%	**30.2%**	30.3%	44.6%	**34.5%**	31.3%

*Based on Binford's (1978) GMUI for sheep, maximum value per element

Cattle skeletal element representation shows little variability and does not differ statistically between periods (Table 9.8). Head (cranium and teeth) and limb fragments are most frequent and there are roughly equal proportions of higher- and lower-utility elements. While not significant, cattle utility follows the same pattern as seen in the smaller livestock, with a 15% decrease in high-utility elements through time.

There are significant differences in horse body part representation through time (Table 9.9). Note that the Early Period sample is very small and cannot be used in several of the statistical measures. Only the general categories of higher- and lower-utility elements can be compared across all three periods. This shows that the Late Period has significantly fewer high-utility portions than in the two earlier periods, a striking 70% decrease through time. Excluding the small Early Period sample, there are significant differences between Late and Florescent Period assemblages that are clearly related to food quality. The Late Period sample has far fewer meaty upper limbs and more low-utility lower limb and foot elements. As stated previously, the abundance of upper limbs in the Florescent Period sample is related to the bone pile features in this occupation (Phases 4 and 5).

Table 9.8: Cattle body part representation, all phases (% NISP)

	Early Period (Ph 6+)	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	Total On Tell
Anatomic Region										
Head	**43.8%**	46.2%	35.7%	37.7%	35.1%	**36.2%**	31.6%	41.8%	**34.2%**	36.4%
Axial	**3.8%**	2.6%	2.1%	1.6%	5.4%	**2.8%**	2.6%	5.1%	**3.2%**	3.1%
Upper Limb	**18.1%**	28.2%	30.8%	27.9%	25.7%	**28.1%**	24.7%	17.7%	**22.9%**	24.8%
Lower Limb	**19.0%**	17.9%	21.7%	18.0%	20.3%	**20.8%**	24.2%	24.1%	**24.2%**	21.9%
Foot	**15.2%**	5.1%	9.8%	14.8%	13.5%	**12.2%**	16.9%	11.4%	**15.5%**	13.8%
Utility										
Very High	**7.9%**	14.3%	10.9%	3.1%	10.0%	**8.4%**	5.6%	5.3%	**5.5%**	7.2%
High	**33.7%**	20.0%	20.3%	21.9%	30.0%	**21.6%**	23.4%	14.0%	**21.3%**	23.0%
Medium	**12.4%**	11.4%	17.2%	25.0%	10.0%	**18.0%**	18.3%	26.3%	**20.1%**	18.0%
Low	**20.2%**	42.9%	28.9%	28.1%	30.0%	**31.1%**	31.5%	35.1%	**32.3%**	30.1%
Very Low	**25.8%**	11.4%	22.7%	21.9%	20.0%	**21.0%**	21.3%	19.3%	**20.9%**	21.6%
Higher	**53.9%**	45.7%	48.4%	50.0%	50.0%	**47.9%**	47.2%	45.6%	**46.9%**	48.3%
Lower	**46.1%**	54.3%	51.6%	50.0%	50.0%	**52.1%**	52.8%	54.4%	**53.1%**	51.7%

*Based on Binford's (1978) GMUI for sheep, maximum value per element

Table 9.9: Horse body part representation, all phases (% NISP)

	Early Period (Ph 6+)	Ph 5	Ph 4	Platform	Ph 3	Flor. Period	Ph 2	Ph 1	Late Period	Total On Tell
Anatomic Region										
Head	**0.0%**	41.9%	25.6%	32.4%	38.2%	**30.5%**	23.1%	26.3%	**23.8%**	28.5%
Axial	**0.0%**	6.5%	3.1%	7.0%	1.5%	**4.1%**	3.1%	10.5%	**4.8%**	4.1%
Upper Limb	**73.3%**	35.5%	50.7%	23.9%	29.4%	**41.2%**	30.8%	15.8%	**27.4%**	39.8%
Lower Limb	**20.0%**	12.9%	14.8%	26.8%	16.2%	**16.5%**	24.6%	31.6%	**26.2%**	18.2%
Foot	**6.7%**	3.2%	5.8%	9.9%	14.7%	**7.7%**	18.5%	15.8%	**17.9%**	9.4%
Utility										
Very High	**40.0%**	26.1%	21.1%	10.2%	13.0%	**18.2%**	14.3%	0.0%	**11.4%**	17.8%
High	**20.0%**	26.1%	26.5%	20.3%	24.1%	**25.0%**	19.6%	14.3%	**18.6%**	23.8%
Medium	**26.7%**	43.5%	37.3%	27.1%	27.8%	**34.5%**	21.4%	21.4%	**21.4%**	32.1%
Low	**6.7%**	0.0%	8.1%	30.5%	16.7%	**12.8%**	23.2%	42.9%	**27.1%**	15.0%
Very Low	**6.7%**	4.3%	7.0%	11.9%	18.5%	**9.5%**	21.4%	21.4%	**21.4%**	11.4%
Higher	**86.7%**	95.7%	84.9%	57.6%	64.8%	**77.7%**	55.4%	35.7%	**51.4%**	73.6%
Lower	**13.3%**	4.3%	15.1%	42.4%	35.2%	**22.3%**	44.6%	64.3%	**48.6%**	26.4%

*Based on Outram and Rowley-Conwy's (1998) (S)FUI for horse, maximum value per element

Summary

The animal economy at Pecica shows great stability in some aspects but dramatic changes in others. Throughout the Bronze Age occupation, livestock husbandry was the central component of animal production systems. Large mammal hunting was of secondary importance, and smaller game, including fur-bearers, was hunted and trapped as well. Gathering mussels from the Maros River produced a large number of shells, but likely little meat. These shells may have also been used as flux in smelting. Fishing was a minor activity and bird and turtles were caught only rarely. There is some variability in the intensity these activities over time. The use of wild resources increased through time, especially mollusk collecting, fishing, and small-game hunting.

Within husbandry systems, ovicaprids were always the most frequent species, generally followed by pig, cattle, and then horses. The use of pigs increased steadily over time. Ovicaprid and horse abundance are inversely related, perhaps reflecting limitations on local high-quality grassland pasture. The importance of horses fluctuated greatly. They are unusually abundant in the Florescent Period, especially in Phase 4, when they occur in numbers equivalent to sheep and goats. At the same time, the number of other high-value animals increases.

The changes in taxon representation are mirrored by the reorganization of ovicaprid and horse husbandry systems. In the Early Period, sheep and goat secondary products (dairy/wool/hair) were very important. In the Florescent and Late Periods, they are being kept primarily for meat. Ovicaprid off-take is also tightly scheduled in the Florescent Period. Prime-aged horses are heavily culled during the Florescent Period, a highly atypical husbandry system for the Bronze Age. There is little change in herding practices for cattle and pig. Cattle secondary products, especially traction/labor, maintain their importance throughout the occupation and pigs show a rapid turnover system of meat production. There may be status related differences in pork consumption in the Florescent and Late Periods.

There are some changes in the proportion of skeletal elements associated with consumption of varying quality of meat through time, especially within livestock. All domesticates show a similar pattern in which there is an increasing frequency of the lowest-utility elements through time, although this is not statistically significant for all species. Nonetheless, it strongly suggests that in the period leading up to settlement abandonment, tell inhabitants were either extracting as much nourishment as possible from animal carcasses, which likely includes increased marrow and grease extraction from the lower limbs, or that there was less differentiation in the distribution of meat cuts between households of varying status. Also of note is the strong correlation of high-quality horse meat consumption and their overall abundance in the Florescent Period.

All of these changes indicate significant reorganization of animal production systems through the Bronze Age occupation. The most significant alterations occur during the Florescent Period, when there is much greater emphasis on the production and consumption of high-value species and meat, seen most clearly in the dramatic restructuring of livestock husbandry systems to focus on horse breeding. These factors underlying these changes in the animal economy are considered in more detail in Chapter 12, where these data are used to test expectations for contrasting levels of centralization.

PECICA ANIMAL ECONOMY: A SYNCHRONIC PERSPECTIVE

This fourth and final section evaluates variability in faunal assemblages between contemporary areas of the site, namely the central on-tell habitation and the peripheral settlement beyond the fortification ditches. The goal is to identify any differences in animal economies that reflect sociopolitical or other differentiation within Pecica's population during the Florescent Period. The variables used in the above section are also used for this analysis, where sample sizes allow.

The off-tell assemblage is from Bronze Age deposits in recovered from OTTU 4. These are divided into two major phases (Phases A and B) based on the nature of strata, associated features, and radiocarbon dates (see Chapter 6). Phase A contains several thick fill layers and an outdoor hearth (NISP=233). It is contemporary with Phase 3 on-tell. Phase B is contemporary with the Phase 4 on-tell occupation and includes Structure 10 and the debris layers immediately adjacent to and overlying it. There are 194 bones and shells from these contexts (Table 9.2).

Taphonomy

There are striking taphonomic differences between on- and off- tell faunal assemblages (Table 9.10, Figure 9.22, Appendix 9.2). There is a much higher fragmentation rate in off-tell contexts, with the average weight of bone pieces being less than half of on-tell materials. This may reflect two processes. First, this may result from more intensive bone processing, such as marrow and grease extraction. Second, this may be related to the greater proportion of smaller-bodied animals in the off-tell materials, resulting in a lower average weight per specimen. Because increased bone processing would render a greater number of elements non-identifiable, the higher rate of taxon identification off-tell suggests that the lower average bone fragment weight is due to an abundance of smaller-bodied species. There is also a much greater frequency of intrusive taxa off-tell, particularly in the Phase A deposits. This is a result of the relative shallowness of Phase A, where there is a very high level of recent bioturbation, especially burrows containing large numbers of Viennese banded snails (Table 9.2).[90]

Table 9.10: Summary taphonomic measures by phase, on- versus -tell contexts (% NISP)

	Ph 3	Ph 4	On Tell	Ph A	Ph B	Off Tell	Total
Fragmentation (avg g/bone)	11.7	16.6	**16.6**	6.7	5.3	**5.9**	**15.9**
Fragmentation (avg g/shell)	4.8	4.2	**4.3**	4.8	4.8	**4.8**	**4.5**
Identifiable*	43.7%	41.1%	**41.0%**	58.8%	63.9%	**58.5%**	**42.5%**
Intrusive Taxa**	0.5%	1.6%	**1.1%**	6.9%	1.0%	**4.2%**	**1.4%**
Weathered	0.1%	0.3%	**0.2%**	0.0%	0.0%	**0.0%**	**0.2%**
Animal Modification***	13.1%	16.7%	**15.2%**	3.9%	6.7%	**5.2%**	**14.3%**
Burned	4.5%	4.3%	**5.2%**	10.3%	4.6%	**7.7%**	**5.4%**
Calcined	0.9%	3.2%	**2.5%**	0.9%	1.5%	**1.2%**	**2.4%**
Butchery Marks	0.9%	0.6%	**0.7%**	0.0%	0.0%	**0.0%**	**0.6%**
Worked	0.6%	0.4%	**0.5%**	0.9%	0.0%	**0.5%**	**0.5%**
Total Modified Bone	**20.1%**	**25.6%**	**24.2%**	**15.9%**	**12.9%**	**14.5%**	**23.4%**

*Identifiable to genus or better
**Intrusive taxa are burrowing rodents/invertebrates and Medival human remains
***Inlcudes carnvivore gnawing, rodent gnawing, and digested bone

There is a much higher rate of bone modification in on-tell (24%) versus off-tell deposits (15%). This is particularly evident for rates of animal gnawing, which is nearly three times as frequent on-tell. Butchery marks are also significantly more common on-tell, despite their low representation (<1%), as they were not observed in the off-tell material. Weathered bones were also not recovered from the test units, but their absence is not statistically significant. The overall abundance of thermally altered bone does not differ statically, although there is a much

[90] The banded snails are of relatively recent origin as these fragile shells are complete (or nearly so) and retain their pigmentation, which rapidly fades through time.

higher proportion of calcined bone on-tell, which, as discussed previously, may be related to smelting. Worked bone occurs in equal frequencies within the two faunal assemblages.

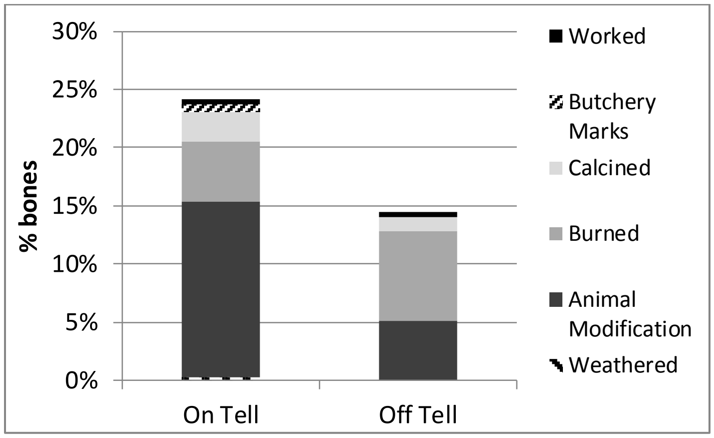

Figure 9.22: Bone modification (%NISP), on- versus off-tell contexts.

Taxon Representation

There are striking differences in taxon representation between on- and off-tell occupation areas and, in some instances, between Phases A and B as well (Tables 9.2 and 9.11, Figure 9.23). The combined off-tell sample is mammal dominated (60%), but there are relatively high frequencies of other animal classes, particularly mollusks (34%) and fish (5%). Bird and turtle remains are very rare (0.2%). Of the materials identifiable to genus or better, wild fauna are more abundant than domesticates primarily due to the large number of river mussels present. Excluding the mollusks, domesticates comprise 60% of the assemblage, wild mammals 24%, and other wild vertebrates 15%. While red deer are the most common mammalian game hunted (44%), there are substantial numbers of other species, particularly roe deer and hare. Sheep and goats (78% sheep) make up half of the livestock sample, followed by pig (29%), cattle (14%), and horse (6%). Overall, medium-sized animals comprise the bulk of the mammals (primarily sheep). In terms of species value, lower-ranked taxa, especially mussels and carp, are most common (63%) and there are few high value species present (10%).

Table 9.11: Summary taxon measures by phase, on- versus off-tell contexts (% NISP)

	Ph 3	Ph 4	On Tell	Ph A	Ph B	Off Tell	Ph 3-4 Site Total
Mammal*	89.4	89.7	89.7	65.9	53.6	60.1	**87.3**
Mollusk	10.2	8.6	9.1	28.6	40.1	34.0	**11.1**
Fish	0.4	1.5	1.2	5.5	5.2	5.4	**1.5**
Bird	0.0	0.2	0.1	0.0	0.5	0.2	**0.1**
Turtle	0.0	0.0	0.0	0.0	0.5	0.2	**0.0**
Domestic	64.2	67.1	65.6	34.9	18.5	26.8	**61.2**
Wild Fauna (incl. mollusks)	35.8	32.9	34.4	65.1	81.5	73.2	**38.8**
Domestic	83.7	84.7	84.1	68.8	48.9	60.4	**82.5**
Wild Mammal	15.5	11.3	12.8	21.9	27.7	24.3	**13.6**
Other Wild Vertebrates	0.8	4.0	3.1	9.4	23.4	15.3	**3.9**
Red Deer	84.1	84.9	84.2	64.3	23.1	44.4	**79.4**
Other Large Game	14.6	9.4	11.7	28.6	53.8	40.7	**15.2**
Other Small Game	1.2	5.7	4.1	7.1	23.1	14.8	**5.4**
Ovicaprid	36.1	29.5	32.3	51.2	50.0	50.8	**33.2**
Pig	31.5	23.8	26.3	30.2	27.3	29.2	**26.5**
Cattle	16.9	18.3	17.7	14.0	13.6	13.8	**17.5**
Horse	15.5	28.5	23.7	4.7	9.1	6.2	**22.8**
Large Mammal*	52.1	59.4	56.2	27.9	28.7	28.3	**54.6**
Medium Mammal	47.5	39.5	43.0	70.5	68.3	69.6	**44.5**
Small Mammal	0.4	1.0	0.8	1.6	3.0	2.2	**0.9**
High Value	32.3	39.4	36.4	13.6	6.5	10.1	**33.4**
Medium Value	43.7	37.0	39.4	32.0	22.0	27.0	**38.0**
Low Value	24.0	23.7	24.2	54.4	71.5	62.9	**28.6**

*All measures but these use only specimens identifiable to genus or better

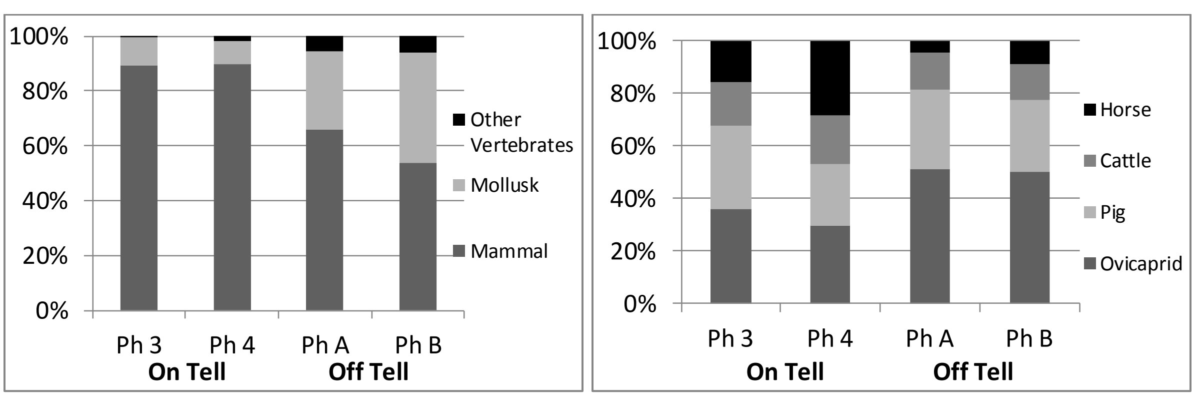

Figure 9.23: On- versus off-tell taxon abundance (%NISP). Left: faunal class, right: livestock.

There are some statistical differences between the off-tell occupation phases (Appendix 9.6). In the earlier Phase B, which is contemporary with Phase 4 on-tell, there are significantly fewer domesticates, reflecting the higher frequency of river mussels, birds, and turtles. There are also fewer large game animals present, particularly red deer. There is no statistical difference in livestock abundance. Primarily due to the contrasting wild faunal assemblages, there are significantly more low ranked taxa in Phase B.

The off-tell fauna differs greatly from the contemporary on-tell assemblage (Appendix 9.7). There is significantly more wild fauna in off-tell deposits (73% versus 34%), with the frequency of river mussels being the strongest contributor (34% versus 9%). However, even when excluding invertebrates, there is still substantially more wild animals off-tell (40% versus 16%), due to a greater abundance of fish, birds, turtles, and smaller-bodied mammalian game. The relative importance of livestock species also differs. There are significantly more ovicaprids in off-tell deposits, occurring 60% more frequently than on-tell. More striking is the difference in horse representation; there are nearly four times more horses in the on-tell livestock assemblage. All of these differences result in the large discrepancy in higher versus lower value species, with off-tell deposits having more than twice as many low-ranked taxa and less than a third the number of the highest value animals.

The comparison of on-versus off-tell fauna shows that the peripheral population did not have the same access to high quality meat as did the central tell inhabitants. Rather, they obtained a much greater proportion of their food from abundant, but relatively low-ranked wild fauna, especially mussels, fish, and smaller game. They also ate far more smaller-bodied livestock, particularly sheep and goat, and had very few horses. Also of interest are diachronic patterns between the on- and off-tell populations. The largest differences in higher versus lower value animals are found in Phase B/4. At this time, the on-tell population were consuming the highest levels of quality meat while the peripheral people were at their lowest, suggesting that socioeconomic differentiation was greatest during this peak period from roughly 1850-1750 cal. BC.

Demography

Ovicaprids

Age can be determined for five long bones and four mandibles in the off-tell sample. All of the bones are unfused (less than 2 years) except for a distal tibia (>10 months). The dentition is more varied and can be tentatively separated into sheep and goats. There are three sheep (2-5 months, 2-3 years, and 8-10 years) and one goat, 6-12 months old. Despite the small sample size, this age distribution suggests the use of both meat and secondary products, particularly for sheep, with the very old animal liked used as a wool producer. There are no sexable elements.

Pig

There are two ageable bones and six sets of ageable dentitions in the off-tell assemblage. The two bones (a fibula and a metacarpal) are both unfused (less than 2-2.5 years). The dental sample is a bit more informative. There is one fetal pig, one aged between 6-12 months, one from 12-15 months, and one between 1.5-2 years. There are no sexable elements. The age distribution does not appear to differ from an expected pig culling profile, which is found in contemporary on-tell deposits.

Cattle

The ageable sample from OTTU 4 is very small for cattle. There are two fused first phalanges and one fused metapodial, aged over 1.5 and 2-3 years respectively. For teeth, there is a moderately worn upper P4 from a younger adult. There is also a horn core from an old individual, greater than 15 years. The horn core and one of the phalanges belong to males. Little can be said about cattle demography, other than that adults, including very old individuals, are present. Again, the use of cattle for dairy or traction is likely, in addition to meat, as seen on the tell.

Horse

There are only two ageable horse bones from off-tell contexts. There is a fused metapodial from an individual older than 15-20 months. There is also a very lightly worn deciduous incisor from a neonate. It is not possible to compare these against on-tell horses.

Body Part Representation

As with taxon representation and taphonomy, there are significant differences in body part representation between on-tell and off- tell assemblages (Table 9.12, Appendix 9.13). For the combined mammalian sample, while the absolute differences are not great, there are significantly more lower limbs (50%) and fewer high utility elements (15%) in the off-tell assemblage. This suggests that the peripheral population had less access to higher-quality meat cuts overall.

Table 9.12: Body part representation, on- versus off-tell (% NISP)

	All Mammals*			Sheep/Goat*			Pig*			Cattle*			Horse**		
	On Tell	Off Tell	Ph 3-4 Total	On Tell	Off Tell	Ph 3-4 Total	On Tell	Off Tell	Ph 3-4 Total	On Tell	Off Tell	Ph 3-4 Total	On Tell	Off Tell	Ph 3-4 Total
Anatomic Region															
Head	31.6%	23.5%	**31.2%**	25.2%	21.2%	**24.9%**	46.1%	47.4%	**46.1%**	34.8%	44.4%	**35.2%**	29.1%	25.0%	**29.0%**
Axial	25.2%	31.4%	**25.6%**	0.7%	0.0%	**0.7%**	5.5%	5.3%	**5.4%**	3.1%	0.0%	**3.0%**	3.0%	0.0%	**3.0%**
Upper Limb	28.4%	22.9%	**28.1%**	47.5%	45.5%	**47.4%**	35.8%	42.1%	**36.1%**	28.1%	0.0%	**27.0%**	45.2%	25.0%	**44.9%**
Lower Limb	10.8%	16.3%	**11.1%**	25.2%	30.3%	**25.6%**	8.2%	5.3%	**8.0%**	22.8%	22.2%	**22.7%**	14.7%	50.0%	**15.2%**
Foot	4.0%	5.9%	**4.1%**	1.2%	3.0%	**1.4%**	4.5%	0.0%	**4.3%**	11.2%	33.3%	**12.0%**	8.0%	0.0%	**7.9%**
Utility															
Very High	27.6%	22.1%	**27.3%**	11.6%	6.3%	**11.1%**	16.7%	16.7%	**16.7%**	10.3%	0.0%	**9.9%**	19.3%	33.3%	**19.5%**
High	31.8%	31.3%	**31.8%**	39.3%	40.6%	**39.4%**	37.9%	44.4%	**38.3%**	22.7%	0.0%	**21.8%**	25.5%	0.0%	**25.2%**
Medium	9.1%	6.1%	**9.0%**	14.7%	15.6%	**14.8%**	11.0%	5.6%	**10.7%**	14.9%	0.0%	**14.4%**	35.4%	0.0%	**35.0%**
Low	25.7%	29.8%	**25.9%**	32.5%	34.4%	**32.6%**	29.1%	33.3%	**29.3%**	30.4%	50.0%	**31.2%**	9.9%	66.7%	**10.6%**
Very Low	5.9%	10.7%	**6.1%**	2.0%	3.1%	**2.1%**	5.3%	0.0%	**5.0%**	21.6%	50.0%	**22.8%**	9.9%	0.0%	**9.8%**
Higher	68.5%	59.5%	**68.0%**	65.5%	62.5%	**65.3%**	65.6%	66.7%	**65.7%**	47.9%	0.0%	**46.0%**	80.2%	33.3%	**79.7%**
Lower	31.5%	40.5%	**32.0%**	34.5%	37.5%	**34.7%**	34.4%	33.3%	**34.3%**	52.1%	100.0%	**54.0%**	19.8%	66.7%	**20.3%**

*Based on Binford's (1978) GMUI for sheep, maximum value per element

**Based on Outram and Rowley-Conwy's (1998) (S)FUI for horse, maximum value per element

For sheep and goats, a pattern similar to the general mammalian assemblage is evident although the differences are not statistically significant. There are slightly lower-utility elements in the off-tell assemblage, particularly lower limbs and feet, but the differences are less than 5%. The body part representation for pigs is nearly identical between on- and off-tell contexts. The frequency of higher and lower utility elements is not statistically different between ovicaprids and pigs. In short, the processing, consumption, and disposal of smaller bodied livestock was similar between the settlement's central and peripheral inhabitants.

However, body part representation for larger livestock differs significantly between on- and off-tell samples and from the smaller species. There is only a very small sample of cattle bones that were identifiable to element in the off-tell assemblage (NISP=9). Nonetheless, there are large and statistically significant differences present. In the off-tell area, only low utility elements were collected, all from crania, lower limbs, and feet. In addition, compared to sheep/goats and pigs, there are fewer higher utility cattle bones off-tell. There is no evidence that the peripheral population had regular access to high-quality beef. The off-tell sample of horse bones is far too small for statistical comparison (NISP=4).

Summary

During the Florescent Period (Phases 3 and 4), the faunal remains from on- and off-tell occupation areas show substantial (and statistically significant) differences that are largely related to socioeconomic status. The relative frequency of various animal taxa show that the off-tell population did not have the same access to high-value species as did the on-tell inhabitants. Off-tell inhabitants were consuming predominately smaller bodied livestock, like sheep, goats, and pigs, and utilizing a substantial number of relatively low-ranked wild resources, particularly smaller game, fish, and river mussels. Unfortunately, little can be said about differences in livestock husbandry practices given the small off-tell assemblages. Nonetheless, both areas show that livestock were raised both for meat and secondary products in a mixed-husbandry system. Both on- and off-tell areas have little primary butchery debris present, suggesting that there were peripheral middens where large and noxious waste likely was disposed of at some distance from habitation areas. Differences in body part representation between on- and off-tell occupations support the patterns documented in taxon abundance. The off-tell inhabitants had less access to high-quality meat cuts, especially beef, although there is less difference in smaller-bodied livestock processing and consumption. The much lower rate of bone modification supports the hypothesis that the off-tell occupation was less dense than on-tell.

CONCLUSIONS

This chapter comprehensively evaluated the faunal remains at Pecica Şanţul Mare through analysis of taphonomy, taxon representation, livestock demography, and body part representation. Where sample size and collection strategies allowed, these factors were compared between phases and occupation areas, highlighting temporal changes and spatial variability in animal production, processing, consumption, and disposal. Overall, basic components of the animal economy show stability through time. However, there are a number of significant changes occurring as well, including the relative importance of wild resources, livestock management strategies, and quality of meat consumption. These are summarized in Table 9.13.

Taphonomic measures demonstrate that the assemblages from most phases are comparable to one another, as documented by similar levels of fragmentation, identification rates, and proportion of invasive species. There are two major exceptions: Phase 6+ (Early Period) and the platform (Florescent Period). Materials from Early Period deposits were not collected systematically for the most part, which resulted in bias against small elements and small-bodied taxa. The platform, which was burned at industrial temperatures, also has differential destruction of smaller and more friable elements. These two contexts were excluded from comparative analyses where necessary.

Table 9.13: Summary of differences between on-tell periods and the off-tell area

	Early Period	Florescent Period	Late Period	Off-Tell
Taphonomy	lower modification rates	higher modification rates increased gnawing increased burning	lower modification rates	lower modification rates
Taxon Abundance	ovicaprid dominated	mixed husbandry	mixed but ovicaprid dominated	mixed but ovicaprid dominated
	few horses	horses very abundant	few horses	few horses
	under-representation small taxa	higher value animals more common	more low ranked wild taxa	much more low ranked wild taxa
Demography	secondary procucts for ovicaprids important	ovicaprid meat focus, tighty scheduled cull	ovicaprid meat focus	very small samples
	pig meat maximization	more juveile pigs, rapid turnover	more juveile pigs, rapid turnover	ovicaprid and pig profiles similar to on-tell?
	cattle traction focus	cattle meat focus and traction	cattle meat and traction focus	no prime aged cattle or horses?
	adult horses only?	more prime aged horses	more very old horses	
Body Part Representation	all taxa more high quality elements	all taxa more high quality elements	all taxa fewer high quality elements	ovicaprid and pig similar to on-tell
			horse lower utility dominant	no high quality cattle elements

? = tentative conclusion

In general, the average weight per specimen in the hand collected assemblages is moderately high (13g/bone), indicating good bone preservation and relatively low rate of intensive bone processing (e.g., grease rendering, etc.). Good preservation contributes greatly to the high rate of identification to genus or better, which averages around 43%. Overall, bone modification is frequent, especially in the Florescent Period, which may be related to the increased intensity of occupation at this time. Carnivore gnawing and burning are the most common modification classes. Butchery marks are infrequent, which in part reflects low-impact carcasses processing methods likely related to bronze tool use (see below). Weathering also occurs rarely, indicating that refuse was not exposed for substantial periods of time prior to burial. Bone tools make up only a small percentage of the faunal assemblage (see also Chapter 11).

Throughout the Bronze Age occupation, the importance of various taxa varies significantly. These temporal differences follow two general patterns, one of which shows relatively steady and unidirectional change and the other set that peaks/falls in the Florescent Period. The former set includes an increase in low-ranked wild resources use though time, especially river mussels, fish, turtles, and smaller game. Pigs also become more abundant. These changes may be related to a decrease in high-value animal/meat at Pecica in the time frame leading to site abandonment, but they also may be influenced by climate to some degree, especially in earlier periods. Further work detailing environmental change is needed to evaluate this hypothesis. The other set of changes is more directly related to production and consumption of high value animals, especially horses and large game. Horse production in particular stands out, as they become the focus of livestock management during the middle of the Florescent Period.

The demographic profiles underscore the changes occurring in livestock management systems. The greatest differences are found within ovicaprid and horse husbandry. In the Early Period, fiber and/or dairy production are primary goals of sheep keeping. In later periods, meat is the main resource. During the Florescent and Late Periods, ovicaprid production is more focused on meat maximization, and in the Florescent Period, off-take is tightly scheduled. As horse husbandry becomes central to pastoral systems in the Florescent Period, their use differs greatly as well. In this period, a substantial (and highly unusual) number of horses were being culled in prime age (5-10 years), presumably for meat. Further, this age class is disproportionally represented in the period's bone pile features, which are also dominated by high meat value elements from mares. These features are likely associated with ritualized feasting, and will be discussed further in Chapter 12. In contrast, Late Period horse mortality more closely follows a typical pattern in which horses tend to be maintained well into old age for their labor/transportation, although local breeding is still practiced.

Cattle and pig rearing does not change significantly through time. In all periods, a mixed husbandry system is employed for cattle, combining primarily meat production and use for labor/traction, but also diary. Pigs follow a standard rapid-turnover meat production system. However, there is some evidence for a more gourmet strategy in the Florescent and Late Periods given their higher proportions of suckling pigs.

Butchery practices are similar through time. Dismemberment was largely achieved by cutting between joints rather than through the bones themselves. Meat removal also seems to have been done with some care, with little trace of cut marks present. The lowest utility elements are strongly under-represented in all periods, a pattern which reflects the disposal of primary butchery waste away from the central habitation areas. Low value elements from large-bodied livestock were utilized more frequently than in smaller species. This likely reflects the greater net amount of nutrients that can be gained from these meat-poor elements in larger species, predominantly marrow from the lower limbs. However, as mentioned above, the relatively low fragmentation rates indicate that bones were not processed very intensively, as would be expected in grease rendering, for example.

Despite these similarities, body part representation studies indicate that there were significant differences in the amount of higher and lower quality meat consumed through time. There is a general trend for an increase in the use of lower utility elements from all livestock species. This may be the result of several processes, which are not mutually exclusive. There may be a general decrease in (or evening out of) relative social status in the Late Period, at least as manifested by access to quality meat. There may have also been an increase in resource stress, causing a greater need to extract more calories from carcasses. Interestingly, the greatest differences in meat quality per species are seen in horses. This is strongly related to the construction of bone pile features in the Florescent Period, which contain a disproportionate amount of the high value meat portions.

In addition to these significant temporal changes in the animal economy, there is also great synchronic variability. During the Florescent Period, people who were living on the tell were obtaining their meat in different ways and consuming different types and quality of meat from people who lived beyond the fortification ditches. The peripheral inhabitants were eating a much lower quality of meat in general, as seen in both the taxon and skeletal element representation. They were obtaining a greater proportion of their diet from low-ranked wild resources in particular, which they were most likely procuring directly. More of their meat also from ovicaprids and pigs and they had little access to high utility meat cuts from large-bodied livestock. In short, these differences indicate that not only is there a strong disparity in the consumption of quality meat, reflecting socio-economic inequalities between on- and off-tell populations, but also that peripheral groups were obtaining much larger portions of their meat through direct production/procurement.

In conclusion, the faunal assemblage demonstrates that the animal economy changed significantly over time. The strongest reorganization occurred during the Florescent Period. At this time, 1) livestock production was refocused on meat rather than secondary products, 2) livestock off-take was highly scheduled, 3) horse breeding became a principal component of husbandry systems, and 4) the on-tell population was consuming large quantities of the highest value meat. There was also substantial socio-economic variability between groups living on the central tell versus the periphery, which is characterized by both greater access to quality meat and perhaps provisioning for on-tell inhabitants. Changes in the animal economy that relate to differences in centralization are evaluated more systematically in Chapter 12, where specific expectations from Chapter 7 are tested.

CHAPTER 10: AGRICULTURE

Agriculture is the second pillar of the agro-pastoral sector. Like animal economies, crop production and distribution systems have not been well integrated within studies of Bronze Age complexity. This chapter provides the primary data used to evaluate the organization of the production, processing, distribution, storage, and consumption of plant resources. This includes plant remains themselves, as well as other artifacts and features associated with agricultural systems. Plant remains that can shed light on environmental conditions are also reviewed. Here, the focus is on data presentation and identifying basic temporal and spatial patterns. These are then used in Chapter 12 to test expectations for increasing centralized control over agricultural production and food distribution at Pecica.

CROP PRODUCTION

Archaeobotanical Evidence

The archaeobotanical assemblage itself provides the most direct means to evaluate crop production strategies. As outlined in Chapter 7, this analysis focuses on which crops were being grown and various cropping strategies employed as indicated by the wild plant species (e.g., intensity, areas under production, time and frequency of cropping, etc.). The analysis of seed remains is still ongoing by L. Motta and her students at the University of Michigan. To date, data is only available for Phases 3, 4 and the platform for the Florescent Period and Phase 2 for the Late Period. Flotations form the very earliest and latest occupations, Phases 1 (Late Period) and Phase 6+ (Early Period), have not yet been studied. The off-tell samples studied thus far all derive from Structure 10 except for one, so the occupation contemporaneous with Phase 4 on-tell is much better represented than the latter sequence. Because analysis was still ongoing at the time of this writing, along with the uneven number of flots studied from different contexts, the following discussion should be considered preliminary.

The archaeobotanical sample is diverse, with at least 71 discrete taxa represented in the 47 flots analyzed to date (Tables 10.1-10.4, Appendix 10.1). However, the vast majority are found either singly or in very low frequencies; only 14 taxa are represented by more than five specimens. Except for those from the burned platform feature, cultivars comprise the bulk of the seed assemblage (67%), although there is considerable variability between periods and individual contexts.[91] Wild taxa are significantly more common in the Late Period (Phase 2) than in Florescent Period contexts (Appendices 10.2-3). This may be caused by a variety of factors, such as less intensive production strategies, allowing more ruderal species grow amongst the crops, or that more crop processing took place on the tell itself during this period, resulting in a higher frequency of weed seeds versus grain (but see below). It is also possible that there was more wild vegetation growing on the tell due to a lower occupation density. Similarly, the greater abundance of wild taxa off-tell versus on-tell (Appendix 10.4) may be due to lower occupation density, but may also reflect more poorly cleaned grain or less well-maintained fields.

Table 10.1: Pecica botanical assemblage (non-wood) by phase (NISP), wild species listed by family

Category*	Ph 2	Ph 3	Platform	Ph 4	Off Tell	Total
einkorn wheat	69	135	15	94	56	**369**
other wheat	8	2		4	2	**16**
wheat (non ID)	55	62	16	59	25	**217**
barley	22	29	18	12	8	**89**
millet	2					**2**
cereal (non ID)	152	244	24	104	84	**608**
domestic legume	1	9	1	1	1	**13**
domesticates	**309**	**481**	**74**	**274**	**176**	**1314**
chenopod	98	49	57	23	26	**253**
grass	68	53	50	14	14	**199**
carnation	15	14	9	7		**45**
buckwheat	26	4	4		2	**36**
clover/wild legumes	3	6	7	5		**21**
mint	6	9	4		2	**21**
elderberry	4	2	7	1	5	**19**
nightshade	1	5	3		7	**16**
sedges	5	2		4		**11**
dewberries/rose family	2	3	1	1	2	**9**
other ID taxa (NISP < 5)	17	3	6	1	1	**28**
wild	**245**	**150**	**148**	**56**	**59**	**658**
total	***554***	***631***	***222***	***330***	***235***	***1972***

*inlcudes tentative IDs, whole seeds, fragments, and chaff combined (NISP)

[91] Compare representation by NISP versus ubiquity. Also, the platform is generally excluded from individual phase comparisons since its unique formation process appears to have substantially affected its composition, with high levels of wild species likely being introduced during its firing. In addition, there are only four samples, the smallest from any context.

Table 10.2: Pecica botanical assemblage (non-wood) summary by phase (%NISP)

Category	Ph 2	Ph 3	Platform	Ph 4	Off Tell	Total
crops	55.8%	76.2%	33.3%	83.0%	74.9%	66.6%
wild seeds	44.2%	23.8%	66.7%	17.0%	25.1%	33.4%
cereals	99.7%	98.1%	98.6%	99.6%	99.4%	99.0%
legumes	0.3%	1.9%	1.4%	0.4%	0.6%	1.0%
einkorn wheat	44.2%	59.2%	30.6%	55.6%	61.5%	53.2%
other wheats	5.1%	0.9%	0.0%	2.4%	2.2%	2.3%
non ID wheat	35.3%	27.2%	32.7%	34.9%	27.5%	31.3%
barley	14.1%	12.7%	36.7%	7.1%	8.8%	12.8%
millet	1.3%	0.0%	0.0%	0.0%	0.0%	0.3%
wheat	85.7%	87.3%	63.3%	92.9%	91.2%	87.1%
barley	14.3%	12.7%	36.7%	7.1%	8.8%	12.9%

Table 10.3: Pecica botanical assemblage (non-wood) by phase (% ubiquity), wild species listed by family

taxon	Ph 2	Ph 3	Platform	Ph 4	Off Tell	Total
einkorn wheat	76.9%	93.8%	100.0%	100.0%	75.0%	**87.2%**
other wheat	15.4%	12.5%	0.0%	33.3%	12.5%	**14.9%**
barley	53.8%	68.8%	100.0%	66.7%	50.0%	**63.8%**
millet	15.4%	0.0%	0.0%	0.0%	0.0%	**4.3%**
domestic legume	7.7%	18.8%	25.0%	16.7%	0.0%	**12.8%**
chenopod	76.9%	43.8%	75.0%	83.3%	62.5%	**63.8%**
grass	69.2%	75.0%	100.0%	66.7%	87.5%	**76.6%**
carnation	53.8%	31.3%	50.0%	33.3%	0.0%	**34.0%**
buckwheat	15.4%	25.0%	25.0%	0.0%	25.0%	**19.1%**
clover/wild legumes	23.1%	25.0%	50.0%	66.7%	0.0%	**27.7%**
mint	30.8%	37.5%	50.0%	0.0%	37.5%	**31.9%**
elderberry	23.1%	12.5%	50.0%	16.7%	25.0%	**21.3%**
nightshade	7.7%	12.5%	25.0%	0.0%	12.5%	**10.6%**
sedges	15.4%	12.5%	50.0%	50.0%	0.0%	**19.1%**
dewberries/rose family	15.4%	12.5%	25.0%	16.7%	12.5%	**14.9%**
total flots	13	16	4	6	8	**47**

Table 10.4: Density and diversity measures for Pecica botanicals

	PH 2	PH 3	PH 4	Platform	Late	Flor.	On Tell	Off Tell	Total
NISP crop	309	481	274	74	309	755	274	176	1314
NISP wild	245	150	56	148	245	206	56	59	658
# crop species	6	7	4	3	6	7	4	4	**9**
# wild species	47	41	17	21	47	49	17	17	**85**
# flots	13	16	6	4	13	22	6	8	**47**
volume (L)	103	142	54	36.5	103	196	54	68	**403.5**
crop seeds/flot	23.8	30.1	45.7	18.5	23.8	34.3	45.7	22.0	**28.0**
wild seeds/flot	18.8	9.4	9.3	37.0	18.8	9.4	9.3	7.4	**14.0**
crop seeds/L	3.0	3.4	5.1	2.0	3.0	3.9	5.1	2.6	**3.3**
wild seeds/L	2.4	1.1	1.0	4.1	2.4	1.1	1.0	0.9	**1.6**
crop species/flot	0.46	0.44	0.67	0.75	0.46	0.32	0.67	0.50	**0.19**
wild species/flot	3.62	2.56	2.83	5.25	3.62	2.23	2.83	2.13	**1.81**
crop species/L	0.06	0.05	0.07	0.08	0.06	0.04	0.07	0.06	**0.02**
wild species/L	0.46	0.29	0.31	0.58	0.46	0.25	0.31	0.25	**0.21**

*Exlcuding the platform

By NISP, less than 2% of the crop specimens are legumes but they are present in 13% of the flots. These include fava beans (*Vicia faba*), pea (*Pisum sativum*), and lentil (*Lens culinaris*). All of the fava beans came from a single flot from the C5 fill layer (Phase 3). The other legumes are found as single seeds in various contexts. The bulk of the grain is wheat, overwhelmingly einkorn (*Triticum monococcum*), comprising 78% of the cereals identified to species and 96% of all the wheat seeds. Other wheats are infrequent and may be unintentionally mixed within einkorn fields. These include emmer (*T. dicoccum*), bread wheat (*T. aestivum*), and "new glume wheat" (Jones, et al. 2000). Barley (*Hordeum vulgare*) is the second most abundant cereal. Thus far, only 6-row barley has been securely identified, although others cannot be excluded (L. Motta, pers. com. 2013). While there is little difference in barley representation by ubiquity, the NISP values show that barley seeds are about twice as common in the Phases 2 and 3 (13-14%) versus Phase 4, both on and off-tell (7-8%).[92] Interestingly, the proportion of the various cultivars is virtually identical between contemporary on- and off-tell contexts.

Although barley is less common than einkorn overall, it dominates in one particular context from 2005 that was not included in the 2012 summary report from which this analysis derives. I mention it here as it is a unique and informative deposit. The feature is a either a thermal feature (hearth/oven) or a clay lined basin that subsequently burned. It was found in

[92] Note that barley is very frequent in the platform, where it comprises 37% of the grains and is found in all samples.

deep layers within Trench 1 (Phase 6+, Early Period) and may be associated with a burned house. This feature was filled with several liters of charred barley, hundreds of grains of which have been counted so far. While it is still being processed, it does appear that the barley was thoroughly cleaned, having only a couple of chaff pieces, weed seeds, and a single wheat grain present (L. Motta, pers. comm.). Lastly, there are two tentatively identified common millet grains (cf. *Panicum miliaceum*), both recovered from Late Period contexts.

Interestingly, there is no evidence of fiber and oil plants at Pecica, despite their presence at other Bronze Age sites. In fact, flax (*Linum usitatissimum*) thread was recovered from the Lower Maros cemetery of Szőreg (Gyulai 2010). Edible wild fruit and berries are uncommon, only represented by a few raspberry (*Rubus cf. idaeus*), dewberry (*R. caesius*), elderberry (*Sambucus sp*.), and wild strawberry (*Fragaria vesca/potentilla*) seeds. There are no nut species. Other plants that are sometimes consumed include common mallow (*Malva cf. neglecta*) and sheep's sorrel (*Rumex acetosella*). While not a food plant, sedges (*Carex* spp.) were used for building materials. There does not appear to be been much use of wild plant foods, at least those parts with seeds.

The wild seeds from Pecica are informative, but can also be a bit problematic as it is not always clear how they arrived on the tell and became charred. There is only a single sample that represents an intentional grain deposit that provides a direct link between crops and their associated segetal weeds, which is the aforementioned 2005 deposit. In addition, only four of the flotation samples meet Bogaard's (2004a) minimum criteria for analysis of crop-weed associations (at least 30 weed seeds and 50 crop seeds).[93] However, none of these are from discrete contexts that would likely preserve the seeds' original association. Rather, they are all from general fill deposits. As a result, the wild seeds could have been brought in along with harvested crops, but also through animal feed or waste, incidentally through various daily activities, or been growing *in situ*. Nonetheless, wild seeds do provide a good proxy measure of the types of plants growing on and around the settlement, as well as the habitats that were most commonly utilized by the site's inhabitants.

By family, the wild taxa do not vary greatly through time, with the exception of the buckwheats (Polygonaceae), which are significantly more frequent in the Late Period. There are no marked differences between contemporary on- and off- tell wild taxa. The vast majority

[93] Actually, two of these samples have only 29 weed seeds.

(nearly 70%) of the wild seeds are from chenopods and grasses, attesting to the importance of open grassland and disturbed areas around the site, including crop fields and pasture land. There are also families associated with wetlands and woodlands present, but these occur comparatively small numbers.

It is more informative to focus on wild species that are indicator species for particular habitats rather than larger taxonomic groupings, as there may be considerable variation between species within the same family in terms of their ecological tolerances. The following analysis uses ecological parameters and plant community associations established by Ellenberg (1988), presented in Appendix 10.1. For each species, Ellenberg presents standardized values that measure the plant's preference for light, temperature, water (soil dampness), reaction (soil pH), soil nitrogen levels, and their association with general European climate zones (continentiality). Sample size is greatly reduced using this method since it requires species level identifications and some taxonomic groups are under-represented due to their low identification rates to species, especially the grasses. Statistical comparisons can only be made between the aggregated Late and Florescent Period assemblages (Appendix 10.5).

Ecological indicator values for Pecica's wild flora provide rich data on the general environment around the settlement and appear to mirror patterns seen in the distribution of plants by family (Table 10.4).[94] The frequency of species falling into different classes of continentality (general climate), light (open versus shaded areas), and reaction (soil pH) does not differ between periods. There is a large and relatively even range of species with different light tolerances, from shade/half shade (associated with woodlands) to light loving (open grasslands, meadows, etc.). There are plants representing oceanic to continental climates, with most of the species (>50%) falling into the oceanic to suboceanic range, typical of modern Central European floras that also range to the east. The others primarily are associated with more eastern subcontinental/continental zones. There is less variability in soil pH values. The majority prefer neutral to basic soils, which reflects the loess plateau and its chernozems on which the site was built, as well as redeposited loess in the floodplain below. The more acid-tolerant species are associated with stagnant wetland and wooded habitats in the floodplain. This suggests that the major land classes around the settlement were being used similarly in both periods.

[94] The percentage of individual species represented (rather than NISP of seeds) does not differ greatly from Table 10.4 and is not presented here.

Table 10.5: Pecica weed species ecological indicator values by period NISP (significant values in bold)

Temporal Change	Late	Florescent	No Temporal Change	Late	Florescent
cool to warm	0.0%	5.8%	shade/half shade	23.5%	27.3%
fairly warm	53.3%	61.6%	half to partial shade	19.6%	20.2%
fairly warm to warm	35.6%	30.2%	partial shade	19.6%	22.2%
warm	**11.1%**	2.3%	partial shade to light loving	7.8%	3.0%
TEMPERATURE			light loving	29.4%	27.3%
			LIGHT		
dry	3.2%	3.8%			
dry to moist	**69.5%**	49.7%	oceanic	9.3%	8.8%
moist	23.2%	33.3%	oceanic to suboceanic	60.5%	55.0%
moist to damp	**2.1%**	8.2%	suboceanic to intermediate	16.3%	15.0%
damp to wet	2.1%	5.0%	subcontinental to continental	14.0%	21.3%
WATER			CONTINENTALITY		
nitrogen poor	4.0%	1.3%	acid to fairly acid	12.9%	18.2%
poor to average nitrogen	7.1%	7.5%	neutral	71.0%	50.0%
average nitrogen	6.1%	4.4%	neutral to basic	16.1%	31.8%
average to rich nitrogen	77.8%	70.6%	REACTION		
nitrogen rich	**5.1%**	**16.3%**			
NITROGEN					
forest/riparian	23.5%	35.8%			
grassland/pasture	**13.3%**	6.2%			
crop weed/disturbed	63.3%	58.0%			
GENERAL HABITAT					

The frequency of plants with other ecological indicators does provide evidence for environmental changes,[95] different land use, and potentially cropping strategies through time. The vast majority of plants (~90%) in both periods are associated with fairly warm to warm temperatures. However, in the Late Period there are no cool species and there are significantly more warmth indicator taxa, suggesting a warming trend through time. The water tolerances of represented species vary greatly, but at least half of the seeds come from plants that prefer moist to dry areas. These, along with the dry taxa, likely originate from the terrace while the more water tolerant species may be found in the floodplain. In the Late Period, there are significantly more dry and fewer moist to damp species, suggesting that the warming trend was also associated with increasing aridity. This fits expectations for changes associated with the warmer, drier period occurring after c. 1800 cal. BC (see Chapter 4), which is supported by new geomorphological data for the region (Sherwood, et al. 2013). Alternatively, this pattern could

[95] While the seed data are suggestive, the environmental changes should be confirmed with palynological data.

also reflect less use of lowland habitats, but this does not appear to be supported by the soil pH data.

The nitrogen values are important for assessing soil fertility. Most of the seeds derive from plants that are found on nitrogen-rich soils. These are primarily members of the Chenopodietea family (especially *Chenopodium album*/white goosefoot),[96] which are ruderals and weeds of arable and frequently disturbed land that would have been common, if not the dominant, land class in and surrounding the settlement. Importantly, there is a significant decrease in the number of plant seeds found in highly nitrogen rich areas through time. Some of these are floodplain and forest edge species, including edible fruits like raspberries and elderberries, whose decrease may be related to environmental change (increasing aridity). However, most of these are arable weeds, including members of the *Polygono-Chenopodietalia* plant association group, which is strongly associated with spring crops and/or more intensive agricultural practices (e.g., hand cultivation, manuring, etc.). This suggests that there may have been a decrease in intensive cultivation practices through time.

Lastly, Pecica's wild seed assemblage is comprised primarily (~60%) of species found in disturbed areas, either around human habitation or in crop fields. There are also substantial numbers of plants from floodplain and forest environments (including wet forests, like fens or gallery forests), about 25-35%, and smaller numbers of grassland and pasture plants (6-13%). The frequency of grassland/pasture plants more than doubles in the Late Period, primarily due to the increase in dry-grass species (versus wet meadow), again indicating increased aridity though time. It is informative to examine these ecological groups in more detail as well. The woodland species are primarily those found in oak-beech forests (e.g., *Moehringia trinervia*/three-nerved sandwort) in drier, more elevated areas, indicating some forest stands on the plateau. The remainder are associated with damper forests, including fens and other lowland/riverine woodlands. The pasture plants are highly variable, with a mix of species from wet meadows to those of drier, calcareous uplands. While not able to be assessed in detail, we must not forget the very large number of grass seeds not identifiable to species (Poaceae), which would greatly increase the contribution of grassland and pasture species. The disturbed habitat species are principally arable/waste land and garden weeds (especially *C. album* and other Chenopodietea).

[96] *C. album* can also be cultivated. Gyulai (2010) notes several Bronze Age settlements in which cleaned deposits of white goosefoot likely represent their use as food, perhaps as a crop replacement.

However, there are also a variety of non-anthropogenic floodplain, river bank, and forest edge taxa, all occurring in small numbers. Interestingly, there is only a single seed from a true freshwater wetland habitat. It is from *Galium cf. palustre* (common marsh-bedstraw), which is a character species of tall sedge swamps.

It is more difficult to assess crop weed species as they relate to husbandry practices as the seeds may have been brought to the site in a variety of ways. Clearly, a variety of habitats were being exploited, but whether these reflect areas of crop production is uncertain given the general lack of weed seeds directly associated with crop stores. Crop weeds are typically divided into fall (wheat) and spring crop (wheat, barley, millet, legumes) species. Fall planting weeds are primarily those belonging to the *Secalinetea* group, none of which were identified at Pecica. Other possible winter crop weeds from the *Molinio-Arrhenatheretea*, *Sedo-Scleranthion*, *Bidention tripatitae* plant associations only comprise 4% of the potential crop weed sample, all from the Florescent Period contexts. Note that the first two groups also pasture plants and Bogaard (2004a) suggests that these may be associated with extensive plow agriculture. Spring/summer weeds are more ambiguous as they are also associated with more intensive crop husbandry practices like hand cultivation and manuring, especially the *Polygono-Chenopodietalia* group, so they may also occur in winter crops. Many of these are also ruderals that thrive in disturbed areas around human settlements, particularly the Chenopodietea. At Pecica, *C. album* dominates the assemblage of what are typically considered spring crop weeds, but again, this is also a common ruderal species and it may have been harvested as well. The only member of the *Polygono-Chenopodietalia* group is *Chenopodium cf. polyspermum* (many-seeded goosefoot), and this is only represented by six seeds, all of which were recovered from a single flot (layer C4/5 fill, Phase 3). The cleaned barley cache is the best direct indicator of crop weeds. Only three weed species were found (four seeds). Two of these were chenopods, one was a buckwheat (*Polygonum sp*.), and one was a wild mustard/turnip *(Brassica rapa*). The first two, while not yet identified to species, are likely taxa that are typical spring cereal weed species found in barley crops (*Chenopodietalia/Polygeno-Chenopodietalia*).

Unfortunately, this assemblage only provides tentative insight into agricultural practices given the nature of the deposits. It appears that few of the weed seeds are directly associated with crop stores and these may instead primarily reflect the natural background vegetation, especially given the great abundance of white goosefoot (although its harvesting cannot be excluded at this point). The absence of specifically identified *Secalinetea* winter weeds is unusual and possibly argues against sowing wheat in the fall. However, this seems unlikely given the widespread practice of fall sowing both prehistorically (including other Bronze Age sites) and historically (Bogaard 2004a; Gyulai 2010). Additionally, there are of number of seeds (n=10) only identified to genus that may be winter crop weeds, depending on which particular species actually they are (e.g., *Avena*, *Bromus*, *Galium*, *Lolium*). There are also a few specimens (n=6) that may represent other winter wheat weeds, but these are more ambiguous as found in multiple habitats. Spring/row crop/intensive cultivation weeds seeds are far more common, comprising 95% of the sample.[97] Even if excluding *C. album*, which may have been harvested, they still comprise 75% of the assemblage.[98] The very low number of more reliable crop indicators (*Polygono-Chenopodietalia*, n=6) complicates evaluation. Nonetheless, it does seem that either most of the cereals were sown in the spring and/or that the winter wheats were grown with fairly intensive methods, perhaps including manuring. Importantly, potential crop weeds that require very high nitrogen levels occur three times more frequently in the Florescent versus Late Periods, suggesting that more intensive practices were used in this period. Analysis of modern flora and crop-weed associations in the study area would greatly improve our understanding of Pecica's wild seed assemblage and its relationship to farming systems (Bogaard 2004b).[99]

Technological Evidence

There is little direct evidence of technologies used in agricultural production at Pecica, a problem common to the Bronze Age in general given that most farming implements were made of perishable materials in this period. This includes some critical technologies used in more intensive crop production, like plows and heavy-transport vehicles. From various lines of direct and indirect evidence (Bartosiewicz, et al. 1997; Bogucki 1993; Bóna 1960; Milisauskas and Kruk 1991; Sherratt 1981, 1997), we know that ards (scratch plows) and ox-carts had been in use since at least the local Late Copper Age and were likely used by the Maros people as well. The

[97] 90% when including the more ambiguous winter species.
[98] But only half if including the ambiguous winter seeds.
[99] See Bogaard (2004) for a valuable overview of the "FIBS" method using modern, local floras and its advantages over Ellenberg's system.

demographic profile of Pecica's cattle, as well as associated traction pathologies, supports this argument (see Chapter 9).

Pecica does have a modest number of smaller agricultural implements made of durable materials (Table 10.5). The tool most directly linked to farming is also the most abundant: chipped stone sickle blades (see Figure 11.11).[100] These trapezoidal or semi-circular lithics are denticulated and primarily made from chert and related raw materials. They typically show heavy sickle sheen.[101] Other tool types can only be indirectly linked to agricultural production. Some of the large hafted antler implements, like the hammers/adzes and picks, may have been used in farming for various digging tasks. The antler adzes may also have been used to fell trees for land clearance, along with stone axes. More detail about these artifact types can be found in the worked bone and stone sections of Chapter 11.

Table 10.6: Pecica agricultural implements by phase (count and density)

		count				density (#/1000 L)			
Phase	vol (L)	sickle/ dentic.	heavy antler tools	stone axe	querns/ ground stone*	sickle/ dentic.	heavy antler tools	stone axe	querns/ ground stone*
1	34813	1	1	1		0.03	0.03	0.03	0.00
2	47268		4		13	0.00	0.08	0.00	0.28
3	10916	5		1	2	0.46	0.00	0.09	0.18
P	23815	2	1		4	0.08	0.04	0.00	0.17
4	7653	3	1	1	6	0.39	0.13	0.13	0.78
5	4588	1	1			0.22	0.22	0.00	0.00
Late	82081	1	5	1	13	0.01	0.06	0.01	0.16
Florescent	46972	11	3	2	12	0.23	0.06	0.04	0.26
On Tell	18569	8	1	2	8	0.43	0.05	0.11	0.43
Off Tell	1582					0.00	0.00	0.00	0.00
Total	**129053**	**12**	**8**	**3**	**25**	**0.09**	**0.06**	**0.02**	**0.19**

note: excludes 2005 materials
*includes fragments not idenifiable to specific artifact class and those not yet examined

The frequency of sickle blades changes significantly through time. They are far more common in the Florescent Period compared to the Late Period, where only a single specimen was

[100] Metal (bronze) sickles are not used until the later Bronze Age.
[101] It is also possible that these were also used for cutting reeds (e.g., for mats and thatching). Residue analysis would help to identify the range of plants being harvested with denticulates.

identified.[102] Heavy-duty antler tools and stone axes are less frequent artifacts than the sickles. Antler digging tools are found in similar densities throughout the occupation. The stone axes are too uncommon to compare in a statistically meaningful way. Note that the density of worked bone and ground stone items is directly related to overall occupation debris density but chipped stone is not. The strong variability in chipped stone abundance appears to be affected by intensity of long-distance exchange over time (see Chapters 11 and 12).

The spatial distribution of agricultural implements by period is presented in Figure 10.1. In the Late Period, the tools are predominately antler and are concentrated in the southern portion of the block. This largely mirrors the distribution of undisturbed layers (see Figure 11.1). Similarly, while farming artifacts in the Florescent Period appear to be clustered around the structures, few of the deposits underlying the platform were excavated, which accounts for their under-representation in the eastern half of the block. Further excavations in these layers will clarify patterning. Nonetheless, a disproportionate number of tools were found in the areas within or immediately outside the structures, including a cluster of three sickle blades just external to Structure 2 (Phase 3). No items associated with farming were found in secure Bronze Age off-tell contexts, but given the small volume excavated, this is likely spurious. Several sickle blades were also found in disturbed off-tell deposits, but given their ambiguous contexts, they are not included here. At least one of these does resemble those found on-tell and likely originates from the Maros occupation, suggesting that there were in fact harvesting tools present in the peripheral habitation area as well. While the available data are limited, it appears that all households were engaged in crop production, even those inhabiting the central tell.

[102] There are five unidentified lithics from Late Period contexts and three from the Florescent Period, which may alter these figures to a minor degree.

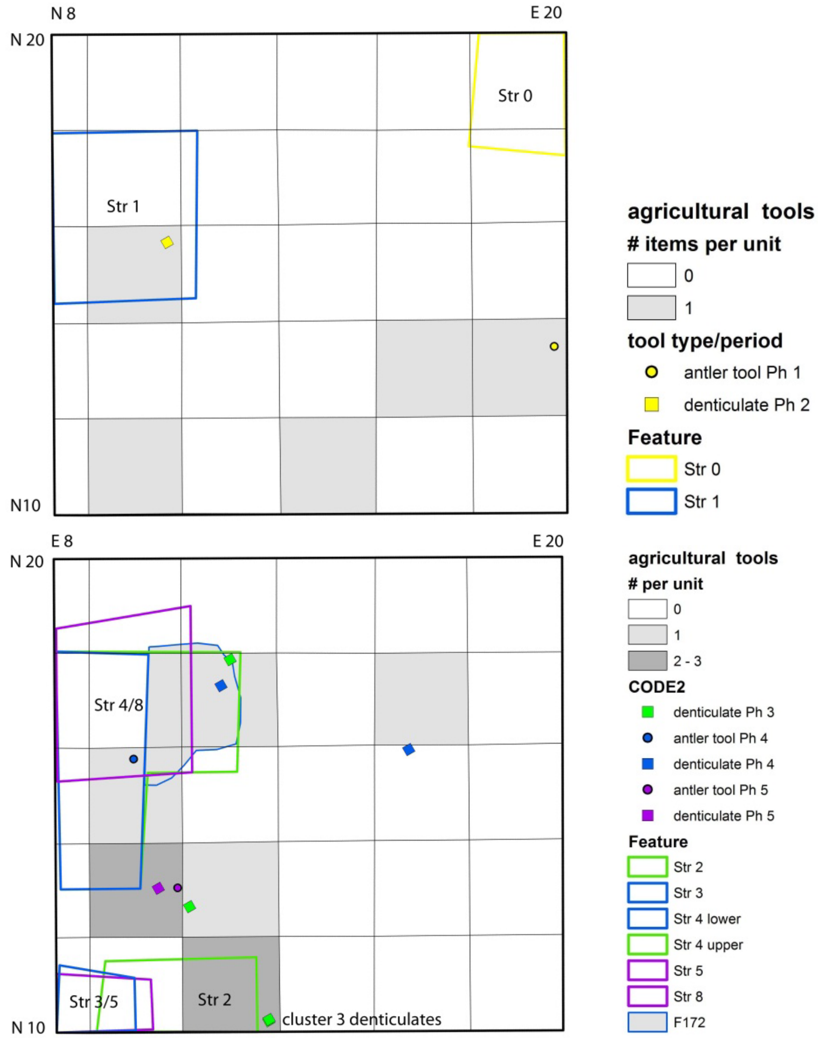

Figure 10.1: Spatial distribution of agricultural implements. ***Top:*** **Late Period,** ***Bottom:*** **Florescent Period.**

CROP PROCESSING, DISTRIBUTION, AND STORAGE

Archaeobotanical Evidence

The best evidence for grain processing is found in the plant remains themselves. The frequency of chaff to clean cereal seeds can be used as a proxy for processing stage, with higher frequencies of chaff expected in areas where processing occurred and lower values for areas with primary end stage clean grain (Hillman 1983, 1985; Jones 1983). There is considerable variation in the frequency of chaff over time. Higher proportions are found in the Florescent Period than in the Late Period, with particularly large values in Phase 4 (Table 10.7). There is also more chaff in contemporary on-tell versus off-tell deposits.

Table 10.7: Pecica cereal seeds and chaff by phase (NISP)

	Ph 2	Ph 3	Platform	Ph 4	Off Tell	Total
seeds	245	385	46	157	113	946
chaff	61	87	14	116	62	340
	306	472	60	273	175	1286
seeds	80.1%	81.6%	76.7%	57.5%	64.6%	73.6%
chaff	19.9%	18.4%	23.3%	42.5%	35.4%	26.4%

It is not immediately apparent why there is so much chaff in Phase 4, especially in on-tell contexts. There may in fact be a greater amount of uncleaned grain brought onto the central tell and further processed during the Florescent Period. However, as with the weed seeds, it is not clear how the chaff is entering the archaeological record. Aside from the single 2005 sample of cleaned stored barley (Phase 6+), there is no other direct evidence of grain stored in various stages of processing or actual processing areas (e.g., threshing floors, winnowing areas). The chaff may derive from *in situ* winnowing/flinging, with occupation density constraining processing areas to near houses in the Florescent Period versus later periods. There are also alternate uses of chaff, for example as pottery temper, daub temper, animal feed, or fuel. Gyulai (2010) has noted two "workshop" areas from the Bronze Age settlement of Albertfalva where tailings appear to have been used as a fuel source. It should be noted that there are very large differences in the percentage of cereal chaff by individual contexts within each phase, ranging from 0%-80%. The much smaller number of samples from Phase 4 may be causing significant sampling bias. At this point, it is not possible to clarify the cause of this particular temporal and spatial distribution of chaff, but the data do not seem to support on-tell provisioning of cleaned grain. Additional flotation samples must be analyzed to verify or refute patterns.

Processing stages can also be assessed by examining the size ranges of weed seeds as their representation changes through processing stages. Sieving and winnowing will selectively remove the smallest seeds first, with primarily the larger grains (those being closest in size to the cereals themselves) being maintained into cleaned grain stores, as these must be sorted out by hand. These tend to be winter weed seeds (hence their absence from the barley store), and their occurrence is also predicated on season of planting. As discussed previously, possible *Lolium, Avena, Bromus*, and *Galium* winter crop weeds have only been identified to genus, so they may not actually be the specific weed species in question. They also occur in very low numbers, especially when compared to the chenopods. Including possible crop weeds identified only to genus, there is no statistical difference in the representation of seeds of different size classes between periods. This may support the hypothesis that the large amount of chaff in the Florescent Period (especially Phase 4 on-tell) may be related to the use of chaff stores (from flinging and winnowing) for various activities versus general/mixed grain processing tailings or fine sieving remains (primarily small seeds).

Lastly, the ratio of weed to crop seeds may also be used as a general measure of cleaned versus unprocessed grain. As discussed above, weed seeds occur at a greater frequency compared to crops in the Late Period and off-tell. This may support some degree of on-tell provisioning during the Florescent Period. However, this may also reflect different crop husbandry practices, especially those related to the level of intensity, as well occupation density.

Technological Evidence

Grain processing technologies, like those for crop production, generally leave few archaeological traces as these implements are also frequently made from perishable materials (e.g., threshing forks, winnowing baskets, etc.). The only implement made from a durable material are grinding stones. These are also of limited use for interpreting crop processing as these are used for the final stages, for grinding cleaned grains.[103] Grinding stones can be difficult to identify as such if they are fragmented, as ground stone is also used for axes, casting molds, and other items. More information about the groundstone sample can be found in the stone working section in Chapter 11.

Only seven items have been specifically identified as grinding stones. There are also eighteen ground stone items that either cannot be precisely identified to type or have not yet been analyzed. There is very little difference in the density of (potential) grinding stones through time (Table 10.5). The relatively high density in Phase 4 must be tempered by the fact that at least two of these directly refit and there is another piece that may be from the same rhyolite quern. The overall density of groundstone is directly related to overall occupation intensity (see next chapter). The spatial distribution of groundstone items (querns and non-identified specimens) is presented in Figure 10.2. Note that the three additional quern fragments from Phase 4 were found in the area between Structure 3 and 4, near to the piece-plotted specimen in the map. Interestingly, unlike the harvesting and planting tools, grinding stones are generally found in the

[103] They can also be used to grind minerals, such as pigments or ores prior to smelting.

open areas rather than within or immediately adjacent to specific structures. This suggests that grinding (or at least deposition of broken or abandoned grinding stones) was done in open areas rather than within houses. Grain grinding was occurring on the tell in all periods and is associated with all households.

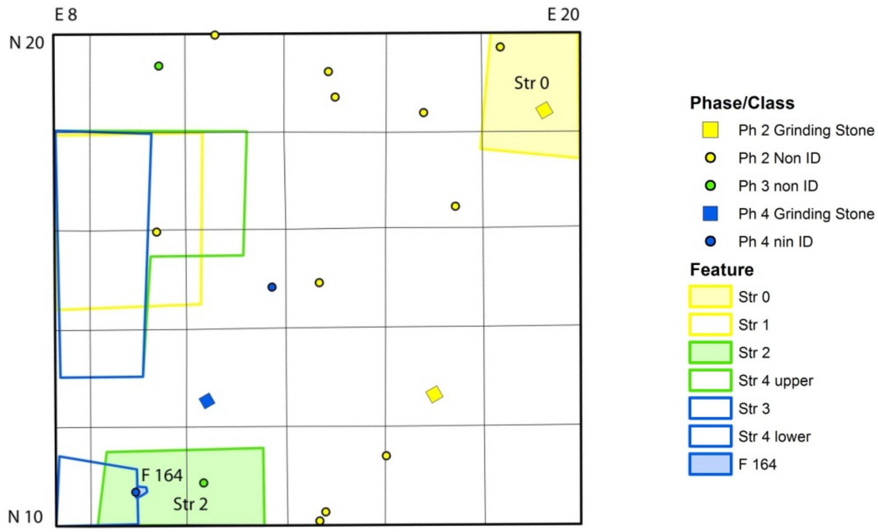

Figure 10.2: Spatial distribution of groundstone (piece plotted grinding stones and non-classified specimens only). Shaded features contain artifacts, platform specimens not shown.

The type and size of grain storage facilities can be used to evaluate differential distribution and accumulation of agricultural products. Unfortunately, there is little direct evidence for grain storage at Maros or other Bronze Age sites in the Carpathian Basin. External granary structures have not been identified to date. It has been argued elsewhere that large quantities of grain were stored in the rafters of houses based on charred remains from burned structures (Csányi and Tárnoki 2003). It is also assumed that the large pits frequently encountered at Bronze Age sites were for grain storage, some of which were lined or fired (Gyulai 2010). There is little direct evidence that these were actually used to store grain however. There have been only a small number of burned *in situ* grain deposits found, including at least three cases in which charred grain was found inside pots that were stored in pits: Ároktő-Dongóhalom, Füzesabony culture (Gyulai 2010) and two Maros settlements, Semlac Şanţul Mic (Oas 2010) and Klárafalva Hajdova (Jones n.d.). Storing grain within pots in pits would obviate the need to line the pits themselves. Note also that pits may contain potted stores of different types of grains, as seen at Klárafalva, where separate vessels contained barley, einkorn, and possibly einkorn chaff. The latter also supports the idea that the chaff was used for various purposes and that its presence is not necessarily a sign of *in situ* threshing areas.

At Pecica, there is similarly little direct evidence for grain storage features. As discussed above, there is a single *in situ* burned grain deposit from within either a hearth or shallow lined basin in Phase 6+. This was not a large store, but rather cleaned grain in the amount used for a single or a few meals (several liters). It is possible, given the distribution of chaff (discussed above), that grain was generally stored uncleaned in larger facilities (perhaps rafters, large pits, large storage vessels?) then cleaned for use when needed and stored short term in basins or small pots. Large storage pits dating to the Bronze Age have been encountered only infrequently thus far at Pecica, but this may be due to a variety of reasons, not the least of which is the relatively small area of undisturbed deposits excavated outside of the major structures and features to date. Only one large pit has been found within any of the houses encountered thus far (F160 in Structure 4) and there is a lined basin (empty when encountered) within Structure 3 which may be analogous to the burned grain storage feature from Trench 1. Minimally, these suggest some level of household grain storage. Future excavations will no doubt help to answer this question.

Currently, the best way to evaluate grain storage is by examining ceramic storage vessels. Unfortunately, these data are also limited as the on-tell ceramic assemblage has only been documented in detail for materials from 2008 and 2009,[104] and the primary data were still undergoing further analysis at the time of writing this thesis. There is also a small ceramic collection from off-tell deposits that I studied in 2011. This allows a basic comparison of frequency of storage vessels within Florescent Period contexts (Table 10.8). In off-tell contexts, there are statistically fewer storage vessels within the ceramic assemblage (18% versus 34%), which largely reflects the absence of prestige storage vessels in this peripheral occupation area.[105] However, some of these vessels, especially the burnished fine ware varieties, may have been used to store liquids.

[104] By John O'Shea and Meghan Howey in 2010.
[105] X^2=12.5311, df=4, p=0.014.

Table 10.8: Pecica Florescent Period ceramics, on- versus off-tell contexts

	On Tell		Off Tell		Total	
	#	%	#	%		%
prestige serving	1089	45.9%	36	60.0%	**1125**	46.2%
non-prestige serving	114	4.8%	*6*	*10.0%*	**120**	4.9%
display storage	202	8.5%	*0*	*0.0%*	**202**	8.3%
non-display storage	599	25.2%	11	18.3%	**610**	25.1%
cooking	370	15.6%	7	11.7%	**377**	15.5%
total	**2374**		**60**		**2434**	

note: cells in *italics* indicate statistically significant differences

The distribution of ceramic storage bins may also be informative as they are not used for the storage of liquids. It should be kept in mind that these are low frequency finds overall and their small numbers are likely to be significantly affected by sampling error. Further, these specimens are documented from field identifications only and are subject to re-evaluation. That being said, bin fragments are more common in Florescent Period contexts than in the Late Period by density,[106] more so than expected given differences in overall occupation intensity. None were found off-tell.

While the off-tell sample is decidedly small and derives from a limited area, the preliminary data do suggest that households living on the central tell had larger stores of grain. Food wealth was displayed through fine-ware storage vessels, which may have been used for both crops and liquids, including potentially milk. Storage bins are more common than expected in the Florescent Period versus the Late Period occupation, which also argues for larger grain stores in the earlier period.

CONCLUSIONS

This chapter presented the primary data from Pecica's archaeobotanical assemblage, provided by L. Motta and her team of student researchers. These data are used in Chapter 12 to assess crop production strategies and the organization of food distribution, with attention paid to changes that would be expected in increasingly centralized systems. Here, some basic assessments are made.

Between the Florescent and Late Periods, the essential formulation of crop production is maintained. Cereals are the dominant crops with lesser use of legumes. Wheat is the most common grain by far, primarily einkorn wheat, with much smaller numbers of emmer, bread, and

[106] Florescent Period 0.23/kL, Late Period 0.09/kL.

new glume wheat present. Except in the platform, barley consistently makes up less than 15% of the cereals, but is more common in the Late Period. Millet is also found in trace amounts in Late Period contexts only. Seeds from wild species are highly variable in their density and composition. Plants that are indicative of grasslands and disturbed areas dominate the weed assemblage in both periods. However, species associated with warmer, drier environments become more frequent in the Late Period, suggesting some large-scale directional climate change through time. This is supported by sedimentological data for the region. In terms of crop production strategies, the wild seeds indicate a similar use of habitat types in both periods, with crops being sown predominantly or only on the loess terrace rather than the floodplain below. This latter area may have been used for pasturage. There are very few weeds associated with fall sown crops, suggesting either that wheat was not generally planted in the fall or that intensive agricultural strategies were used that favored the growth of spring weeds. The greater frequency of plants with very high nitrogen requirements in the Florescent Period is indicative of more intensive practices, perhaps including manuring. The distribution of agricultural tools shows that all households were producing their own crops, at least to some degree.

Differences in crop processing, distribution, and storage are more difficult to assess. There is only a single context in which an intentional grain deposit was found. It appears that grain was stored semi-processed in bulk, perhaps in rafters, pits, or large storage vessels. Grain was further cleaned by individual households and kept in pots or within in-house bins or basins for short-term use. The relative abundance of chaff seems to be more associated with its use as temper, for house construction, or as fuel, rather than as *in situ* processing by-products. While there is little evidence for differential access to cleaned grain by the on-tell population during the Florescent Period, preliminary ceramic assemblage data do suggest that they had larger food stores.

CHAPTER 11: CRAFT PRODUCTION AND EXCHANGE NETWORKS

This chapter provides the primary analysis of artifacts related to local craft production and long-distance exchange. The first section reviews crafts, presenting basic descriptions[107] and density, spatial distribution, and standardization measures. The second section provides similar data for imported goods, including types, quantity, and distribution. This includes both raw materials and finished items. These data are then used to test expectations for craft specialization and elite control over long distance trade in the following chapter.

There are a few limitations in the data evaluated here. The hypotheses presented in Chapter 7 assume ideal samples for all classes of archaeological materials. Of course, in reality this is not possible. First, not all craft or exchange good types have sufficiently large samples sizes to evaluate organization. Second, the quality of data differs by both artifact class and year of excavation. For most artifact types, only field evaluations are available for excavation years 2005-2007. Systematic analysis of flotation and screen artifacts is not yet available for 2005 and 2006. Excavated volumes were not calculated for the exploratory trenches in 2005. More detailed documentation of stone, metallurgical debris, and ceramics are restricted to materials from 2008-2011, and the respective specialist analyses are currently in progress. Issues concerning specific artifact classes are presented in their individual subsections and only comparable datasets are used to assess temporal and spatial patterning.

Spatial distribution of artifacts within the central excavation block is strongly affected by intrusive features, especially in Late Period layers. These include a series of very large Iron Age (Dacian) pits, several previous excavation trenches, recent looter pits, and substantial animal burrow complexes (e.g., foxes or badgers) (Figure 11.1). As a result, there are sometimes gaps in the spatial data that must not be interpreted as resulting from Bronze Age activities. In deeper Florescent Period layers, more than half of the excavation block was part of the platform construction (Phase 3, Layer D0), containing very thick deposits (up to one meter) of reworked and redeposited sediments. The materials recovered from this feature cannot be included in the

[107] More detailed description of craft and trade items from Pecica can be found in this chapter's appendices.

spatial analysis as they are in secondary position. Only the uppermost portion of the underlying E layer deposits were excavated or collected in 2009, resulting in strong under-representation of Florescent Period (Phases 4 and 5) artifacts in the eastern part of the block. At the time of this analysis, Early Period deposits were only excavated in the deep exploratory trenches from 2005, and given their limited areal extent and content and imprecise volumetrics, these materials are not included.[108] As a result, the spatial analyses performed in this thesis are focused primarily on the association of materials with specific houses, features, or open areas of the site (where adequately represented), and at a larger scale, on- versus off-tell occupation. Attention is paid to changes between the Florescent and Late Periods. Three-dimensional piece-plot data are used where possible, but in other cases density is evaluated by counts per unit square or feature.

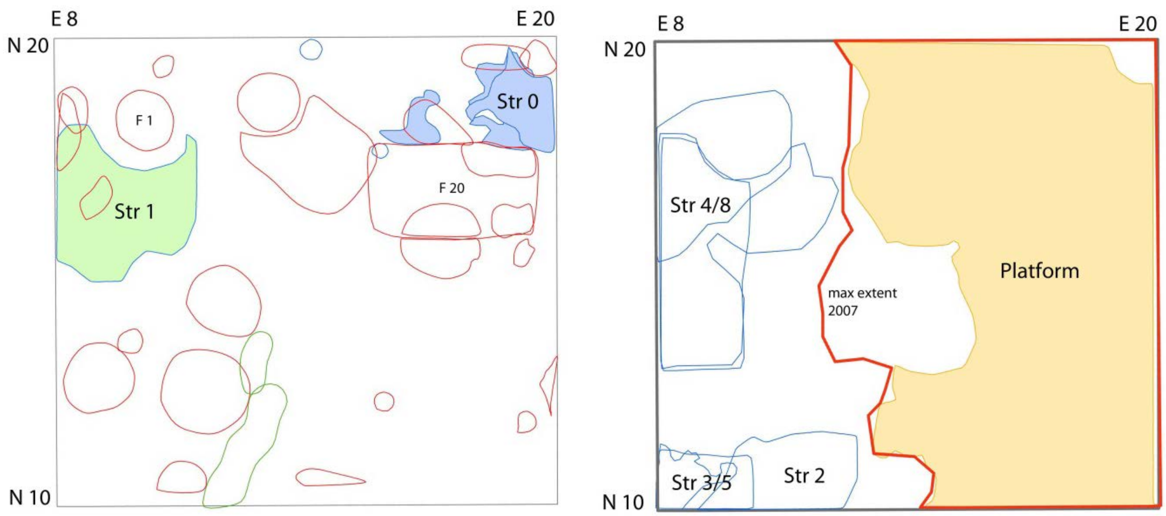

Figure 11.1: Distribution of major features and later intrusions. Left: Late Period, later intrusions in red. Right: Florescent Period, platform maximum extent in red.

CRAFT PRODUCTION

Bone Working

"Bone working" describes working of any durable materials derived from animals, including bone, antler, teeth, horn, and shell. Other than pottery, bone working is one of the best represented crafts at Pecica, with 115 items in the sample from 2005-2011 excavations. It is also one of the most important as many implements used in the manufacture of other crafts are made

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[108] As discussed in previous chapters, additional Florescent and Early Period layers were excavated in 2013, but these materials have not yet been analyzed systematically. However, important finds are mentioned where relevant.

from bone and related materials. In addition, there are a number of ornamental items made from finely carved antler, shell, and perhaps horn, some of which are likely to have entered regional prestige goods exchange networks.

Pecica's worked bone assemblage is fairly diverse. However, nearly all of the represented types are common to other Carpathian Basin Bronze Age traditions (Table 11.1).[109] These can be divided into several major classes, including heavy-duty hafted antler tools, scrapers, smoothers, awls, and ornaments, with a small number of other miscellaneous tools as well. The ornamental items include decorated antler cheek pieces for horse harnesses, pierced teeth, and a variety of shell artifacts, mostly marine shell beads (see also trade section below). There is also a large collection of debitage, primarily antler but also from horn working. The worked bone typological system and a more detailed description of Pecica's assemblage can be found in Appendix 11.1.

Distribution of Finished Worked Bone

Comparing major worked bone classes over time, there are some interesting changes in the composition of Florescent and Late Period assemblages (Tables 11.1 and 11.2). Most striking is the greater representation of heavy-duty antler tools and smoothers in the Late Period and more awls/punches, ornaments, and to a lesser degree, scrapers, in the Florescent Period. This suggests a change in the intensity of crafts and activities associated with these items, with more hide working in the Florescent Period. Display items are also more important at this time. No finished tools were found in off-tell areas and none of the worked bone from the Early Period has been analyzed in detail.

The number of worked bone items per unit volume also shows considerable variability (Table 11.3). Worked bone of all types is far more common in the Florescent Period as a whole, where they occur at three times the density compared to the Late Period. However, the very low number of items in Phase 1, which has a very light occupation in general, contributes greatly to this disparity. Phase 2 densities fall within the lower ranges of Florescent Period items. Within the Florescent Period, worked bone is far less abundant in the platform than elsewhere. While there is an overall trend for a decrease in the density of worked bone through time, this tracks overall artifact deposition rates at the site rather than items per household (Chapter 12), which is

[109] With the exception of the possible horse pelvis "planer."

more likely to reflect use intensity. These temporal patterns are explored more fully in the individual craft subsections that follow, as well as spatial distributions of individual tool types.

Table 11.1: Pecica worked bone inventory

Type	Ph 1	Ph 2	Late Total	Ph 3	Platform	Ph 4	Ph 5	Flor. Total	On Tell (Ph 3-4)	Off Tell	*Site Total*
antler hammer/flat end		4	**4**				1	**1**			***5***
antler mattock/adze						1		**1**	1		***1***
antler beam unknown type	1		**1**		2		1	**3**			***4***
antler pick						1		**1**	1		***1***
total heavy-duty hafted antler tools	**1**	**4**	**5**		**2**	**2**	**2**	**6**	**2**		***11***
scraper (flat end-rib)		3	**3**	2	1	2		**5**	4		***8***
scraper (flat end-other)				1		3	2	**6**	4		***6***
scraper (round end/gouge)		2	**2**			3		**3**	3		***5***
total scrapers		**5**	**5**	**3**	**1**	**8**	**2**	**14**	**11**		***19***
smoother (antler tine)		3	**3**	3		4		**7**	7		***10***
smoother (flat, bone)		2	**2**								***2***
total smoothers		**5**	**5**	**3**		**4**		**7**	**7**		***12***
total awls/punches		**1**	**1**	**3**	**1**	**3**	**1**	**8**	**6**		***9***
needle/pin					1	1	1	**3**	1		***3***
"skate"/beamer		1	**1**								***1***
planer						1		**1**	1		***1***
harpoon/toggle		1	**1**			1		**1**	1		***2***
total misc. tools		**2**	**2**	**0**	**1**	**3**	**1**	**5**	**3**		***7***
cheek piece					1			**1**			***1***
worked shell		1	**1**		1	2	1	**4**	2		***5***
total ornaments		**1**	**1**		**2**	**2**	**1**	**5**	**2**		***6***
debitage (antler)		10	**10**	3	3	4	4	**14**	7	2	***26***
debitage (horn)						2		**2**	2		***2***
total debitage		**10**	**10**	**3**	**3**	**6**	**4**	**16**	**9**	**2**	***28***
total unknown type	**3**	**5**	**8**	**2**	**1**	**3**	**1**	**7**	**5**		***23***
Site Total	***4***	***33***	***37***	***14***	***11***	***31***	***12***	***68***	***45***	***2***	***115***

Table 11.2: Worked bone class summary, finished items, identifiable to class

Type	Ph 1	Ph 2	Ph 3	Platform	Ph 4	Ph 5	Late	Flor.
heavy-duty antler tools	100.0%	22.2%	0.0%	28.6%	9.1%	28.6%	26.3%	13.3%
scrapers	0.0%	27.8%	33.3%	14.3%	36.4%	28.6%	26.3%	31.1%
smoothers	0.0%	27.8%	33.3%	0.0%	18.2%	0.0%	26.3%	15.6%
awl/punch	0.0%	5.6%	33.3%	14.3%	13.6%	14.3%	5.3%	17.8%
ornaments	0.0%	5.6%	0.0%	42.9%	13.6%	28.6%	5.3%	17.8%
other	0.0%	11.1%	0.0%	0.0%	9.1%	0.0%	10.5%	4.4%

Table 11.3: Pecica worked bone density

		count								density (#/1000L)							
Phase	vol (L)	debitage	heavy-duty antler	scrapers	smoothers	awl/punch	ornaments	other	total (incl. nonID)	debitage	heavy-duty antler	scrapers	smoothers	awl/punch	ornaments	other	total (incl. nonID)
1	34813		1						3	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.09
2	47268	10	4	5	5	1	1	2	31	0.21	0.08	0.11	0.11	0.02	0.02	0.04	0.66
3	10916	3		3	3	3			12	0.27	0.00	0.27	0.27	0.27	0.00	0.00	1.10
P	23815	3	2	1		1	3		11	0.13	0.08	0.04	0.00	0.04	0.13	0.00	0.46
4	7653	6	2	8	4	3	3	2	31	0.78	0.26	1.05	0.52	0.39	0.39	0.26	4.05
5	4588	4	2	2		1	2		12	0.87	0.44	0.44	0.00	0.22	0.44	0.00	2.62
Late	82081	10	5	5	5	1		2	34	0.12	0.06	0.06	0.06	0.01	0.00	0.02	0.41
Florescent	6972	16	6	14	7	8		2	66	0.34	0.13	0.30	0.15	0.17	0.00	0.04	1.41
On Tell	18569	9	2	11	7	6		2	43	0.48	0.11	0.59	0.38	0.32	0.00	0.11	2.32
Off Tell	1582	2							2	1.26	0.00	0.00	0.00	0.00	0.00	0.00	1.26
Total	**129053**	**28**	**11**	**19**	**12**	**9**		**4**	**102**	**0.22**	**0.09**	**0.15**	**0.09**	**0.07**	**0.00**	**0.03**	**0.79**

note: excludes 2005 materials

Worked Bone Distribution

Bone working as a craft can be identified through the distribution and density of debitage and bone-working tools. Nearly all of the identifiable debitage is from antler working, which can be easily identified as cut sections of antler and unfinished tools (see also Appendix 11.1). While horn itself (keratin) does not preserve, there are two cattle horn cores (bone) that show cut marks for horn sheath removal. Unfortunately, there is little trace of bone or tooth working as these are typically expediently made and/or are minimally modified items, relying on extant breaks or natural bone shape. Chipped stone blades and metal knives were used for cutting and drilling and abrasives for polishing and drilling (Sofaer 2010). As these tools are multipurpose, or in the case of metal items, not present or sufficiently preserved, this section instead focuses on debitage.

Debitage is found in similar proportions to finished items in each phase (Table 11.4), with the exception of contexts with very low sample sizes (Phase 1 and off-tell). This suggests little change in the intensity and organization of bone working through time per unit volume. Debitage is more frequent in Phases 4 and 5, but this closely tracks overall worked bone densities (Table 11.3). Note that the frequency of worked bone within the total faunal assemblage does not differ statistically between periods, with worked items consistently making up only a small portion of the materials (0.3% to 0.4%) (Chapter 8).

Table 11.4: Debitage versus finished items

Type	Ph 1	Ph 2	Ph 3	Platform	Ph 4	Ph 5	Late	Flor.	On Tell	Off Tell	Total
debitage	0.0%	35.7%	25.0%	30.0%	21.4%	36.4%	34.5%	26.2%	22.5%	100.0%	**30.4%**
finished items	100.0%	64.3%	75.0%	70.0%	78.6%	63.6%	65.5%	73.8%	77.5%	0.0%	**69.6%**

The spatial distribution of debitage is presented in Figures 11.2 and 11.3. Antler debitage is fairly widespread in the later part of the Late Period (Layers B1-C1a) and strongly corresponds to non-disturbed areas of the block. In the earlier part of the Late Period (Layers C2-C3a) and in the Florescent Period, antler debitage is principally found in areas within or immediately adjacent to houses, with a particularly high concentration around Structure 2. Antler working seems to have been a common craft that was done at the household level by most, if not all, families, although some may have more involved than others. Interestingly, horn working debitage is spatially and temporally restricted, found only in Phase 4 in E layer deposits (Florescent Period) immediately underlying the platform along the N10 tier of units (Figure 11.3). This suggests that horn working may have been a relatively specialized craft, perhaps associated with the production of ornamental or other non-utilitarian items.

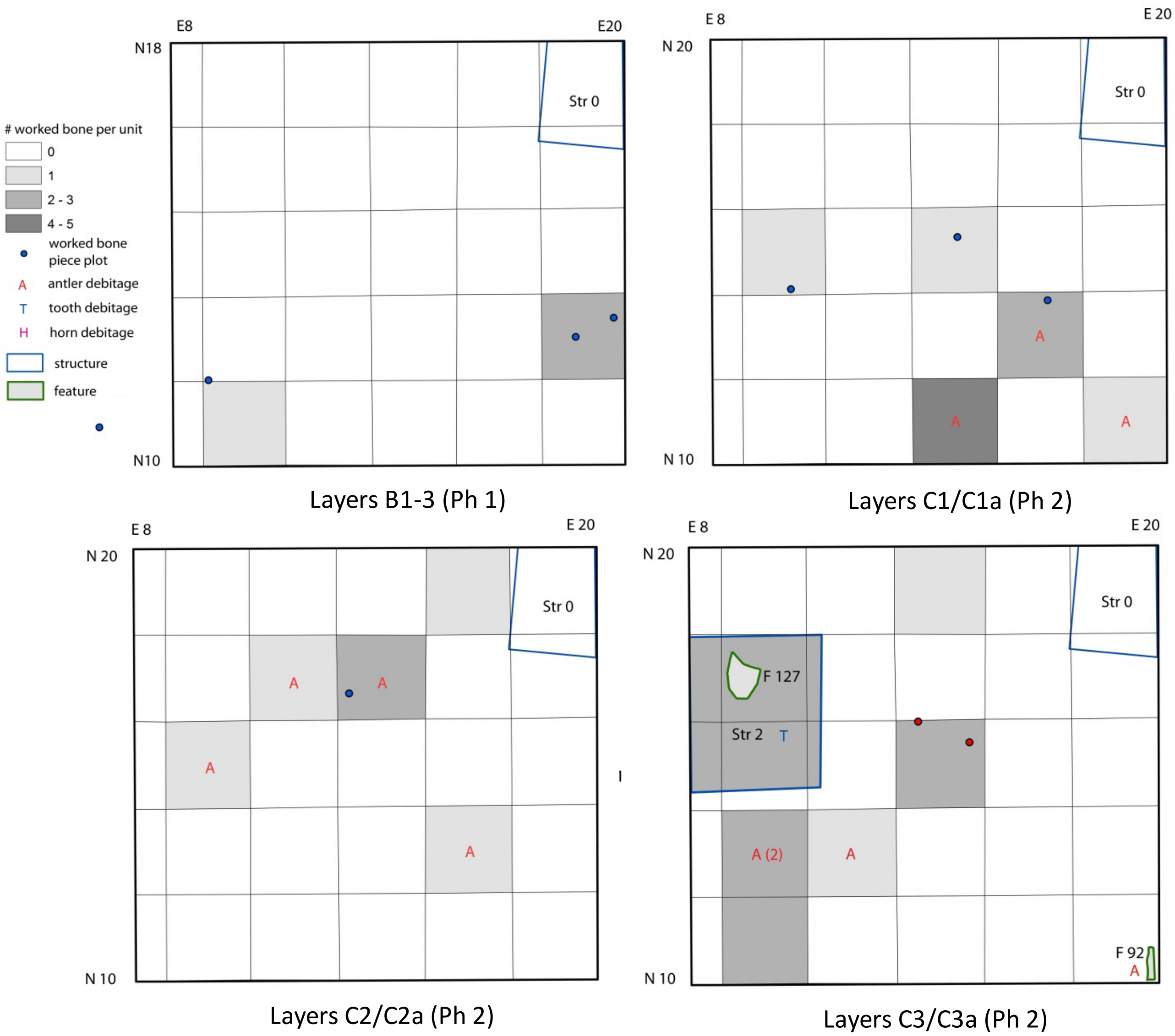

Figure 11.2: Distribution and density of worked bone debitage in the Late Period layers

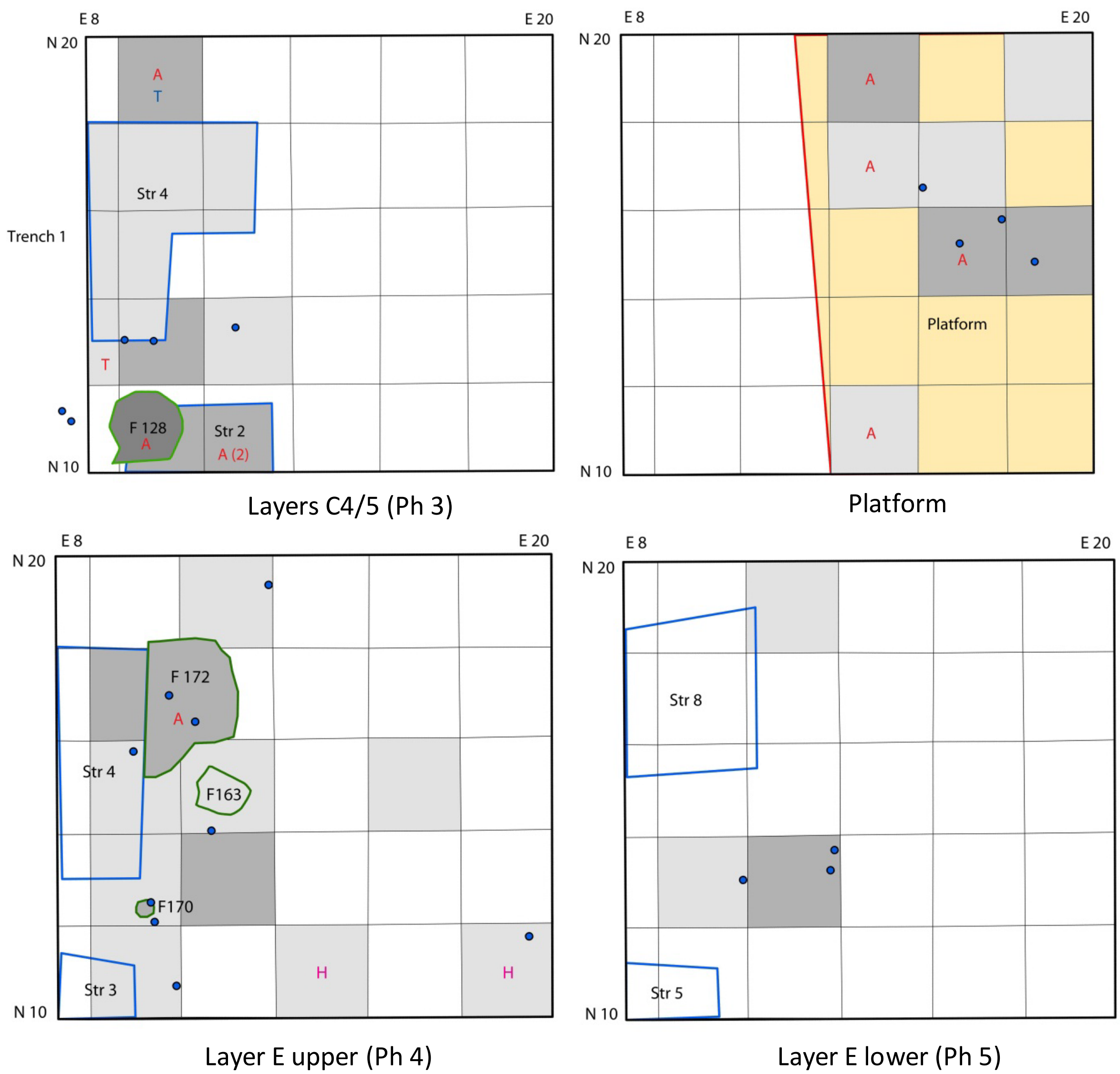

Figure 11.3: Distribution and density of worked bone debitage in Florescent Period layers (see Figure 11.2 for key)

Standardization cannot be statistically assessed in the worked bone assemblage given that very few of these items are complete enough to obtain their original measurements and there insufficient sample sizes within any given class. Nonetheless, this assemblage shows little standardization in terms of raw material selection. For forms with more than one specimen, all bone (proper) tool classes except for rib scrapers are made on a variety of elements from a range of species (Table 11.5). Most of these are expedient tools and raw materials were likely chosen opportunistically. Rib scrapers and antler tine smoothers are made on single elements, but these are only minimally reworked and raw materials were chosen for their natural form. Heavy-duty antler tools require more extensive working, especially during tine removal and drilling hafting holes. While metric evaluation is not possible, basic visual inspection does show high variability in the size, form, and degree of modification of heavy-duty tools within each class. In short, worked antler, shell, and especially bone are highly diverse and show little evidence of production standardization.

Table 11.5: Bone tool composition by element and taxon

	All			Florescent Period			Late Period		
tool type	**# items**	**# elements**	**# species**	**# items**	**# elements**	**# species**	**# items**	**# elements**	**# species**
scraper (flat end-rib)	**8**	1	1	**5**	1	1	**3**	1	1
scraper (flat end-other)	**6**	6	3	**6**	6	3			
scraper (gouge)	**5**	2	3	**3**	1	2	**2**	2	2
smoother (flat, bone)	**3**	2	2				**3**	2	2
awl/punch	**9**	7	6	**8**	7	5	**1**	1	1
needle/pin	**3**	2	2	**3**	2	2			
worked shell	**2**	2	2	**2**	2	2			

Stone Working

Ground Stone

Ground stone is an important but low frequency artifact class at Pecica. Other than river pebble burnishing stones, all the ground stone items were made on imported raw materials, which can be used to trace the direction and intensity of long-distance exchange networks. Ground stone is also used to make a variety of craft items, including prestige goods. Pecica's ground stone items fall within a wide range of identifiable types. These include burnishing stones, hammerstones, querns, pestles, spindle whorls/model wheels, metallurgical molds, polished axes, beads, and pendants (Appendix 11.2, Figure 11.8A).[110] There are also a large number of fragments that were not able to be identified to particular type, either due to their great fragmentation or access to only preliminary field assessments. Groundstone will be assessed generally here in order to incorporate the non-specific items. Raw material classification and sourcing will be considered in more depth in the subsequent exchange networks chapter.

[110] Note that the pestle, pendant, whetstone, and one of the beads were recovered in 2013 and not included in this study.

The local production of groundstone items is difficult to identify given the general low level of debitage produced and the tools involved (other groundstone, abrasives). Currently, there is little direct evidence for local manufacture. Most of the items are highly fragmented and, unless there is clear use wear present, it is nearly impossible to distinguish items that were broken and abandoned during manufacture versus from use. However, a roughly made square limestone bead (from just outside of Structure 4) is unfinished, indicating at least local manufacture of some small stone ornaments.[111] The only groundstone specimen that may be a manufacturing tool is a possible "hammerstone" recovered from deep layers in Trench 1 (Early Period) that has not been examined by the author.

Using all groundstone that have been piece-plotted (n=34), there are temporal differences in the density of these items (Table 11.6). They are more common in the Florescent Period than in the Late Period. Very low densities are found in Phases 1 and they have not been recovered from Phase 5 deposits[112] or off-tell. However, Phase 1 materials have not yet been examined in detail. Phase 5 and the off-tell units have limited excavations, so the apparent absence of groundstone is likely due to small samples. Individual groundstone classes cannot be compared given their low frequencies but it should be noted that no molds or crucibles were found in Late Period contexts.

The spatial distribution of ground stone artifacts by period is presented in Figure 11.4. The majority of items were recovered from open areas external to the structures, which is not unexpected given the size of these artifacts and their specific uses. Note that there are three additional grinding stone fragments from the E layer between Structures 3 and 4 that were not piece-plotted. Two of these refit and it is possible that the third (on the map) also originated from the same large quern. Because there is no direct evidence for local working other than for the bead to date, the organization of groundstone production cannot be discussed in any detail at this point.

[111] A finished example from 2013 is presented in Figure 11.8A (also from upper E layer, Phase 4, Florescent Period).
[112] Note that a significant number of groundstone items were found in Phases 5 and 6 in 2013, which are not included in this study. These have not yet been systematically evaluated.

Table 11.6: Density ground stone, all periods, piece-plot data

		count					density (#/1000L)				
Phase	vol (L)	ground-stone all	grinding stones	stone axes	molds/ crucibles	nonID ground-stone	ground-stone all	grinding stones	stone axes	molds/ crucibles	nonID ground-stone
1	34813	1		1			0.03	0.00	0.03	0.00	0.00
2	47268	14	2			11	0.30	0.04	0.00	0.00	0.23
3	10916	5		1	2	2	0.46	0.00	0.09	0.18	0.18
P	23815	9	1		5	3	0.38	0.04	0.00	0.21	0.13
4	7653	5	1	1	1	2	0.65	0.13	0.13	0.13	0.26
5	4588						0.00	0.00	0.00	0.00	0.00
Late	82081	15	2	1	0	11	0.18	0.02	0.01	0.00	0.13
Florescent	46972	19	2	2	8	7	0.40	0.04	0.04	0.17	0.15
On Tell	18569	10	1	2	3	4	0.54	0.05	0.11	0.16	0.22
Off Tell	1582						0.00	0.00	0.00	0.00	0.00
Total	**129053**	**34**	**4**	**3**	**8**	**18**	**0.26**	**0.03**	**0.02**	**0.06**	**0.14**

note: excludes 2005 materials

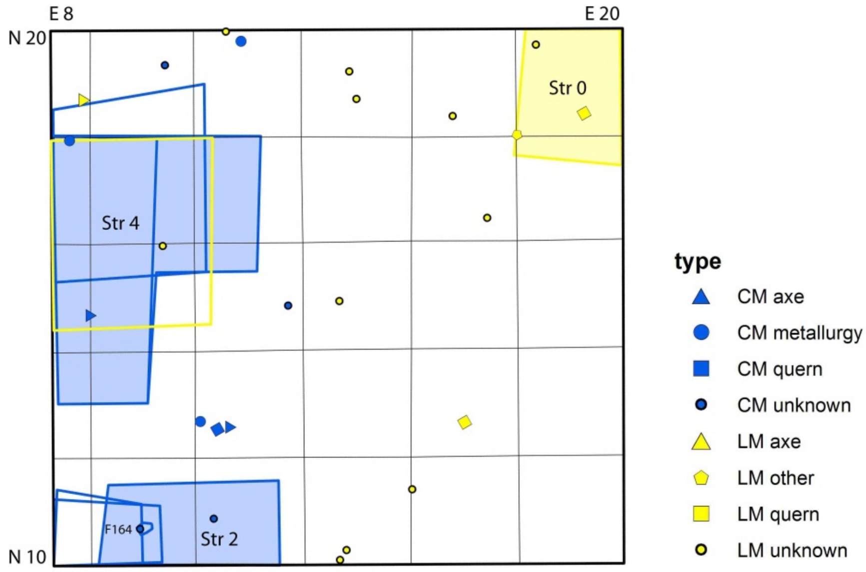

Figure 11.4: Distribution of piece plotted ground stone, all periods (features with groundstone artifacts labeled and shaded). CM = Florescent Period, LM = Late Period.

Chipped Stone

The chipped stone inventory from Pecica includes a variety of tools and debitage, allowing for the organization of production to be described in more detail than groundstone. The following is based on preliminary assessment of materials housed at the University of Michigan by me and K. Gillikin, a UM undergraduate volunteer. This is limited to materials from 2008-2011, which are overwhelmingly from Florescent Period contexts. Only a general consideration of unanalyzed materials from others years can be made. Sourcing is treated in more detail in the exchange section below.

Finished chipped stone items fall into a very small number of categories. These include denticulated sickle blades, prismatic blades, and points (Appendix 11.2, Figure 11.9A).[113] Sickle blades (often called "saws" in the literature) are rectangular, trapezoidal, or semi-circular, with the largest side being the denticulated cutting edge, often showing very high levels of sickle sheen. They are typically made on cherts and other non-obsidian materials. Small prismatic blades are the second most common tool. All made on obsidian in the study assemblage.[114] Given the lack of sickle sheen and the presence of small use wear chips, these small obsidian blades were not likely used for harvesting plant materials. They may have been used for cutting meat and other animal products (e.g., hides) or possibly fine carving of various raw materials (bone, antler, wood). There are two points from secure Bronze Age contexts,[115] but two others from mixed or surface deposits may be Maros as well. These are all made on chert or other non-obsidian materials. They are small, likely arrow heads.

Table 11.7 presents the lithic assemblage from 2005-2011 (n=63) using all data sources (mapping, lots, screens, and flots). The Early and Late Period samples cannot be compared against those from the Florescent Period as only the latter have been examined systematically (n=40). Intra-phase variability within the Florescent Period sample is considered here using the analyzed subsample (Table 11.8). The density of chipped stone as a whole is similar between Phases 3 and 4, decreases in Phase 5, and is very low in the platform. Of the finished tools, sickle blades are always most frequent.

Table 11.7: Chipped stone inventory, 2005-2011, all data sources

	Ph 1	Ph 2	Ph 3	Platform	Ph 4	Ph 5	Ph 6+	Late*	Flor. *	Early	On Tell	Off Tell	Total
sickle blade	1		5	2	3	1		1	11		8		**12**
obsidian blade			4	1	3				8		7	1	**9**
point		1						1					**1**
core/debitage		4	3	5	2	3		4	13		5	2	**19**
fire cracked cobble				5	1				6		1		**6**
unknown		6		2	1		2	11	3	2	1		**16**
Total	**1**	**11**	**12**	**15**	**10**	**4**	**2**	**17**	**41**	**2**	**22**	**3**	**63**

*includes lithics from non-specific phasing

[113] Preliminary assessment of 2013 materials shows possible scrapers and a borer/burin as well.
[114] There is a chert blade from Phase 6+ (Early Period) in the 2013 assemblage. See also trade section.
[115] One is from 2013 and not included in this study (Figure 11.9A left).

Table 11.8: Density chipped stone (systematic sample only)

		count					density (#/1000L)				
Phase	**vol (L)**	**all lithics**	**deniticulates**	**obsidian blades**	**cores/ debitage**	**fire cracked cherts**	**all lithics**	**deniticulates**	**obsidian blades**	**cores/ debitage**	**fire cracked cherts**
2		1			1						
3	10916	13	5	4	4		1.19	0.46	0.37	0.37	0.00
P	23815	14	2	1	5	6	0.59	0.08	0.04	0.21	0.25
4	7653	9	3	3	2	1	1.18	0.39	0.39	0.26	0.13
5	4588	4	1		3		0.87	0.22	0.00	0.65	0.00
Late	82081	1			1						
Florescent	46972	40	11	8	14	7	0.85	0.23	0.17	0.30	0.15
On Tell	18569	22	8	7	6	1	1.18	0.43	0.38	0.32	0.05
Off Tell	1582	3		1	2		1.90	0.00	0.63	1.26	0.00
Total	**129053**	**44**	**11**	**9**	**17**	**7**	**0.34**	**0.09**	**0.07**	**0.13**	**0.05**

note: excludes 2005 materials

The density and distribution of completed tools versus debitage (including flakes, sickle “blanks,” and cores) is informative. In the Florescent Period, debitage comprises 37% of the assemblage when considering only clearly modified stones, rising to 55% if fire-cracked cobbles (knappable stone types only) are included. There is evidence for local stone working in all phases and contexts, and excluding samples with less than five specimens, there is little variability in the proportion of debitage to finished items through time or in their density. However, there are differences in this ratio when broken down by raw material class. For locally available cobble jaspers, the ratio is 11:3 for debitage: finished items. In sharp contrast, the ratio is 3:7 for obsidian and 4:7 for non-obsidian imported materials, which argues for a difference in conservation of raw materials between local and non-local sources. The distribution of debitage (of all types) is strongly associated with individual houses (Figure 11.5) or the areas immediately adjacent to them, like antler working. It is likely that stone was obtained by individual households and worked within or just outside their homes. It should also be noted that obsidian, even though an imported material, is not restricted to on-tell inhabitants.

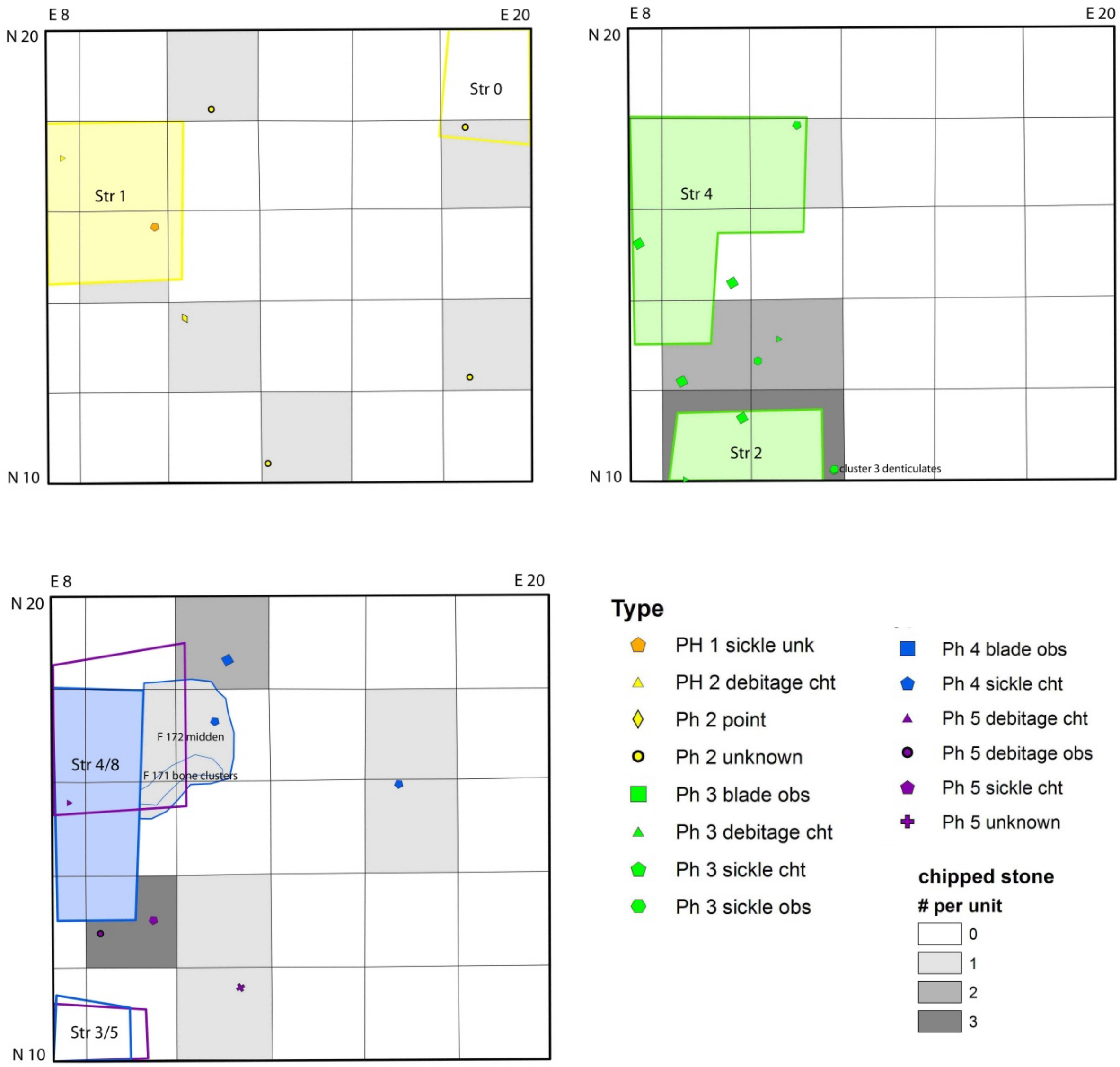

Figure 11.5: Distribution of chipped stone. Top left: Late Period; top right: Phase 3 (Florescent Period); bottom left: Phases 4 and 5 (Florescent Period).

In some respects, chipped stone manufacture is fairly standardized, in others there is considerable variation. There are only a very small set of finished tool types produced, and these share basic formal characteristics in terms of their overall shape, which is related to their specific functions. Raw materials chosen for their manufacture is also highly standardized, with obsidian used for blades and non-obsidian stone used for points and sickles. There is one exception where there is a small denticulated sickle blade made from obsidian from Phase 3 (Florescent

Period).[116] The general restricted use of obsidian for blades may also reflect function to some degree, as obsidian produces a sharper cutting edge. But it is also more friable, being less amenable for heavy-duty harvesting activities.

On the other hand, size ranges of the denticulates and blades show considerable variation that would not be expected in the production of highly standardized lithics (Tables 11.9 and 11.10). It should be noted that some of the variation within the denticulates may be due to reworking/re-sharpening, as noted by Horváth (2005) for Százhalombatta, where fairly intensive curation was documented. However, the obsidian blades have not been reworked and maintain their original widths except for some minor use-wear damage. It can be seen that some blades are more than twice the size of others. Unfortunately, sample sizes are insufficient to compare between periods.

Interestingly, there have been very few tools associated with chipped stone manufacture identified thus far at Pecica. There are no antler billets or antler tine pressure flakers in the current assemblage and there is a single possible hammerstone. A bronze-tipped tool may have been used for pressure flaking, but none have been found to date. Further analysis of the ground stone and unworked cobbles may identify battery marks associated with chipped stone manufacture.

Table 11.9: Denticulate measurements and distribution statistics

	L cutting	L base	W edge 1	W edge 2	Th max	Wt (g)
8-192	36.5				6.5	5.1
8-201		27.9	21.6		7.4	4.0
8-285	27.8				10.1	6.6
8-308	17.7	12.3	16.5	16.1	7.7	3.1
8-336	48.0	28.1	30.2	28.9	7.1	12.6
8-561	28.8	30.4	26.0	25.3	8.3	7.9
8-602			16.9		7.1	3.3
9-425					3.1	0.3
9-456	25.6	24.4	10.2	15.8	8.0	3.8
9-510	26.9	23.2	16.5	16.2	6.9	4.4
SS542*	15.6	16.6	9.6	10.1	3.9	0.9
mean	28.4	23.3	18.4	18.7	6.9	4.7
median	27.4	24.4	16.7	16.2	7.1	4.0
std. dev.	10.3	6.6	7.2	7.0	1.9	3.4
co. var.	0.36	0.28	0.39	0.37	0.28	0.72

*obsidian

[116] Again, there is a non-obsidian blade from 2013 excavations. As will be discussed below, there is no obsidian from pre-Phase 4 deposits and alternative high-quality imported stone may have been used.

Table 11.10: Obsidian blade measurements and distribution statistics

	W max	Th max	Wt (g)
F8-213	6.8	2.3	
8-151	6.2	2.6	0.2
8-157	15.5	4.8	1.4
8-237	14.4	5.5	1.6
8-320	10.9	2.4	0.3
8-404	16.2	6.5	3.1
8-414	12.1	3.2	0.3
9-107	12.9	4.1	1.0
9-369	13.8	4.9	1.3
9-486	15.6	4.7	1.7
11-257	7.1	1.1	0.1
mean	12.0	3.8	1.1
median	12.9	4.1	1.2
std. dev.	3.7	1.6	0.9
co. var.	0.31	0.43	0.85

Ceramics

The organization of ceramic production is somewhat difficult to track as many of the steps took place away from central habitation areas (e.g., clay quarrying, sediment and temper sorting, firing, etc.). Clay sourcing studies at Lower Maros settlements show that local clays were used (Michelaki 1999, 2008). Clay quarrying tools, most of which are made from worked bone and antler (heavy-duty tools, picks), may be considered here, but these are multipurpose implements that are not primarily associated with pot making. Some of the groundstone items may have been used for crushing grog temper.

We are currently limited to items used in their decoration/surface treatments (burnishing, smoothing, channeling, incising), including antler tine and other small smoothers and bone awls. These items were discussed in more detail in Appendix 11.1. Quartz river cobbles sometimes are used for burnishing, but none of the samples examined from 2008-2011 excavations show obvious wear indicative of their use as burnishers. Only items specifically identified as such in the field are included.[117] Unmodified freshwater mussel shell may have been used as scraping and incising tools and have been found in potter's graves (Michelaki 1999, 2008; O'Shea 1996).

[117] These cobbles do not occur naturally on the tell and their presence is deliberate. However, not all show clear signs of use wear. In this study, all field documented occurrences of these cobbles are used, but further evaluation is necessary to confirm use wear associated with burnishing.

However, use wear has not been identified on any of the ubiquitous *Unio* sp. shells from Pecica to date.[118]

In general, tools that may be associated with ceramic production are infrequent (Table 11.11). Possible bone and antler decorating tools are found in most periods but are most common per unit volume in Phases 3 and 4. Possible burnishing stones have only been documented in Phases 2 and 4 and the platform, but additional specimens may be noted with further evaluation of stone materials. Spatial analysis is not possible given the low number of items and the limited availability of piece-plot coordinates. Little can be said about the organization of ceramics production from this data other than that tools that are likely used in their decoration and surface treatment are present in all periods. While they are more frequent in the Florescent Period, their density covaries with overall artifact frequency. Further analysis of the ceramics themselves can provide additional data on manufacturing techniques, but this is beyond the scope of this thesis.

Table 11.11: Density possible ceramic decorating tools

		count			density (#/1000L)		
Phase	vol (L)	burnishing stone	antler tine burnisher	bone awl	burnishing stone	antler tine smoother	bone awl
1	34813				0.00	0.00	0.00
2	47268	3	3	1	0.06	0.06	0.02
3	10916		3	3	0.00	0.27	0.27
P	23815	2		1	0.08	0.00	0.04
4	7653	2	4	3	0.26	0.52	0.39
5	4588			1	0.00	0.00	0.22
Late	82081	3	3	1	0.04	0.04	0.01
Florescent	46972	4	7	8	0.09	0.15	0.17
On Tell	18569	2	7	6	0.11	0.38	0.32
Off Tell	1582				0.00	0.00	0.00
Total	**129053**	**7**	**10**	**9**	**0.05**	**0.08**	**0.07**

note: excludes 2005 materials

[118] These may have been expedient tools with little use wear. Nearly all of the *Unio* shells from Pecica have poor preservation of their margins, so minor wear traces may not be evident.

Hide Working

In contrast to pot making, hide working tools are fairly common at Pecica. These include a variety of bone scraping and smoothing tools, needles, punches, and chipped stone blades.[119] Metal knives, needles, and awls were also likely used, but none have been securely identified from current Pecica excavations to date. These classes of bone and chipped stone tools are found in all periods but Phase 1, and for reasons mentioned above, it is possible that with further study of artifacts stored at the Arad Museum some additional specimens may be identified. Hide working tools are more abundant in the Florescent Period (Table 11.2), with a particularly high density of scraping tools in Phase 4. It is possible that the increased production of large domesticates in the Florescent Period is associated with more intensive hide working, perhaps for export. The density of hide working tools is only moderately related[120] to the density of fur-bearing animal bones and has virtually no relation to the proportion of fur-bearers within all game animals.[121] This would suggest that more intensive hide working in the Florescent Period is not related to fur production, but more likely the leather made from livestock.

Table 11.12: Hide working tool density and fur-bearing animal representation

		count						density (#/1000L)						
Phase	**vol (L)**	**chipped stone blades**	**bone scrapers and smoothers**	**awls/punches**	**needles**	**all bone hide working tools**	**bones of fur bearers**	**chipped stone blades**	**bone scrapers and smoothers**	**awls/punches**	**needles**	**all bone hide working tools**	**bones of fur bearers**	**% fur bearers of wild fauna**
1	34813						10						0.29	9.9
2	47268		8	1		9	28	0.00	0.17	0.02	0.00	0.19	0.59	9.5
3	10916	4	3	3		6	1	0.37	0.27	0.27	0.00	0.55	0.09	1.2
P	23815	1	1	1	1	3	2	0.04	0.04	0.04	0.04	0.13	0.08	2.4
4	7653	3	8	3	1	12	6	0.39	1.05	0.39	0.13	1.57	0.78	5.7
5	4588		2	1	1	4	1	0.00	0.44	0.22	0.22	0.87	0.22	4.5
Late*	47268		8	1		9	28	0.00	0.17	0.02	0.00	0.19	0.59	9.6
Florescent	46972	8	14	8	3	25	10	0.17	0.30	0.17	0.06	0.53	0.21	3.4
On Tell	18569	7	11	6	1	18	7	0.38	0.59	0.32	0.05	0.97	0.38	3.7
Off Tell	1582	1					4	0.63	0.00	0.00	0.00	0.00	2.53	14.8
Total	**129053**	**9**	**22**	**9**	**3**	**34**	**52**	**0.07**	**0.17**	**0.07**	**0.02**	**0.26**	**0.40**	**7.6**

note: excludes 2005 materials

*excludes Phase 1

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119 Some of the tools are multi-purpose and cannot be solely classified as hide working tools, including the gouges, awls/punches, needles, and blades.

120 $r = 0.57$

121 $r = 0.003$

The spatial distribution of hide working tools is varied in both the Late and Florescent Periods (Figure 11.6). Bone tools are found within houses and external to them, but most were found in open areas of the site. This likely reflects that fact that most hide processing is done outside as it requires fairly large facilities like drying and stretching racks, and the early stages of processing, including skinning and tanning, are messy, smelly activities. While the blades are more strongly associated with houses, these are multipurpose tools that are less directly linked with hide working. There is no indication that hide working was a specialized activity.

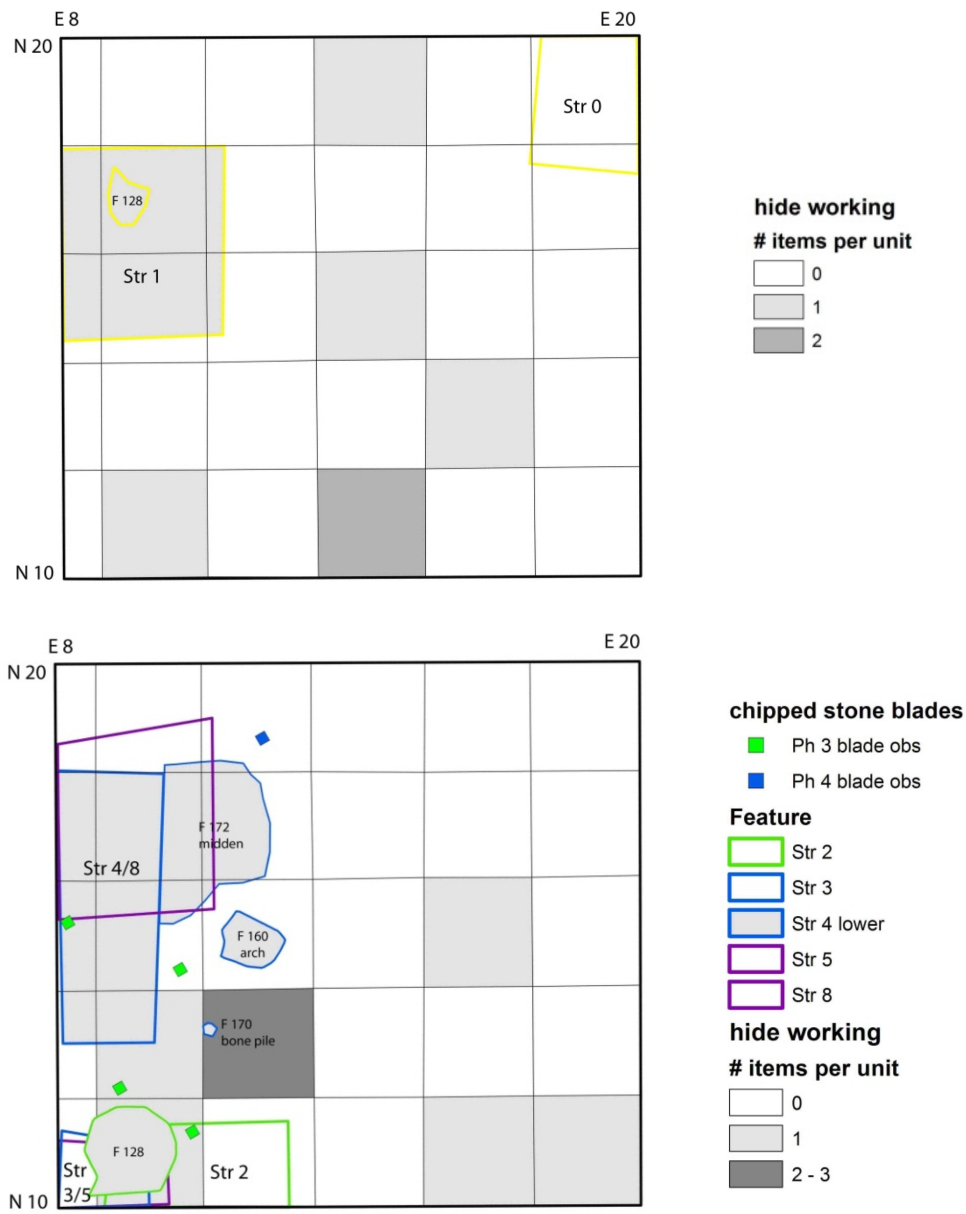

Figure 11.6: Distribution hide working tools. Top: Late Period; bottom: Florescent Period.

Wood Working

Wood working was likely an important activity in the Bronze Age. I use this term broadly to include a range of activities, including felling trees for land clearance and fuel, shaping lumber for house construction, and more complicated wood working crafts, like the manufacture of carts, chariots, and boats as well as fine, ornamental items. Understanding the organization of woodworking can be approached in two ways: through woodworking tools and through remains of the wood itself. There has been a surprising amount of wood recovered from Pecica, falling into two general classes: construction materials and fuel wood. We have not yet found any other types of wooden objects unfortunately, including any finely made or complex items. The construction materials are represented by posts and wood planking. The wood planking consists of both burned and unburned pieces from within the base of wall trenches and occasionally on what appears to be the surface of floors.[122] There is also a very large assemblage of burned wood from flotation samples. Unfortunately, the wood analysis is in progress at the time of this writing and cannot be included.

Currently, wood working can only be assessed through associated tools. These include antler beam hammers and adzes, stone axes, bone planers, and for finer work, chipped stone blades and metal cutting and carving tools (Table 11.13). None of these items are particularly abundant and no identifiable woodworking metal tools have been recovered from current excavations.[123] Heavy-duty antler tools and groundstone axes are found in both the Late and Florescent Periods, and there is little difference in their density over time considering the small sample sizes involved. No blades have been identified yet from the Late Period. The single "planer," perhaps used to smooth posts, was found in Phase 4 deposits. The sample of woodworking tools is too small to examine their spatial distribution systematically. It can be said, however, that only one of the heavy duty tools were found within a structure. This was a small fragment of a broken ground stone axe which was found in the upper layers of Structure 4.

[122] In 2013 a series of large, unburned wooden planks were found scattered in an open area underlying the platform in E layer fill (Phases 4 and 5, Florescent Period), not in direct association with houses. Some of these were faced with clay/plaster, suggesting that ultimately originated from houses, perhaps from wall or floor planking, as was used in some contemporary Bronze Age houses at other settlements (e.g., Túrkeve-Terehalom, Törökszentmiklós-Terehalom) (Csányi and Tárnoki 2003; Tárnoki 1994).

[123] However, ax molds have been found and finished metal axes are presumed to have been used as well.

Table 11.13: Wood working tool density

		count				density (#/1000L)			
Phase	vol (L)	antler hammer/adze	stone axe	planer	chipped stone blade	antler hammer/adze	stone axe	planer	chipped stone blade
1	34813	1	1			0.03	0.03	0.00	0.00
2	47268	4				0.08	0.00	0.00	0.00
3	10916		1		4	0.00	0.09	0.00	0.37
P	23815	2			1	0.08	0.00	0.00	0.04
4	7653	1	1	1	3	0.13	0.13	0.13	0.39
5	4588	2				0.44	0.00	0.00	0.00
Late	82081	5	1			0.06	0.01	0.00	0.00
Florescent	46972	5	2	1	8	0.11	0.04	0.02	0.17
On Tell	18569	1	2	1	7	0.05	0.11	0.05	0.38
Off Tell	1582				1	0.00	0.00	0.00	0.63
Total	**129053**	**10**	**3**	**1**	**9**	**0.08**	**0.02**	**0.01**	**0.07**

note: excludes 2005 materials

Weaving

Weaving implements are very low frequency finds at Pecica. These items fall into three main classes: loom weights,[124] spindle whorls,[125] and needles (Appendix 11.2, Figure 11.10A). It is also possible that the worked large mammal ribs may have been used as warp spacers, but the use wear on their tips is consistent with scraping (Christidou 2008). All of the needles found thus far are made from bone. Metal needles have been found in Maros burials (O'Shea 1996) and were likely used as well, but these may also have been used as clothing fasteners.

Table 11.14 shows the number of weaving items per period using all available datasets, which includes mapping (all years), field lot sorts (excluding 2006), screen and flotation subsample sorts (excluding 2005 and 2006), and the detailed ceramics and worked bone study by

[124] Loom weights are large, roughly made, semi-pyramidal or conical clay objects that are perforated on the top for attaching the warps (Figure 11.10A, lower left).

[125] Spindle whorls come in two forms: flat discoidal (Figure 11.10A, upper left) and ovoid (Figure 11.10A, upper right). Most are discoidal. Note that the discoidal variety is similar in form to model cart wheels (flat, circular, central hole, generally made from clay) except that in the latter, there is a raised central area ringing the perforation (axle hub). Wheels are also sometimes decorated, spindle whorls are not. Spindle whorls are also more likely to be made expediently and often are not burnished. Some are crafted from recycled sherds. If the central portion is missing, it can be difficult to distinguish between undecorated model wheels and spindle whorls, so an undifferentiated whorl/wheel category is used for ambiguous specimens. This category also includes items classified as wheels in the field but not further examined, as more detailed analysis of the 2008-2009 assemblage has shown that nearly all of these are actually whorls. Further study is needed on these remaining specimens.

O'Shea, Howey, and the author (2008-2011). It is difficult to do temporal comparisons of this material as the source data are not equivalent, but it is apparent that textiles were being made on the tell in all occupation periods. No weaving implements have been recovered from off-tell contexts. Table 11.15 shows weaving artifact densities for the Florescent Period, which has a well-analyzed dataset. As a whole, weaving tools are more frequent per unit volume in the earlier part of the Florescent Period (Phases 4 and 5), but their density is strongly associated with the rate of artifact deposition at the site per phase, so there does not appear to be any significant change in the intensity of weaving over time.

Table 11.14: Weaving tools by phase, all data sources

	Ph 6+	Ph 5	Ph 4	Platform	Ph 3	Ph 2	Ph 1	Off Tell	Total
loom wieght	2		1	1		2	1		7
spindle whorl	2	3	5	5	4	4			23
wheel/whorl	2		3	3	1	3	1		13
Total	**6**	**3**	**9**	**9**	**5**	**9**	**2**		**43**

Table 11.15 Weaving tools densities, all data, Florescent Period

		count				density (#/1000L)			
Phase	vol (L)	loom wieght	spindle whorl	whorl/ wheel	needle	loom wieght	spindle whorl	whorl/ wheel	needle
3	10916		4	1		0.00	0.37	0.09	0.00
P	23815	1	5	3	1	0.04	0.21	0.13	0.04
4	7653	1	5	3	1	0.13	0.65	0.39	0.13
5	4588		3		1	0.00	0.65	0.00	0.22
Off Tell	1582					0.00	0.00	0.00	0.00
Total	**48554**	**2**	**17**	**7**	**3**	**0.04**	**0.35**	**0.14**	**0.06**

It is not known which fibers were being used and in what proportion as they have not preserved. As mentioned previously, no flax seeds have been recovered from Pecica, despite their presence (as well as flax fiber itself) at contemporary sites. Wool was used to a greater or lesser extent. Clearly, in the Early Period wool production was a major focus of sheep husbandry systems. And even though meat became the primary resource in later periods, the maintenance of small numbers of old sheep in Florescent and Late Periods indicates that at least a part of the sheep population was kept as wool producers. It is hoped that future analysis of the weaving tools will be able to differentiate been wool and linen textile manufacture.

It should also be noted here that there are several samples of plaited reed mats preserved between clay floors in the houses in the Structure 1/4 complex. These do not need special implements in their crafting other than a frame (and a sickle to harvest them). Reeds are available in the marshy areas of the floodplain below the settlement. Unlike wool or flax textiles, these coarse reed mats are unlikely to have been made for exchange beyond the settlement.

Metallurgy

Metal production is a hallmark craft of the Bronze Age. It relies on extensive trade networks to obtain raw materials and fine finished products were exchanged across the continent. It also requires specialized knowledge in its production, especially for the elaborate pieces that have come to define this period. For these reasons, metalworking is an economic sphere that is more likely to fall under some degree of centralized control than other domestic crafts. It must be kept in mind, however, that not all metal working is equally sophisticated and it has been argued that it should be viewed as a two-tier industry (Earle 2002; Papalas 2008; Pare 2000; Wells 1996). The upper tier is high-end metallurgy that requires highly specialized knowledge and a large investment in labor and raw materials. This would include the manufacture of weapons, armor, and fine jewelry. The lower tier would be the crafting of simple items, like small utilitarian goods (e.g., fish hooks, awls, etc.), that would not require elaborate facilities, large qualities of high-quality raw materials, or a great skill level. It is not easy to differentiate between the two from metallurgical debris to the lay person (including the author). However, metals and metalworking by-products (ores, slags, furnace remains) can be used, but this is beyond the scope of this study.

Several classes of data are examined in this section, including forging implements, smelting facilities, smelting and casting debris, ores, and the metals themselves. The quality of these data are highly variable as only metallurgical materials from 2005 and 2008-2011 have undergone preliminary assessment by C. Papalas, the project’s metallurgical specialist. Similarly, only the stone and ceramics from 2008-2011 field seasons have been recorded in detail by the author, J. O’Shea, and M. Howey. 2006-2007 ceramic assemblages rely on field identification and mapping. Because slags and ore stones from these years also have not been studied in detail yet, field identified specimens are not included in this assessment.

Table 11.16 presents the counts and densities for metal and metal related items from piece-plots and special samples for all years. Metals include finished metal objects as well as unidentified corroded pieces (Figure 11.11A, left). Molds are made from clay or fine-grained, soft stone. There are examples of both types at Pecica, including a stone mold for a disk-butted axe that shows scorching from use. Crucibles are typically small flat-bottomed ceramics, some with spouts, and are often scorched as well. The "fish plates" are unusual boat-shaped, flat bottomed ceramic vessels that were likely used as crucibles as well (Figure 11.11A, right). The combined "mold/crucible" category includes all of the identified molds and crucibles as well as fragments that could not be differentiated.

While not included in this study, the very large assemblage of molds and metalwork from Pecica recovered from previous excavations should be mentioned, compiled and described by Gogâltan (1999:100-101). These are listed in Appendix 11.3. It will be noted here that the size and range of this collection is far beyond that recovered from most, if not all, contemporary Bronze Age settlements in the region, underscoring Pecica's role as a central metal producer. There are 34 molds, primarily for weaponry (n=23), especially axes of various types, although molds for tools (chisels, awls, n=9) and ornaments (belt buckles, n=2) are also present. There 28 finished metal items, all copper/bronze except for one gold button. In contrast to the molds, the finished items are dominated by ornaments (pins, pendants, bracelets, etc., n=15), which is similar to the range of items found in recent excavations. A smaller number of tools (n=4) and one ax fragment were also recovered from previous work. Unfortunately, these generally lack detailed provenience information so their phase associations cannot be established at this time.

Returning to the current collection, there are very strong temporal differences in the density of metals and metal working artifacts. They are infrequent in Late Period contexts, especially from Phase 1. Within the Florescent Period, these items are particularly abundant in Phase 3 and within the platform, with the latter having by far the largest number of molds and crucibles. It appears that the context from where the platform matrix was quarried included a metal producing area. The relatively low density of metalworking finds from Phase 4 is unexpected given the relative abundance of other artifact classes. There is only a very weak relationship[126] between the density of finished metal objects and molds/crucibles, suggesting

[126] $r = 0.163$

spatial differentiation between the production and consumption of metals. As can be seen from Figure 11.7, metal pieces are fairly ubiquitous, occurring both within houses and throughout external deposits. None of the possible molds or crucibles were recovered from within structures, which may be due to their size (house floors were kept fairly clean, larger items were discarded in outside middens) or that they broke during use, which would not likely to have been done inside these small houses given the noxious fumes. Note also that two fish plate crucible fragments found in the off-tell area as well.

Table 11.16: Metal and metal working tool density (from piece-plots)

		count					density (#/1000L)				
Phase	**vol (L)**	**metal**	**molds**	**crucibles**	**"fish plates"**	**moulds/ crucibles**	**metal**	**molds**	**crucibles**	**"fish plates"**	**moulds/ crucibles**
1	34813	3					0.09	0.00	0.00	0.00	0.00
2	47268	6	1	1	5	7	0.13	0.02	0.02	0.11	0.15
3	10916	7	1			2	0.64	0.09	0.00	0.00	0.18
P	23815	10	2	4	7	14	0.42	0.08	0.17	0.29	0.59
4	7653	1	1			1	0.13	0.13	0.00	0.00	0.13
5	4588	3					0.65	0.00	0.00	0.00	0.00
6+		2									
Late	82081	9	1	1	5	7	0.11	0.01	0.01	0.06	0.09
Florescent	46972	21	4	4	7	17	0.45	0.09	0.09	0.15	0.36
On Tell	18569	8	2			3	0.43	0.11	0.00	0.00	0.16
Off Tell	1582	1			2	2	0.63	0.00	0.00	1.26	1.26
Total	**129053**	**31**	**5**	**5**	**14**	**26**	**0.24**	**0.04**	**0.04**	**0.11**	**0.20**

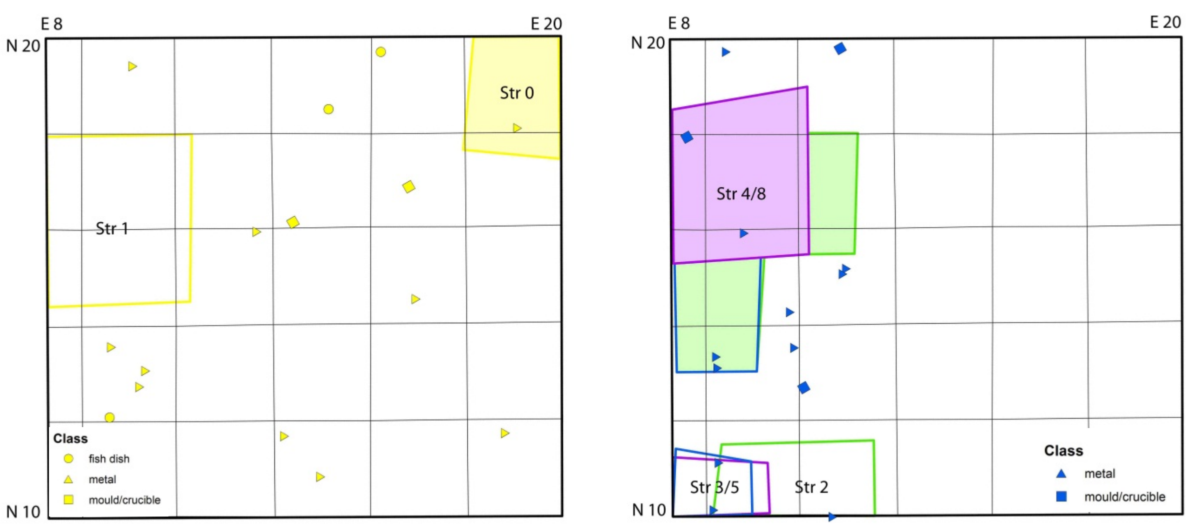

Figure 11.7: Metal and mold/crucible distribution (piece-plots only). Left: Late Period; right: Florescent Period.

More can be said concerning metallurgy in the Florescent Period as this material has been better studied. The preliminary assessment of metallurgical materials by C. Papalas has produced very interesting data (Table 11.17). This assemblage includes items recovered during the general lot sorting and from flotations, in addition to the field identified samples (piece-plots and special samples). Of the 166 samples submitted for analysis, 91 were classified as likely being related to metalworking. Most of the rejected items were daub (87 samples), nearly half of which were small fragments from flotation samples. The rest include 29 metal pieces (2 from flots), 40 slags (17 from flots), 22 possible “furnace linings” (2 from flotation), and 5 possible ores (2 from flotation). This shows that while most of the larger items were identified correctly during hand excavations, a substantial proportion of the slags were recovered instead from flotation, highlighting the importance of flotation sampling in the successful study of metal working.

Table 11.17: Metal and metal working tool counts and densities, analyzed specimens

		count							density (#/1000L)						
Phase	**vol (L)**	**metal artifacts**	**metal casting debris**	**possible ores**	**slag**	**"furnace lining"**	**molds**	**fish plates**	**metal artifacts**	**metal casting debris**	**possible ores**	**slag**	**"furnace lining"**	**molds**	**fish plates**
2				1	3	2		2							
3	10916	5	5	6	11	6	2	12	0.46	0.46	0.55	1.01	0.55	0.18	1.10
P	23815	7	6	4	22	9	4	43	0.29	0.25	0.17	0.92	0.38	0.17	1.81
4	7653	1	1	7	1	1		9	0.13	0.13	0.91	0.13	0.13	0.00	1.18
5	4588	1	2	1				3	0.22	0.44	0.22	0.00	0.00	0.00	0.65
6+					1	4									
Off Tell	1582	1			2			2	0.63	0.00	0.00	1.26	0.00	0.00	1.26
Total		**15**	**14**	**19**	**40**	**22**	**6**	**71**							

note: inlcudes all examined materials (piece plots, lots, flots)

The metals include both artifacts and casting debris. Fifteen copper/bronze specimens appear to be artifacts. Given their state of preservation, which is typically fragmented and highly corroded, some of these may not be completed items (further analysis is needed). Of those that could be identified more precisely, most are pieces of ornaments, including pins, beads, pendants, and rings. There are also several non-descript sheet metal fragments, a piece of wire, and a possible rivet. Note also that there is a bronze pin from layer B1-2 (Phase 1) and a bronze spear head from Trench 1 (possibly related to the C5 layer and/or the Structure 1/4 complex based on elevation, see Figure 11.16), and a "bow pendant" from Phase 6+ that are not included in this sample. In Phase 3 (n=5), most of the metal artifacts were found in the general C5 layer fill, but the possible rivet was found in the upper floor layers of Structure 4 and an undefined hammered piece was pulled from a post within Structure 2. The two metal pieces were also recovered from the E layer (Phases 4/5). The largest collection of metal artifacts come from the platform deposit (n=7), but they do not occur at a higher density than in other deposits. These finds are all ornaments except for a twisted wire and a square cast bar (chisel/awl?). There is also a small triangular fragment from Structure 10 in the off-tell area, but this was found within a rodent run so its original context is uncertain.

There are fourteen metal specimens identified as possible casting debris, including droplets, runnels, and furnace conglomerates. Their frequency is modestly related[127] with the objects identified as artifacts (again, some of the artifacts may not have been finished items). In Phase 3 (n=5), these were recovered from general fill layers (C5), Structure 2, and an external thermal feature (F132), possibly a furnace.[128] In Phases 4 and 5 (n=3), they all were found in general fill outside/east of Structure 4/8. The remaining six specimens are from the platform, including a piece of partially smelted ore.

There are a range of slags present at Pecica, which likely represent a variety of smelting stages and raw materials. While these are currently under analysis, only general spatial and temporal distribution can be assessed. Phase 3 and the platform have the highest densities of slags, all of which come from fill layers except for a single specimen from one of the basal floors of Structure 1. Slags are infrequent in earlier phases. There is one piece from the upper E layer immediately under the platform (Phase 4) and the other is associated with charred grain deposit in the lower layers of Trench 1 (Phase 6+). There are also two slag samples from Structure 10 (off-tell).

Preliminary examination of field identified "geological samples" by the author shows that less than half of these represent specimens that may be ore stones. The rejected items are locally available quartz pebbles (unmodified) and calcareous concretions found in loess deposits. However, it is possible that these concretions were being used as flux. Other large concretions are found predominately in association with architectural remains and bone pile features where

[127] $r = 0.697$
[128] This piece may be an artifact fragment?

they appear to be used to support posts. Of the sixteen specimens that are being analyzed further, preliminary observations show that most of these are granitic (n=5) or micaceous, perhaps micaceous schist (n=4). There are also several small quartz fragments that may or may not be local. I was unable to identify the remaining specimens. The potential ore stones are most abundant per unit volume in Phase 4, followed by Phase 3. They were recovered in comparably low numbers elsewhere.

Smelting- and casting-related artifacts show a similar density to the metals and slags. Formal molds (stone and clay) have only been identified in Phase 3 and the platform. Fish plate crucibles are very abundant in the platform and also occur at high rates in both Phase 3 and 4. Their density is positively related with molds, slags, furnace linings, very weakly with metal casting debris and ores, and inversely with finished metal items.

The distribution of possible furnace fragments is strongly related to the density of other slags and these items were likely produced from the same smelting activities. Most of the furnace linings are from the platform and fill from Phase 3, however there are two similar pieces found within Structures 1 and 3. One was found in Phase 4 fill and none were recovered from Phase 5 or off-tell. However, there are four furnace fragments from lower levels of the 2005 trenches (Phases 6+, Early Period). One of these was from a complex of thermal features in Trench 2 that were identified in the field as furnaces (Figure 11.8). Note, however, that one is also from the lining of the feature in which the aforementioned charred barley deposit in Trench 1 (Chapter 10). This highlights the problem of identifying actual furnace linings in the absence of copper or metal remnants[129] as daub/clay will vitrify in any circumstances in which sufficient temperatures are reached (c. 1250 C). No formal "workbenches" have been identified yet at Pecica, as were documented at Lovasbereny-Mihaivár (Kovács 1977). But it is not necessary to have elaborate facilities to smelt bronze. It is possible that a number of the small thermal features, especially those that have evidence of very high temperatures, were used for informal metallurgical production.

In sum, finished metals are found in all phases but, to date, metal working implements and by-products have not been securely identified from the final occupation during Phase 1. Field identified specimens suggest that there was a significant decrease in metal production after its peak in Phase 3. The analyzed specimens from 2008-2011 also show that metal working was

[129] Only two of the "furnace linings" have copper noted in their matrix.

particularly intensive during Phase 3. Interestingly, there is little evidence of centrally regulated metal production as debris and implements were widely distributed in the central occupation area and were also found off-tell. However, at this point it is not yet possible to distinguish the manufacture of simple items versus more elaborate metalwork other than through the presence and/or density of molds, which have only been found in the central tell area thus far.

Figure 11.8: Superimposed thermal features in Trench 2 (Early Period), possible metallurgical furnaces

IMPORTED GOODS

Raw Materials

This section reviews first the sourcing data for raw materials by individual type. This study is focused on imported minerals and stone, including those for chipped stone, ground stone, and metal manufacture. Salt, which cannot be identified archaeologically at this point, is excluded. Wood analysis is in progress and is also not presented. Density, diversity, and spatial distribution of different stone types are then compared between periods to identify changes in the frequency of importation from different sources over time. This section presents primary data and measures only. More detailed assessment of patterning is done in the following chapter as a part of hypothesis testing.

Chipped Stone

Stone resources are the most frequently imported raw materials at Pecica,[130] including those for the manufacture of chipped and ground stone items, as well as ores for metallurgical production. Cryptocrystalline materials used for making chipped stone items are somewhat problematic, as it is not always readily apparent if they derive from local river cobbles or were imported. Obsidian is certainly imported and chemical sourcing studies have already been completed for some of the assemblage from Pecica (Rosania and Barker 2009). Out of the five chemically distinguishable sources in the northern arc of the Carpathians, ranging from Hungary through the Ukraine, all of the analyzed specimens are of the C1a type, which is found in the Slanské Mountains of southeast Slovakia, near the modern town of Vinicky (See also Chapter 4 locations of raw materials). This source produces the highest quality obsidian in the region and is found in larger nodules than the nearby Tokaj source in Hungary. While the importation of finished obsidian blades cannot be excluded, the presence of obsidian debitage at Pecica does indicate that at least some local working was being done. Given the fragility of these fine blades, it is unlikely that they were traded in finished and final form over any significant distance. Nodules or prepared cores are more likely to have been exchanged. While neither cores or raw obsidian nodules of these have been found at Pecica to date, none of the debitage shows any remnant cortex, which would argue for the exchange of prepared cores.

Some basic information can be presented from my preliminary analyses of chipped stone. Non-obsidian chipped stone (chert and related cryptocrystalline materials) manufacture was done locally, at least in part, given the abundance of debitage. Note that cortex is present on nearly half of the non-obsidian chipped stone, which indicates early-stage manufacture on site from raw nodules. There are a number of cobbles, some of which were clearly used as cores; others are fire-cracked. Most of these are from the platform. The cobbles are predominantly pink with dark red cortex and similar tan-yellow-orange cobbles have also been found. Their color and texture suggests that these are jasper, which is a high quality, typically reddish chalcedony with high iron oxide content. There are jasper sources in the Apuseni Mountains, in the Slovakian Zemplín Mountains (near the obsidian sources), and in the Maramureş region of northern Romania.[131]

[130] At least for those that are archaeologically visible.
[131] The Zemplín jasper source is extensively mottled with gray and white veins (Flintsource.net, 2013), which are not apparent in the local assemblage.

The jaspers from the Apuseni Mountains, both in the Metalliferous and Trascău Mountains,[132] contain red and brown-yellow variants (Crandell 2008), as found at Pecica. Note also that jasper cobbles from Apuseni sources are known to travel down the Maros River to Arad County (O. Crandell, pers. comm. 2013). I would tentatively argue that the Pecica cobble specimens of both color variants are locally obtained jasper cobbles that originate ultimately from the Apusenis, likely from the Metalliferous Mountains given that they have outcrops along the Maros River itself. At this point, however, it cannot be excluded that the cobbles were traded to Pecica from communities further upriver, perhaps along with ore stones from the Metalliferous Mountains.

Jasper cobble specimens identified with a high degree of certainty (including debitage, cores, fire-cracked cobbles, and finished tools) comprise 1/3 of the non-obsidian assemblage. An additional 1/3 are classified as possibly originating from cobble jaspers (but they lack diagnostic cortex). It appears that a large portion, if not most, of the non-obsidian chipped stone may have been made from local resources. The last 1/3 of the non-obsidian chipped stone assemblage is highly variable and their identification must await specialist analysis.

As discussed above, the ratio of debitage and cores to finished tools for the cobble jaspers (excluding unworked, fire cracked cobbles) is 11:3. In sharp contrast, the ratio is 4:7 other non-obsidian stone and 3:7 for obsidian, which argues for a difference in conservation of raw materials between local and non-local sources. It is also possible that the unidentified chert sickle blades may have been imported as finished items, or as blanks, as they are more robust than the obsidian blades. There is at least one possible sickle blank from Pecica, found in the off-tell deposits. Large numbers of sickle blanks have been found at other sites, including Százhalombatta (Horváth 2005). Further analysis of regional blade styles may help to clarify their origin.

Ground Stone

Ground stone is more difficult to evaluate than chipped stone because evidence for local manufacture is scarce, so it is not possible to establish with certainty if they were coming into Pecica as raw materials or as finished items. I would argue that bulky, utilitarian items, like querns, are more likely to be imported in completed (or partially completed) form given the high

[132] These two sources are similar macroscopically, along with jasper from the Maramureş region in northern Romania. These can, however, be distinguished chemically and it is hoped that this will be done in future work.

cost of raw material transport for such utilitarian items. Metallurgical molds and other stone used in local fine craft production may have been made on-site to meet local stylistic traditions, especially if the finished goods were going to enter regional exchange networks. Other prestige items may have imported in finished form as well. These may be differentiated based on regional stylistic differences, but none of the Pecica assemblage is sufficiently complete for evaluation.

A few basic types of groundstone types have been differentiated by the author, but more precise determination must await specialist examination. This analysis is limited to items from the 2008-2011, comprising only Florescent Period materials. There is no ground stone from off-tell contexts. There are records of field identified ground stone and geological samples from lot and flot sorting logs as well as mapping piece plots for earlier field seasons. However, these are treated with extreme caution as similar samples examined at UM show a nearly 50% misidentification rate. These include small river cobbles and pebbles (mostly quartz), loess calcareous concretions, and burned soil. These are excluded from discussion.

Most of the ground stone is made of igneous materials, finer-grained varieties for polished stone items and coarser-grained varieties for querns (see Appendix 11.2, Figure 11.8A). Unfortunately, igneous rocks have wide distributions throughout volcanic areas in the mountains systems ringing the Carpathian Basin. More precise sourcing may rely on chemical analysis. The dark, fine-grained stone is probably basalt, which is commonly used in axes. There is also one grinding stone that appears to be made from coarse vesicular basalt. A pink, medium-grained igneous stone is used to manufacture most of the querns from Pecica, as well as several unidentified objects. This may be rhyolite. One of the fine-grained items, a rectangular fragment of unknown type, is made from an unusual light and dark gray banded material. A mold fragment for a disk-butted axe was carved into an unidentified fine grained sedimentary stone. There are also a few unidentified ground stone fragments made from limestone, which has a widespread distribution throughout the regional mountain systems as well. As mentioned above, a roughly made, small square bead from the midden and bone pile area outside of Structure 4 also is made from limestone.[133] There are several specimens that are made on unknown stone types.

[133] A nearly identical second specimen was recovered in 2013 from a post in E layer fill, contemporary with Str 4 (Figure 11.8A, lower center). Again, several other unusual items were also recovered in 2013, including a small

At this early stage in analysis, little can be said about the importation of ground stone raw materials other than that: 1) they are primarily igneous, but also sedimentary, 2) these raw materials have very widespread distributions and require specialist and perhaps chemical analysis for further differentiation, 3) evidence for local production of groundstone is tentative.

Ore Stones

Ore producing stones must have been imported to Pecica given the lack of local metal sources. As with the ground stone, field identifications cannot be reliably used for analysis and specific raw material typing and sourcing is currently in progress. There is a large range of host materials for copper, including igneous, metamorphic, and sedimentary formations. All of these host materials are found near the closest copper source, the Apuseni Mountains (Borocoş, et al. 1983; Papalas 2008). From the 2008-2011 samples, most of the geological samples that have been tentatively identified are granitic or micaceous,. It is possible that these may be gangue or ore stone. Both granitic and micaceous stones are common to volcanic and metamorphic regions throughout the mountains of the greater Carpathian region. C. Papalas has identified five likely ore stones in his preliminary study, three of which have malachite/azurite and the other two are sedimentary with high iron content (Kupferschiefer/bog iron).[134] These also have not yet been precisely sourced.

Imported Raw Materials: Diversity

Diversity measures are calculated from the number of raw material types per class for the Florescent Period. There is little evidence for major differences in the diversity of chipped stone raw material types by period or on-tell versus off-tell areas when excavated volumes are taken into account (Table 11.18). All contexts have obsidian and cobble jasper, with variation in the diversity of other non-obsidian stones. The latter are absent in Phase 5 and off-tell, but these have much lower excavated volumes. While not included in this study, the field identified specimens from Late Period contexts include both “chert” and obsidian. There does not appear

pestle and a pendant/weight, both of which appear to have been made from fine-grained basalt or related igneous material.

[134] Kupferschiefer, or copper shale, deposits are found throughout northern Europe in basin deposits from the Zechstein Sea. Bog iron is widespread and may have been used as a fluxing agent (C. Papalas, pers. comm. 2013).

to be any significant change in the range of raw materials obtained through time or between central and peripheral site inhabitants.[135]

Table 11.18: Diversity of raw material imports (examined specimens only)

			Phase 5		Phase 4		Platform		Phase 3		On-Tell		Off-Tell	
Class	**Raw Material**	**Use**	**# types**	**# types/ kL**	**# types**	**# types/ kL**	**# types**	**# types/ kL**	**# types**	**# types/ kL**	**# types**	**# types/ kL**	**# types**	**# types/ kL**
chipped stone	local and import	utilitarian	2	0.44	3	0.39	5	0.21	4	0.37	4	0.22	2	1.26
ground stone	import	utilitarian and prestige	1	0.22	2	0.26	5	0.21	2	0.18	2	0.11		0.00
ore stone	import	utilitarian and prestige	1	0.22	5	0.65	4	0.17	4	0.37	3	0.16		0.00

note: # types is the *minimum* number observed

In the analyzed sample, the diversity of ground stone raw material types mirrors that for chipped stone. The platform has widest range of raw materials, but this is expected given the very large volume of earth excavated. Per unit volume, there is little difference between phases. There is no ground stone off-tell, but again, this may reflect the much smaller area excavated. Interestingly, while most periods have basalt, rhyolite, and/or limestone present (as well as unidentified types), the platform also has two items made from a fine-grained micaceous stone and an axe mold made from a sedimentary rock.

Possible ore stones/gangue (geological samples) do not follow the same pattern of diversity as the chipped or ground stone. Potential ore stone diversity is not strongly related to volume excavated as there is a greater range of materials in Phase 3 and 4 per unit volume than the platform. There is a similar range of materials in all on-tell contexts, with the exception of Phase 5, with all having granites,[136] micaceous stone, and malachite/azurite. These stone types are associated with copper sources in the Apuseni Mountains upriver from Pecica (Borocoş, et al. 1983; Papalas 2008), but granite is also regularly used for ground stone, so its presence is more ambiguous. Phase 4 and the platform also have possible Kupferschiefer/bog iron.

There is little change in access to imported raw materials through time during the Florescent Period. Importantly, the diversity of both chipped stone and ground stone is related to volume excavated, with diversity increasing with volume, especially the appearance of rare

[135] Preliminary analysis of 2013 materials from Phases 5 and 6+ show no obsidian and a different range of other stone types. It is possible that in these earlier deposits, different stone exchange systems were operating, ones that did not have strong contact with obsidian producing regions.
[136] None of these appear to be large-crystalled pegmatites from initial inspection, which are tin bearing deposits.

types. However, the diversity of possible ore stones is not related to volume, being more frequent than expected in Phases 3 and 4. This pattern likely reflects an increase in the intensity of importation of metallurgical raw materials at this time.

Imported Raw Materials: Abundance

The overall abundance (density) of chipped stone (finished items and debitage) decreases by more than half from the Florescent to Late Periods (Phase 2) (Table 11.19). While this may in part be related to the general decrease in occupation intensity in the Late Period, it is not entirely explained by this phenomenon as the density of general debris (as measured by fauna) only decreases by a third. Note also that of the 16 specimens recorded, only a single piece was field identified as obsidian from Late Period contexts.

Table 11.19: Abundance of chipped stone (all types, all specimens, 2007-2011)

			Florescent		Late Period	
Class	Raw Material	Use	# items	# items/ kL	# items	# items/ kL
chipped stone	local and import	utilitarian	41	0.87	16	0.39

Table 11.20: Abundance of raw material imports (examined specimens only)

			Phase 5		Phase 4		Platform		Phase 3		On-Tell		Off-Tell	
Class	Raw Material	Use	# items	# items/ kL	# items	# items/ kL	# items	# items/ kL	# items	# items/ kL	# items	# items/ kL	# items	# items/ kL
chipped stone--jaspers	local	utilitarian	3	0.65	4	0.52	7	0.29	3	0.27	7	0.38	2	1.26
chipped stone--other "cherts"	import	utilitarian		0.00	2	0.26	6	0.25	4	0.37	6	0.32		0.00
chipped stone--obsidian	import	utilitarian	1	0.22	2	0.26	1	0.04	5	0.46	7	0.38	1	0.63
chipped stone--all	local and import	utilitarian	4	0.87	8	1.05	14	0.59	12	1.10	20	1.08	3	1.90
ground stone	import	utilitarian and prestige	1	0.22	5	0.65	7	0.29	2	0.18	7	0.38		0.00
ore stone	import	utilitarian and prestige	1	0.22	7	0.91	4	0.17	6	0.55	13	0.70		0.00

Considering only the materials examined in detail, the overall density of chipped stone does not differ greatly by period during the Florescent Period occupation (Table 11.20). There are, however, significantly fewer items per unit volume in the platform. Comparing the percentage of raw material types represented in each phase, jasper cobbles are most frequent in the earlier phases (4 and 5), with non-local sources becoming increasingly common in Phase 3 as well as within the platform (Table 11.21).

Table 11.21: Chipped stone raw material representation

	Ph 5	Ph 4	Platform	Platform*	Ph 3	On Tell	Off Tell	Total
jasper**	75.0%	50.0%	50.0%	25.0%	25.0%	35.0%	66.7%	46.3%
other "cherts"	0.0%	25.0%	42.9%	62.5%	33.3%	30.0%	0.0%	29.3%
obsidian	25.0%	25.0%	7.1%	12.5%	41.7%	35.0%	33.3%	24.4%

*excluding fire-cracked cobbles
**includes tentative IDs

Density measures of ground stone specimens show a different pattern to the chipped stone. Ground stone occurs at especially high rates in Phase 4 only. There is little variation in densities between other contexts and none was recovered off tell. There is almost no relationship between chipped stone (including or excluding local jaspers) and ground stone density.[137] Unlike chipped stone, the density of ground stone items is strongly related to overall occupation intensity as measured by bone refuse density (Chapter 12). This suggests that chipped and ground stone exchange networks were operating at different intensities at different times, or at least that their end products were used at different rates and/or in different areas. It will also be important to consider sourcing more precisely when the data are available.

There are substantial temporal differences in ore stone distribution through time. Like ground stone, possible ores are most frequent in Phase 4, but they are also very abundant in Phase 3. Ores are comparatively infrequent in Phase 5 and in the platform, and absent from the off-tell occupation area. Interestingly, possible ore stone ("geological samples") density covaries moderately with groundstone and imported chipped stone and varies strongly with overall occupation intensity.[138] There is weak inverse relationship between ore stone and other

[137] All chipped stone r = 0.215, import chipped stone r = -0.001
[138] Import chipped stone r = 0.650, groundstone r = 0.766, fauna r = 0.920, other metallurgical items r = -0.254

metallurgical items and debris, which may suggest that a large portion of the possible ores are actually ground stone fragments.

Finished Prestige Goods

Marine Shell Beads

There are few worked shell items from Pecica, which is not unexpected given that these are valuable items that are unlikely to be carelessly disposed of. Like other ornaments, they primarily are recovered from burial contexts rather than settlements. The three worked shell pieces described in the craft production section were made on locally available species and were probably manufactured on-site. The other worked shells are all beads made from *Columbella rustica*, a marine gastropod from the Aegean and southern Adriatic seas. They have small holes drilled into their apex for stringing, and some show extensive use-wear polish, suggesting fairly intensive curation.[139] These are used commonly in Lower Maros composite ornaments such as head dresses, sashes, and necklaces, which have been found in burial contexts (O'Shea 1995, 1996). These are important items are they are used to mark vertical distinctions, including hereditary social offices. While there is no direct evidence for their local manufacture, it cannot be excluded that they were made locally on imported shells.

To date, there have been five *Columbella* shell beads found at Pecica, four of which I examined. Most of these are from Florescent Period contexts, and all were found within or immediately adjacent to houses (Structures 0, 3, 4, and 8). In 2013, a fragment of a cardium shell pendant was also found in lower E layer fill deposits (Appendix 11.4, Figure 11.12A, left). It is surprising that *Spondylus* or *Dentalium* shell was not found as these are more commonly traded prehistorically, and *Dentalium* is used in Maros burial ornaments.

Amber Beads

There is a single amber bead from secure Bronze Age contexts at Pecica.[140] It was recovered from the base of a hearth (F 125) within the final occupation of Structure 1 (Phase 2, Late Period). A second amber bead was found within Crişan's redeposited backfill in Trench 2,

[139] Note that the 2013 specimen from a hearth within Structure 8 (Phase 5), the earliest example recovered, is drilled perpendicular to its long axis (Figure 11.7A, right), in contrast to all of the other specimens. This may reflect stylistic changes over time.
[140] A third possible amber bead was found in 2013 but has not been examined in detail.

but as this contains mixed deposits, it is not known if this bead originates from Bronze Age contexts or not. Importantly, a lump of raw amber was found in 2013 which indicates that at least some of the amber beads were manufactured locally (Appendix 11.4, Figure 11.12A, right). While amber is one of the hallmark Bronze Age long-distance exchange goods, there is little evidence that these are used in Maros ornaments displayed in funerary contexts, at least in the Lower Maros region. Amber does seem to have greater importance at Middle Maros sites however, at least at Pecica.

As with the worked shell, the sample is too small to adequately assess temporal or spatial distribution. There best known amber deposits are found in the Baltic Coast region, however, there are amber sources elsewhere in Europe, including Sicily, Spain, southern Poland, and Romania (Rapp 2009), which have not been extensively studied. Romanian amber (*romanite*) is found throughout the Carpathian Mountains, with the largest and most accessible source located in the Buzău Mountains of the Outer Eastern Carpathians. Currently, evidence of its exploitation begins only in the Late Bronze Age (Heck 1999). I t is more likely that Pecica's amber is Baltic, but only chemical analysis can conclusively confirm or reject this assertion.

Fine Metalwork

Elaborate metalwork is another of the classic Bronze Age prestige goods that is known to be traded across the continent. There are only a handful of finished goods that are sufficiently preserved to be assessed in any detail. These are all from the 2005 excavation of Trenches 1 and 2. There is a bronze spearhead from the north end of Trench 1 (Figure 11.6) that corresponds to Phase 3 (Florescent Period) and a bronze "bow pendant" from deep layers of Phase 6+ (Early Period). There is also a bronze belt buckle from Crişan's backfill in Trench 2 but the original context is unknown.[141]

The source of imported metal goods can be traced both through stylistic differences and sometimes through compositional analysis.[142] Unfortunately, both of these sourcing methods are problematic. First, finely crafted and well preserved metalwork cannot be exported to the United States, so these cannot be chemically sourced at this time. Second, few of the bronze/copper

[141] As discussed previously (see also Appendix 11.3), there are a significant number of finished metal pieces from previous excavations. Unlike the molds, most of these are ornaments and it is possible that some of these may have been imported, but nothing stands out as being clearly of foreign origin.
[142] This is also problematic; see Papalas (2008) for further discussion. The use of recycled metal items and ores from different sources are primary issues.

items are in sufficient condition to assess form or style in any detail, excepting the three aforementioned specimens. Most are highly fragmented and corroded, and it is not possible to differentiate local versus imported types at this point. As discussed above, C. Papalas has been able to tentatively identify a small number of additional specimens to general form, most of which are small fragments of ornaments. These include pins, rings, pendants, and beads. While bronze or copper items of all types are far more common, there is also a single gold hair ring fragment that was collected in 2008 (Florescent Period). Note that the range of items parallels those found in previous excavations (Gogâltan 1999), including the paucity of weaponry in comparison to ornaments and tools.

While it is currently not known which of these specific items were made locally, mold types found at Pecica from current and previous excavations do demonstrate the manufacture of fine metal (and utilitarian) items on site. Again, it should be underscored that while the molds are predominantly for weaponry, the finished items are largely ornamental. It is not clear if this reflects differences in local manufacture or in consumption/deposition. However, I would argue that the smaller size of the recovered ornaments would make them more likely to be lost. There are no specimens that clearly are of foreign styles to date. It is hoped that compositional analyses will be able to identify foreign metals.[143]

Imported Finished Goods: Diversity

Diversity measures use beads and metalwork as primary classes. The same number of bead types is found in each period (Table 11.22). Both have shell beads, while the Late Period also has amber and the Florescent has stone (although this may have been made locally). Metalwork is tentatively included here, since any imported items cannot be differentiated from locally made ones at this point. There is a significant difference in the diversity of finished fine metalwork, with only a pin found in the Late Period. In the Florescent Period, there is a range of other ornament types (including gold) and a spear head. This high level of diversity is far greater than expected given the volume excavated or general level of occupation intensity. There are no

[143] Note that nine metal pieces from "lower layers" at Pecica were included in Junghans et al.'s 1968 compositional study of Bronze Ag metalwork. While no specific sources were identified, none of the samples were alloyed with tin. Like those found in the Lower Maros region, they are either fairly pure copper or show low levels of arsenic. This is consistent with sources in the Apuseni Mountains (As) or in the Banat (pure copper). Other sources cannot be excluded at this time.

beads and no identifiable fine metalwork off tell. Their absence may be due to small off-tell samples given the rarity of these items.

Table 11.22: Diversity of imported finished prestige goods

	Late		Florescent		On Tell		Off Tell	
Class	**# types**	**# types/ kL**	**# types**	**# types/ kL**	**# types**	**# types/ kL**	**# types**	**# types/ kL**
beads	2	0.04	2	0.02	1	0.05		0.00
finished fine metalwork*	5	0.11	1	0.01	3	0.16		0.00

*may or may not be imported

Imported Finished Goods: Abundance

The density of items shows the same general patterns through time and among occupation areas as do the diversity measures (Table 11.23). Other than items occurring singly, there is a far greater density of exotic finished goods and metalwork[144] in the Florescent Period. Note that the density of faunal remains, which is used as a proxy for deposition rates, is only twice as high in this period, compared to the differences seen in these materials, which are minimally five times as common per unit volume. Other than a non-identifiable piece of copper from a rodent run, there are no exotics off-tell, but sample size limits interpretation.

Table 11.23: Distribution and density of imported finished prestige goods

	Flor. Period		Late Period		On-Tell		Off-Tell	
Class	**# items**	**# items/ kL**	**# items**	**# items/ kL**	**# items**	**# items/ kL**	**# items**	**# items/ kL**
Columbella beads	3	0.06	1	0.01	2	0.11		0.00
stone bead*	1	0.02		0.00	1	0.05		0.00
amber beads		0.00	1	0.01		0.00		0.00
all metal items*	23	0.49	9	0.11	10	0.54	1	0.63
finished fine metalwork (bronze)*	7	0.15	1	0.01	3	0.16		0.00
finished fine metalwork (gold)*	1	0.02		0.00	1	0.05		0.00

*may or may not be imported, inlcudes possible IDs of fine items (pendants, pins, rings, weapons)

CONCLUSIONS

This chapter presents the primary data for crafts and import goods that are used to test models of economic centralization in the following chapter. For craft production, I provided an

[144] All metal uses only mapped field identified items, to maintain comparability between periods. This includes all types of metal. The other metal categories include items identified to type in the field and by C. Papalas. Additional finished types may be found in the Late Period sample.

overview of the major crafts produced at Pecica with a basic description of materials, density, spatial distribution, and standardization wherever possible. It appears that most crafts were manufactured at the household level with little evidence for spatial segregation, including for metallurgy. The only exception may be horn working, which may be a prestige craft. Over time, the density of crafting debris and associated artifacts and facilities is strongly related to overall occupation intensity. The only exceptions are chipped stone and metalworking, which occur at greater than expected frequencies in the Florescent Period, especially Phases 3 and 4. Both of these require imported raw materials. Interestingly, ground stone, while also using foreign materials, does not follow this same pattern.

For imported goods, the diversity, density, and distribution of both raw materials differ over time. Imported raw material abundance, except for ground stone, does not directly relate to overall artifact density, being more common than expected during the Florescent Period. Finished foreign goods are more difficult to assess given their very small numbers, and for metals, poor preservation.

CHAPTER 12: THE POLITICAL ECONOMY AT PECICA ŞANŢUL MARE

This chapter presents a comprehensive overview of the political economy at Pecica Şanţul Mare. Expectations for economic organization within more or less centralized systems, as outlined in Chapter 7, are assessed for Pecica's three major occupation phases.[145] These draw on the primary analyses presented in the previous three chapters for agro-pastoral systems, craft production, and regional exchange. Attention paid to the timing, scope, and degree of changes occurring over time within these three specific economic sectors and how these may be inter-related. It is expected that centralization will be most strong during the Florescent Period as a whole compared to other periods, especially in contrast to the Late Period occupation. Finer scale temporal changes are also examined wherever data are available, with centralization expected to be variably developed within individual phases as well. When possible, this economic reorganization is related to environmental, cultural, and other factors, to better understand the relative role of internal and external influences on Pecica's development.

ANIMAL ECONOMY

Pecica's animal economy is examined through changes in livestock production strategies, the degree of indirect versus direct procurement, the relative influence of elite consumption patterns, and the presence of feasting activities. While Chapter 9 presented a comprehensive overview of Pecica's faunal assemblage and provided some discussion of major trends over time, here the results are synthesized and a subset of variables is used to test specific expectations for the influence of increasing (or decreasing) centralization over time. These primarily target significant changes in taxon composition, cull patterns, and body part representation. Again, all of the primary data, including the summary tables from which these secondary analyses draw, can be found in Chapter 9.

[145] Note that the Early Maros can only be assessed for the faunal assemblage in any detail. Other sectors focus on changes between (and within) the Florescent and Late periods.

Production Systems

Intensification: Energy Maximization versus Security

The primary means to evaluate intensification used here is through the distinction between herding systems that maximize resource output over herd security, the latter of which is more strongly associated with smaller-scale, decentralized herding systems. These can be distinguished by livestock composition and demographic profiles, particularly as a delayed juvenile cull in generalized maximizing strategies. Given the differences in the range of resources that can be exploited from different species and their variable return rates, trends towards resource maximization should also be evaluated through measures of specialized or diversified production, which are considered in subsequent sections. In this study, intensification proper excludes horses as they are not primarily used as meat producers in this region.

Resource maximization can take varied forms. It may entail a shift to larger animals with more meat available per individual (cattle), species that have multiple resources that can be exploited (dairy and meat for ovicaprids and cattle), or animals that can be encouraged to reproduce more times a year and mature rapidly (pigs). Between Pecica's major occupation periods, there are only minor changes in the importance of pigs and especially cattle, although they are slightly more common during the Florescent and Late Periods (Table 12.1). Ovicaprid use decreases over time to a greater degree.

However, there are significant demographic differences present that indicate a greater emphasis on protein production in later periods, especially in the Florescent Period, and no periods are strongly tailored towards herd security (Table 12.2).[146] In the Early Period, ovicaprids are dominated by mature animals rather than prime-aged individuals or juveniles. In both the Florescent and Late Periods, which do not differ statistically, there are very large culls of animals between 2-6 months which is not expected in either of these systems. However, greater concern with increasing meat output per animal is seen in the dominance of prime-age animals between 1-3 years in both periods. There are somewhat more individuals culled before reaching one year and those over four years in the Late Period, which may indicate either a greater concern with security or a more diversified production strategy.

[146] Again, the Pecica sample may not be directly compared to the cull rate figures in Redding's model as the environmental conditions differ greatly and Pecica's herds are overwhelmingly dominated by sheep. However, the underlying principles are applicable and general patterns are targeted, allowing for considerable variation between idealized models and actual data.

For cattle, there are very large proportions of senile animals and very few juveniles in all periods, which is not expected in an energy maximizing or herd security system, as these old cattle require significant upkeep costs with no return in meat weight and diminished capacity for reproduction and dairy output. The maintenance of old animals is related to their primary use as traction animals in most periods, which is discussed further below. There are, however, a comparatively high number of prime-aged cattle in the Florescent Period, which shows a greater emphasis on protein production via meat.

Table 12.1: Variables used for assessing intensification (energy maximization versus herd security)

		Early Period†	Flor. Period	Late Period	On Tell	Off Tell††
% livestock taxa	**ovicaprid**	59%	43%	46%	42%	54%
	pig	24%	33%	33%	35%	31%
	cattle	17%	24%	21%	23%	15%
peak cull(s): age-(sex)	**pig**	prime	juv/prime (F)	juv/prime (F)		
	ovicaprid	mature	prime (F)	juv/prime		
	cattle	senile	prime (M/F)	prime/senile (M/F)		

†small sample, non-systematic collection strategies
††small sample

Table 12.2: Ovicaprid age class representation (% MNI) for Pecica's three periods, compared against herd security versus energy maximization models (adapted from Redding 1981, Marom and Bar-Oz 2009)

	0-2m	2-6m	6m-1y	1-2y	2-3y	3-4y	4-6y	6-8y	>8 yrs
Early	0	9	9	17	17	22	22	4	0
Florescent	0	22	2	50	4	13	0	0	9
Late	2	27	8	29	15	6	4	2	8
Energy	10	0	13	30	23	1	8	4	12
Security	10	0	26	27	13	1	8	4	12

Pigs differ greatly from bovids in their ecology are not expected to fit Redding's models given their very high fecundity and rapid maturation rates. They also are not used for milk, so generalized protein (meat-dairy) maximization models are not applicable. Instead, focus is placed on the presence of rapid turnover systems (higher juvenile cull) with the possibility of double farrowing. The average age of pig off-take is a full year older in the Early Period than in later periods, which may reflect a greater concern with maximizing the amount of meat per animal. In the Florescent and Late Periods, the very high number of juveniles is suggestive of a rapid turnover system that places more emphasis on the number of animals produced annually rather than the amount of meat per individual. Double farrowing may have been practiced, but unfortunately the sample of mandibles is too small to evaluate this directly (Ervynck 1997). This shift may also be influenced by elite consumption preferences, discussed below.

In sum, there is little evidence to support a primary concern with ovicaprid or cattle herd security in any period. They also do not meet expectations for a generalized energy (dairy-meat) maximization strategy. But there is a clear trend for increased meat production over time, peaking in the Florescent Period. Ovicaprid husbandry shifts from a more balanced meat-secondary products system to meat maximizing (see below) and pig breeding becomes rapid-turnover. And while traction is important for cattle in all periods, in the Florescent Period there is a greater off-take of prime-age animals for meat.

Specialized Production Systems: Secondary Products versus Meat

Specialized production is examined through the mortality profiles and species composition of Pecica's livestock, particularly cattle and ovicaprids. At Pecica, there are not dramatic shifts between periods in the proportion of cattle or ovicaprids within the overall livestock assemblage that would be associated with a strong specialization in secondary products (Table 12.3). However, there are significantly more ovicaprids in the Early Period, which is coupled with an off-take pattern which indicates greater use of secondary products at this time, albeit in a generalized meat-dairy-wool system (Table 12.4). It is has been argued elsewhere that this profile form shows an increase in the importance of wool specifically (Vretemark 2010; Vretemark and Sten 2005). While there may in fact be more fiber production, the near absence of animals older than six years suggests that dairy production was also a central concern. After this age after which the reliability of milk production drops (Redding 1981:308). This assumes a dairy strategy in which infants are not immediately culled but rather weaned early and separated from their mothers (e.g., Vigne and Helmer Type B dairy system), as would be more typical in pre-market production systems. Unfortunately, there are no sex data to clarify the relative roles of dairy versus fiber production.

Table 12.3: Variables used for assessing specialized production (meat versus secondary products)

		Early Period†	Flor. Period	Late Period	On Tell	Off Tell††
% livestock taxa	ovicaprid	59%	43%	46%	42%	54%
	cattle	17%	24%	21%	23%	15%
peak cull(s): age-(sex)	ovicaprid	mature	prime (F)	juv/prime		
	cattle	senile	prime (M/F)	prime/senile (M/F)		

†small sample, non-systematic collection strategies

††small sample

Table 12.4: Ovicaprid age class representation (% MNI), Pecica versus specialized production models (adapted from Payne 1973, Vigne and Helmer 2007, Marom and Bar-Oz 2009)

	0-2m	2-6m	6m-1y	1-2y	2-3y	3-4y	4-6y	6-8y	>8 yrs
Early	0	9	9	17	17	22	22	4	0
Florescent	0	22	2	50	4	13	0	0	9
Late	2	27	8	29	15	6	4	2	8
Meat*	15	10	5	20	20	8	3	9	10
A Meat**	19	47	23	4	0	4	2	0	1
B Meat**	14	18	40	22	0	5	0	0	1
Milk*	53	5	3	4	7	5	5	8	10
A Milk**	78	11	7	1	0	1	1	0	1
B Milk**	17	33	14	18	0	12	5	0	1
Wool*	15	10	10	2	6	7	7	23	20

*Payne 1973

**Vigne and Helmer 2007

In the Florescent and Late Periods, ovicaprid mortality profiles differ greatly from the Early Period pattern. In neither the Florescent nor Late Periods is wool or dairy maximization evident. There is not the very large number of infant animals that would be expected in most specialized dairy models, even accounting for differential destruction of infant bones.[147] There are also not large numbers of animals older than six years which would be present in specialized wool systems, and at least in the Florescent Period, no adult males have been identified, which would be common in whethers flocks. While the fits are not exact, as they rarely are with archaeological data, both the Florescent and Late Period ovicaprid profiles most closely match Payne's meat maximization and Vigne and Helmer's Type B milk model, in which infants are segregated, not culled (Figure 12.1). Looking only at the ratio of juveniles to prime-age animals, both fall closer to the meat model, suggesting specialized meat production. The Florescent

[147] It must be kept in mind that the very low numbers of animals less than two months at Pecica is an expected by-product of differential destruction of very young animal bones due to low bone density and size. In addition, it is possible that neonates, especially those that died of natural causes, were not brought to the tell for consumption.

Period stands out with its very strong modal cull of animals 1-2 years old, to which I will return later.

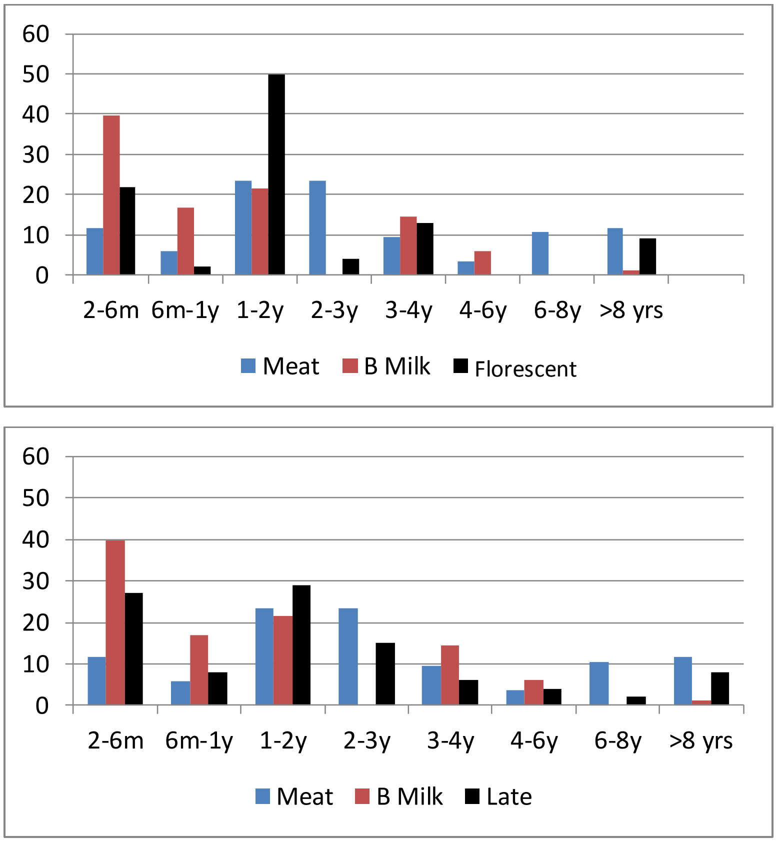

Figure 12.1: Ovicaprid age class representation (% MNI), Pecica versus meat (Payne 1973) and Type B milk (Vigne and Helmer 2007). Top: Florescent Period; bottom: Late Period. 0-2 months removed.

The cattle age profiles are not as precise nor have as large of samples as those for sheep/goat. Nonetheless, the mortality patterns do differ considerably between periods. No period has a very large infant population represented that would be expected in a highly specialized dairy production system. While prime-aged subadults are the largest class represented in the Florescent Period, there are large numbers of senile animals present in all periods (Early 67%, Florescent 27%, Late 39%), far more than would be expected in a specialized meat production system, in which they would contribute around 10% of the population. I argue that these old animals are primarily kept for traction, which is supported by the equal male to female sex ratios, the presence of oxen/castrates (as determined by horn cores), and traction pathologies. Dairy may also have been an important, but secondary, component of this system, but it cannot be directly tested at this point. So while meat production was more important in the Florescent Period than in other periods, draft cattle were important resources at all times, indicating diversified cattle husbandry. This underscores the importance of plow agriculture and transport of heavy bulk goods via ox-cart at Pecica.

In sum, there is no evidence for highly specialized production of secondary products in ovicaprids or cattle. Cattle husbandry balanced the production of beef with the maintenance of older animals for their labor. However, meat production was more important in the Florescent Period. In the Early Period, ovicaprids were raised in diversified, mixed meat-secondary products system. The only specialized production is seen in the meat systems for ovicaprids in both the Florescent and Late Periods. Importantly, there is little evidence for large-scale wool production at this time, arguing against highly specialized and intensive wool textile manufacture. This is supported by other artifactual evidence as there is no increase in tools related to textile production at this time (see below and Chapter 11).

Specialized Production Systems: Livestock Exchange

The exchange of livestock in various local and regional networks was likely widespread in the Bronze Age given their inherent value. However, with the exception of highly centralized provisioning systems (see below) or the exchange of otherwise rare animals, in most cases this would occur at an imperceptible level. The specialized production of animals for export can be seen in mortality profiles that have very strong under-representation of prime-age animals, as these are generally the targeted age class for exchange. Rather, the producing site would be dominated by a breeding profile, comprised by adult females and the very young. From the above discussion it is clear that specialized breeding profiles are not present for pigs, ovicaprids, or cattle. However, the issue is more complicated when considering horses.

Horses are a prime candidate for animal export given their very high-value and general infrequency (and often absence) in Early and Florescent Bronze Age settlements (see also Chapter 13). Pecica is situated in a region that is very well suited to horse breeding. There are large tracts of high-quality, defensible pasture on both the grassy loess plateau and the floodplain below. While historically the Pannonian Plain has been famed for its horses, Bronze Age settlement was not as dense in the dry grassland regions where it was concentrated in more recent times. Rather, Bronze Age settlement was more tied to major waterways rather than the drier and often salt-affected interfluves. Many sites were located in areas with limited flood-free land, including much of the Lower Maros region and the Körös drainage. Areas in more mountainous regions would have been forested. Pecica, with its specific geographic and ecological placement, would have been in an ideal position to export horses to communities in the marshes downriver and those in the highlands to the east. They may have been travelling even greater distances, perhaps into the Körös valley to the north, or as gifts in elite exchange networks.

Horse production at Pecica varies strongly though time and is a defining character of its animal economy. Horses comprise just 2% of the livestock in the Early Period and 5% in the Late Period. In sharp contrast, 20% of the domesticates are horses in the Florescent Period, peaking in Phase 4 at nearly 30%. Clearly, horse breeding was greatly increased during this time, at rates far beyond the range of most contemporary settlements. However, it is not immediately clear why horses became so important. Demographic profiles can shed some light on the issue, at least for the Florescent and Late Periods for which there are larger samples. Both periods have evidence for local breeding with very young and neonatal animals present (including off-tell). Juveniles comprise between 30-40% of the ageable specimens. Other aspects of the age profiles are more difficult to interpret as horses are not primarily food animals so prime-age animals will be infrequent even if no export is occurring. Most prime-age animals will be natural deaths or slaughters for special circumstances. The comparatively high frequency of prime-age horses in the Florescent Period reflects their occurrence principally in bone pile features, which appear to be related to ritual feasting (see below). Excluding these, there is very little difference in age profiles between periods, except for the greater number of animals kept well into old age for labor in the Late Period.

The sex ratios can help to clarify this patterning. Unfortunately, to date there is no reliable way to sex fragmented horse pelves. While the relatively large sample of pelves from Pecica have been tentatively classified by the author, morphological variability is continuous with no clear break between males or females (or castrates).[148] The dentition is more reliable, as only males have large canines, but the sample is very small. For the Late Period, there is only a single male identified, and in the Florescent Period, the six specimens show an even sex ratio.

[148] If the tentative pelvis sexing is correct, then the sex ratios mirror that seen in the teeth. No females were found in the Late Period and there is an equal ratio of males to females in the Florescent Period as a whole. However, the female pelves were only recovered from Phase 4. If combined with the dental data, Phase 4 would have a ratio of 6:1 F:M, compared to other periods which are either male dominated (Phase 5) or completely male.

However, all of the females came from Phases 4 and 5 (bone piles). While the current data are limited, the teeth do suggest that there was a female biased population in the earlier part of the Florescent Period, which, along with the age profiles and abundance data, do provide evidence for increased horse production geared for export. This must be verified through isotopic or genetic studies, as males would be under-represented if they died away from the site under any circumstances, perhaps while traveling on a trade expedition or in battle.

Extensification

Extensification is generally linked with longer-distance sheep herding under a balanced meat-wool or specialized wool production system. It cannot be excluded that there was an extensive sector at Pecica, but certainly the changes seen in the animal economy between earlier and later periods do not show a strong shift towards more extensified systems. If the Early Period pattern of ovicaprid dominance paired with a mixed meat-secondary products system is associated with a more extensive system, then the shift in the Florescent Period would be in the opposite direction, towards more intensive husbandry. This conclusion is tentative but does parallel a reorientation to more intensive pig and specialized ovicaprid meat production.

Distribution Systems: Direct versus Indirect Procurement

In all societies, there is a combination of direct and indirect procurement of animals and their products, but in increasingly centralized economies there is a greater indirect component. Increased indirect procurement can be identified through a combination of taxon representation, demographic profiles, quality of meat cuts, and degree of standardization over time. Comparison is also made between on- and off-tell occupation areas to document whether these populations were in a producer-consumer relationship (Table 12.5). Note that the Early Period sample is problematic as it is relatively small and much of it was not collected systematically, causing under-representation of small bones. This is reflected in the very low representation of wild taxa and contributes to the infrequency of very young animals. The off-tell sample is also too small to evaluate except for measures of taxon abundance and body part representation.

Table 12.5: Variables used to assess distribution systems at Pecica

		Early Period†	Florescent Period	Late Period	On Tell	Off Tell††
% domestic*		91%	65%	52%	66%	27%
peak cull(s)	**pig**	prime	juv/prime	juv/prime		
	ovicaprid	mature	prime	juv/prime		
	cattle	senile	prime	prime/ senile		
	horse	(adult)	juv/mature	juv/mature /senile		
% neonates/ infants**	**pig**	0%	23%	25%		
	ovicaprid	9%	22%	29%		
	cattle	0%	12%	15%		
	horse	n/a	present	present?		
off-take standardization	**pig**	mod	mod	mod		
	ovicaprid	mod	high	mod/high		
	cattle	n/a	mod	mod		
	horse	n/a	mod	low		
body part representation***	**pig**	76%	70%	66%	66%	67%
	ovicaprid	72%	67%	62%	66%	63%
	cattle	54%	48%	47%	48%	0%
	horse	87%	78%	51%	80%	33%

*includes invertebrates

**fetal, neonate, infants <6 mo

*** % higher utility elements

†small sample, non-systematic collection strategies

††small sample

In terms of taxon representation, an increase in indirect procurement can be seen by a greater proportion of domesticates. The Early Period sample cannot be evaluated, but there are more domestic animals being consumed in the Florescent versus Late Periods. There is also a very strong distinction between occupation areas as the off-tell population is obtaining a large portion of their meat directly through low ranked wild resources, especially small game, fish, and freshwater mussels.

Groups that are being entirely provisioned will have a very specific demographic profile in their livestock. The provisioned animals would be mostly prime-age males, and few to no infants or neonates should be present. No periods have such a specific profile at Pecica, suggesting that complete provisioning was not occurring. However, there are prime-age dominated or mixed juvenile/prime-age cull patterns for pigs in all periods, for cattle in the Florescent Period, and sheep/goats in the both the Florescent and Late Periods. While these are clear markers for increased meat production, they also may be related to more indirect procurement.

In indirect procurement systems, there tends to be highly standardized culling patterns as well, reflecting not only the need to maximize meat per animal, but also a greater degree of centralized coordination of animal transfer, especially if this is occurring over longer distances. Pig off-take is not highly standardized, with fairly even cull rates in 6-month intervals up to 18 months (up to three years in the Early Period). Off-take patterns differ considerably for cattle and ovicaprids. Cattle show strongly bi-modal cull with peaks in prime-age and senile age classes (meat-traction), varying in proportions between periods. Only in the Florescent Period is the largest cull within prime-age animals, which may support more indirect procurement as part of a greater focus on meat production. It is in ovicaprids that we see the strongest evidence for indirect procurement, especially in the Florescent Period.

As discussed above, both Florescent and Late Periods show fairly specialized meat production systems. Both are also strongly bimodal, with peak off-take of animals in the 2-6 month and 1-2 year ranges. While this pattern meets expectations for meat maximization in general, there is greater emphasis than expected on these age ranges, being much more narrowly focused, especially in the Florescent Period in which 70% of the animals fall within these two age classes. In both periods, most of the animals within these age groups cluster at 5-6 months and 16-22 months, which would correspond to fall or fall-winter off-takes. Note that these peak culls do occur earlier than predicted for a provisioning system in which meat maximization is stressed as the animals have not yet reached the point of diminishing returns (2-3 years) (Zeder 1991). Again, as discussed below, this may relate to elite consumption preferences superimposed on indirect procurement systems.

If meat cuts were being obtained indirectly, rather than, or in conjunction with, whole animals, then we would expect to see a greater proportion of high value, meaty elements. This is most likely to occur if the indirect procurement was occurring within the settlement, between local producers and consumers. Except for horse (which is unlikely to be a major provisioned animal for meat supply), there is a less than 10% difference in the quality of meat cuts between periods, although it does steadily decline through time. However, there are very large differences in the quality of meat between on- and off-tell areas for larger animals, which indicate unequal access to high quality meats between different sectors of the population. I would argue that the off-tell population, presumably non-elites, were raising and consuming their own smaller livestock. However, they do not appear to have been raising many larger animals, at least for themselves, and given the strong under-representation of quality meat cuts, may have obtained much of their beef (or horse meat?) indirectly as low-value or potentially as waste products.

In sum, I argue that there is limited evidence for substantial indirect procurement for pigs or cattle. However, ovicaprid husbandry is specialized for meat production and the large degree of standardization in culling practices, especially in the Florescent Period, suggests fairly high levels of indirect procurement, perhaps even some degree of provisioning.[149] There also appears to be different distribution systems for meat of larger versus smaller livestock, with those for cattle and perhaps horse being preferentially directed to on-tell inhabitants. The off-tell population does not have sufficient demographic data to determine if they were the local producers for on-tell consumers, but other evidence does strongly support that they were using primarily direct procurement (self-producing) and utilizing substantial amounts of low ranked wild resources.

Elite Consumption

Differences in access to higher-quality meat can be documented using taxon representation, age profiles, and body part representation. These patterns will be superimposed onto characters related to direct versus indirect provisioning systems, with elite preferences affecting both production and distribution systems. All of these data classes have been assessed in some detail in previous sections and are summarized in Table 12.6.

There is some evidence for changes in the elite consumption on the tell through time. Compared to earlier and later periods, there is somewhat more consumption of high value taxa, both domestic and wild, in the Florescent Period. There is also slight decrease in the consumption of higher-quality meat over time, which is pronounced for horses. For all species,

[149] It is possible that this increased cull standardization may be related to more extensive ovicaprid husbandry practices that are specialized for meat production, although this would have resulted in lower meat weight and quality per animal. If meat quality was not a central concern, then the advantage of more animals being maintained with similar labor may have been important. However, there is no evidence for any increase in the number of sheep and goats—in fact they decrease at this time substantially. On the other hand, the movement of ovicaprid herds to more distant and perhaps lower quality grazing areas may also reflect the need to preserve closer, high quality land for either crop production (perhaps associated with expansion) or for horses, which greatly increase at this time.

the highest-quality meat by age class (juveniles and prime-age) is found in the Florescent Period, except for sheep/goats which are equivalent for Florescent and Late Periods.

Far more striking differences are found between on- and off-tell populations during the Florescent Period. The off-tell population is consuming substantially more low-ranked livestock and wild resources. For larger livestock, they have little access to high-value meat cuts, as discussed above. Again, this is partly reflecting more direct procurement by the off-tell inhabitants, but also a decreased ability to either produce or obtain indirectly high-quality meat and/or live animals.

Table 12.6: Variables used to assess elite consumption at Pecica (% NISP)

		Early Period†	Flor. Period	Late Period	On Tell	Off Tell††
% high ranked (all)		24%	34%	24%	37%	10%
% high ranked livestock		31%	39%	25%	41%	20%
% high ranked wild mammals		93%	97%	90%	92%	44%
peak cull(s): age-(sex)	pig	prime	juv/prime (F)	juv/prime (F)		
	ovicaprid	mature	prime (F)	juv/prime		
	cattle	senile	prime (M/F)	prime/senile (M/F)		
	horse	(adult)	juv/mature (M/F)	juv/mature /senile		
body part representation***	pig	76%	70%	66%	66%	67%
	ovicaprid	72%	67%	62%	66%	63%
	cattle	54%	48%	47%	48%	0%
	horse	87%	78%	51%	80%	33%

*includes invertebrates

*** % higher utility elements

†small sample, non-systematic collection strategies

††small sample

Feasting

Feasting foods tend to mirror elite preferences in general, with the main difference being quantity (deFrance 2009). In feasting that is more ritual or religious in nature, there may also be cultural-specific taxon preferences as well. Food preparation, serving, and consumption tend to be more formalized, elaborate, and spatially segregated. Importantly, the remains of feasts are often disposed of specially, either in specific refuse areas or often as ritual or commemorative deposits. This is especially the case when feasting involves animal sacrifices, a common practice both prehistorically and historically.

Feasting deposits in special middens or refuse pits can be identified not only by the nature of the animal remains (high value meat), but also by the deposition of associated feasting paraphernalia. Ritual deposits of animal parts may also be practiced, which can be identified archaeologically as "associated bone groups" (Hill 1995). These may be articulated, semi-articulated animal portions, or disarticulated remains that were deposited in association (Morris 2010). While these can occur from non-ritual events, they can be differentiated though their highly structured form and inclusion of a specific subset of animal remains that are culturally important.

One of the unique feature types at Pecica are the "vertical bone piles," which to date have been found exclusively in the open area between the houses and the central platform (see also Figures 6.8, 6.10). They are concentrated in Phases 4 and 5 but may occur in Phase 3 infrequently. None have been found in Early or Late Period contexts. They have a discrete temporal and spatial distribution and are highly structured in their form. There are comprised of a small number of mostly to fully complete large animal bones placed vertically in very small pits, about the size of a large corner house post at the site. Sometimes they just contain bones, other times there are also large calcareous concretion nodules or brazier fragments. In a couple of examples, there appears to be the remnants of wooden posts, and these bones may have been used to brace large poles or posts. However, they are not arranged in a coherent manner and are not associated with other architectural remains. If at least some of these were supporting posts, then they were likely free standing.

But these vertical bone piles are not just a random assortment of bones used for bracing. They stand out from contemporary site refuse in a number of ways. Because they are intentional deposits, they are very well preserved. But their high level of completeness also shows that intensive food processing was not occurring. Some have evidence of disarticulating cut marks and many of the largest bones are broken in half (without further reduction), suggesting pot sizing or marrow extraction. However, there is no evidence for intensive marrow or grease processing or further butchery into smaller meat cuts. A few are lightly gnawed, indicating some level of exposure either prior to or after deposition, but the level of destruction is minimal compared to most bones at the site. Some bones are also unequally discolored between their proximal and distal ends, suggesting that part of the bones were projecting above the ground surface and would have been visible for an extended period of time, again providing evince for their use in display.

These features are dominated by bones from largest and most valuable animals, with a focus on horses, but large numbers of cattle are also present. Red deer and boar are also represented, along with occasional elements from smaller species, most of which appear to be incidental as they are not part of the central construction. The proportion of cattle and especially horses is far greater than in other contemporary deposits, with cattle being nearly 70% more frequent and horse bones being more than twice as common. It is not a simple matter of selecting large bones opportunistically as the species do not occur in equal proportions between bone piles and other contexts. There is a clear selection for livestock over wild animals since large game, especially red deer, are nearly three times more common in non-bone pile deposits. The ratio of horse to cattle, however, is similar but there are slightly more horses in the bone piles.

In terms of elements represented, there are more of the highest-quality meat joints present in the bone piles, comprising 57% of the elements within the bones piles and only 33% elsewhere. The age distribution is also interesting. While the cattle mirror the general age distribution of non-feature refuse, the horses show a highly selective subset of the population that in centered on prime-age animals between 5-10 years (Figure 12.2). This is the most valuable age class since by this point animals have reached full size, have been trained, and are able to reproduce. They are also young enough that they will be top condition for riding or traction. Also of note is that all of the mandibles that could be sexed are females, while those in other Florescent Period contexts are all male, so sex also appears to have been highly selective.[150] The removal of prime-age females in particular is an extremely costly act as these are valuable breeding stock.

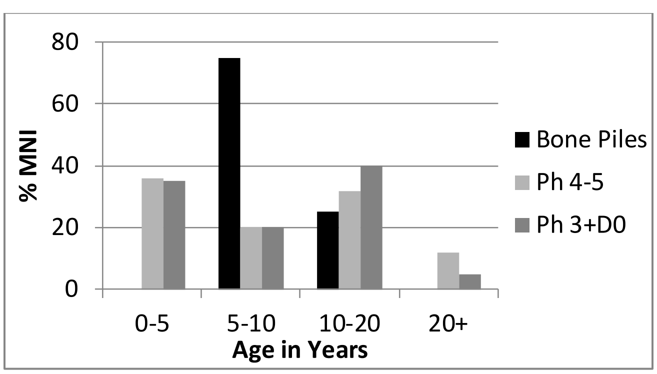

Figure 12.2: Age distribution of horses in years (%MNI) in bone-pile features and non-feature contexts

[150] If the tentative pelvis sex attributions are used, then there may be a few males included as well, but limited to Phase 5. In any case, they are female dominated as whole, in strong contrast to general refuse.

Summary

The pastoral sector undergoes a number of changes over time that are associated with different levels of centralization within the political economy, although these changes vary in kind and strength (Tables 12.7, 12.8). The current evidence points to a major reorganization of the animal economy between the Early and Florescent Periods. Over these periods, there is increasing intensification (and specialization) of meat production in all species and more indirect meat procurement by central tell inhabitants, especially for ovicaprids. Most striking is the very large increase in horse production, with some evidence for export, which is paralleled by feasting events that are centered on conspicuous consumption of high-value, reproductive females. At the same time, there are very strong asymmetries in the access to high-quality meat between people living on and off of the tell, with the latter obtaining most of their meat directly and supplementing their diet with wide range of low-ranked wild resources. While some aspects of the animal economy continue into the Late Period, there are a suite of changes that indicate a reduction in economic centralization over time. This includes more informal organization of ovicaprid meat production, a dramatic decrease in horse breeding, fewer indicators of elite consumption and indirect procurement, and loss of ritualized animal-focused feasting.

Table 12.7: Summary production strategies by period and taxon

		% NISP	Production Principle	Comments
Early Period	Ovicaprids	58	mixed meat-secondary products	wool and/or dairy important
	Pigs	23	meat maximization	
	Cattle	16	mixed meat-traction	mostly traction
	Horses	2	n/a	
Florescent Period	Ovicaprids	**35**	**meat maximization**	**very high cull standardization**
	Pigs	27	**rapid turnover**	
	Cattle	19	mixed meat-traction	**stonger focus on meat**
	Horses	**20**	**mixed meat-traction-export**	**major increase in production**
Late Period	Ovicaprids	43	meat maximization	
	Pigs	31	rapid turnover	
	Cattle	20	mixed meat-traction	
	Horses	**5**	**mixed meat-traction**	**mostly traction**

note: major changes between periods in **bold**

Table 12.8: Summary distribution strategies and consumption patterns by period

	Early Period	Flor. Period	Late Period	On-Tell	Off-Tell
Procurement System	n/a	some indirect	little indirect	some indirect	direct
Elite Consumption Patterns	moderate	high	moderate	high	low
Feasting/Ritual Deposits	n/a	present	absent	present	n/a

In sum, the Florescent Period does meet a number of expectations for greater centralization compared to earlier and later periods. What is particularly interesting is that reorganization within the animal economy affected livestock species in different ways. There is no evidence for the entire animal production system becoming specialized in the production of a single species or any secondary products. However, specialized meat production is evident for ovicaprids and pig husbandry shifts to an intensified, rapid-turnover system. For cattle, a diversified husbandry system is maintained, although meat output becomes increasingly important. The most significant change is seen in horse breeding, which becomes a central pillar of the animal economy, especially within Phase 4. At the same time, there is demographic evidence for export production. Overall, changes in livestock husbandry fit the model for diversification with targeted production, in which high-value but high-cost species that are otherwise infrequent, greatly increase in their importance. Given the high investment expenses and specialized knowledge needed in horse breeding, maintenance, and especially training (including chariotry), their production is likely to have been directly sponsored by elites. Elites could use these animals for exchange in various networks, gift giving and alliance building, rapid transportation and communication, and warfare. Further, there is clear evidence that horses were central components for elite-sponsored feasting, which would have further enhanced the sponsors' social standing. These data demonstrate that horses were highly valuable economically and served as potent symbols of status and power.

AGRICULTURE

Production Strategies

Evaluating the evidence for agricultural intensification under centralized regimes is a more challenging task than for the animal economy given the unevenness of data availability. This analysis is limited to changes between the Florescent and first part of the Late Period.

Nonetheless, several interesting patterns do emerge (Table 12.9).[151] Crop production only meets a small number of the expectations for more intensified production during the Florescent Period. In several respects, there appears to be greater concern with risk mitigation in the Late Period, as there is a wider variety crop species and increased use of fast-growing and/or hardier species like barley and millet. Neither period has evidence for maslin crops (mixed taxa). The only crop with a growth period short enough for double cropping is millet, which only appears in the Late Period. However, this which is also a species associated with poor growing conditions and dry habitats, the latter of which may increase at this time. Further, there are no fall associated weeds for the required planting system that is necessary for double cropping in this period.

The wild species may or may not be directly associated with crop production. Nonetheless, there is less diversity of species belonging to different habitats in the Late Period, which would argue against a risk mitigation system in which a greater variety of areas are brought into production. There is not a significant difference in the proportion of annual to perennial species that would indicate a change in fallow period length, nor more extensive cultivation practices. However, the weeds do suggest that the Late Period people may have been cultivating using less-intensive methods on average as there is a greater ratio of wild seeds to crops[152] and there are fewer wild taxa that are associated with nitrogen-rich (manured?) soils. Both periods have very high proportions of draft cattle, based on their demographic profiles. This suggests that large-scale agriculture was practiced throughout the occupation sequence.

There is no evidence for targeted production either through diversification or specialization. Surprisingly, there are no remains of specialty crops used for the production of export goods, such as flax (fine textiles), or oil seeds, and diversity measures clearly do not show the production of one crop to exclusion of others. Given the distribution of agricultural implements, there is no evidence that the on-tell population was exempt from farming duties.

There is very little difference in crop or weed species between contemporary on- and off-tell occupation areas, suggesting similar practices and decision making. The only major contrasts between habitation areas are found in the frequency of weeds to crops, but this is ambiguous as most of the seeds are from species that are both ruderals and segetals and their high numbers may be due to a more open settlement area off-tell.

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[151] See also Chapter 7 for further explanation of expectations under different cropping systems.
[152] It cannot be excluded that the larger number of wild seeds is at least partially related to an overall reduction in occupation density, allowing more ruderals to grow, or differences in processing stages on the tell over time.

Table 12.9: Test expectations for agricultural intensification (production)

Practice	Variable	Measure	Flor. Period	Late Period	On Tell	Off Tell
intensification	lenth of fallow period	ratio annuals: biennials/perennials	even	even	even	even
	single vs. double cropping	frequency of short growing period crops	lower	higher	even	even
		fall vs. spring planting weeds	both	spring only	even	even
	lower vs. higher maintenance	ratio weeds:crops	lower	higher	lower	higher
		frequency nitrophilous weeds	higher	lower	even	even
extensification	plow vs. hand cultivation	proportion traction cattle	lower	higher	n/a	n/a
		proportion disturbance tolerant weeds	even	even	even	even
		ratio annuals: biennials/perennials	even	even	even	even
diversification (risk buffering)	dispersed vs. concentrated fields	variability weed species of different habitats	even	even	even	even
	risk buffering vs. output maximization	diversity crop species	lower	higher	even	even
		evenness crop species	lower	higher	even	even
		proportion hardy species	lower	higher	even	even
		presence of maslin crops	no	no	no	no
	staggered vs. uniform crop planting	fall vs. spring planting weeds	both	spring only	even	even
diversification (targeted production)	subsistence vs. export/ speciality production	proportion speciality crops	none	none	none	none
specialization	risk buffering vs. specialized production	very low crop species diversity	no	no	no	no
		proprtion high:low value crops	higher	lower	even	even
other	all households producing vs. producing and non-producing groups	spatial distribution agricultural implements	even	even	even	even

note: "even" is used to denote no statistical differences
shaded cells meet test expections

Crop Processing, Distribution, and Storage

Crop processing measures also show a mix of more or less intensive indicators, but in general there is little evidence for differences through time or between occupation areas (Table 12.10). There is a higher ratio of weeds to seeds in the Late Period and off-tell, but this may reflect several distinct processes, as discussed in Chapter 10. There is a higher chaff to crop seed ratio in the Florescent Period, especially in Phase 4, compared to the Late Period, and there are no significant differences between contemporary on- and off-tell occupations. There is also not a difference in the distribution of weed seed size classes that are associated with different processing stages. There is no evidence to support any provisioning of cleaned grains. The density and distribution of grinding stones, which reflect only end-stage processing, also does not show temporal differences or spatial differences and occur at rates related to overall depositional intensity.

Table 12.10: Test expectations for agricultural intensification (processing, distribution, and storage)

Practice	Variable	Measure	Flor. Period	Late Period	On Tell	Off Tell
crop processing	all households processing vs. processing and non-processing groups	ratio of chaff: seeds	higher	lower	even	even
		ratio of weeds: crop seeds	lower	higher	lower	higher
		ratio small: large weed seeds	even	even	n/a	n/a
		density of processing tools	even	even	n/a	n/a
crop distribution and storage	equal vs. unequal access to crops	density of crop seeds	higher	lower	higher	lower
		frequency prestige or speciality crops	none	none	none	none
		proportion of storage vessels	n/a	n/a	higher	lower
		proportion of display storage vessels	n/a	n/a	higher	lower

note: "even" is used to denote no significant differences
shaded cells meet test expections

Unlike crop production and processing, there clearer evidence for differences in the size of grain stores, especially between contemporary on- and off-tell occupation areas. Per unit volume, there is a greater density of crop seeds during the Florescent Period on the central tell, particularly in Phase 4. The lower density of grain in the Late Period may reflect smaller grain stores, but also may be a product of the overall decrease in occupation intensity (lower grain density per unit volume but not necessary per person or household). There is insufficient data to clarify this pattern with other lines of evidence for crop storage, namely pits and storage vessels. However, the lower density of grain off-tell is correlated to other measures. Compared to on-tell contexts, off-tell there are statistically fewer storage vessels, particularly fine-ware display vessels and bins.

It appears that while most households were growing and processing their own crops, during the Florescent Period, central tell inhabitants were able to store larger amounts of grain, which were used to communicate their wealth and status. It is currently unclear whether these larger grain stores derive from a greater productive potential from on-tell households (larger or more fields, greater access to efficient technologies like ox-plows, or extra human labor) or if at least a portion of this grain was obtained indirectly through some sort of provisioning or resource mobilization from other households at Pecica. At minimum, this does suggest some level of socioeconomic inequality that is especially pronounced in the Florescent Period.

Summary

There are changes in crop husbandry that mirror patterns of restructuring within the animal economy, although they are not as pronounced. The basic organization of crop production is similar between the Florescent and Late Period, with the use of large-scale, extensive plow agriculture, a focus on einkorn wheat and secondarily barley, similar land use patterns and season of planting (predominantly or entirely spring). Crop production and processing was done by most, if not, all of the population and there is almost no difference in the types of crops utilized by people on and off of the tell. However, there does appear to be significant contrasts in the amount of food available to these populations, with the central tell inhabitants having larger grain stores, some of which were publicly displayed. In the Late Period, the weed assemblage indicates decreased use of intensive production strategies, with less field maintenance, including manuring, given the reduction in nitrophilous species. There is also a greater use and wider range of hardy crops in the Late Period, including the addition of millet, which may indicate more concern in risk reduction, as seen in animal husbandry. In short, while there is some evidence for the effects of increased centralization present during the Florescent Period, principally through more intensive crop production strategies and unequal access to food perhaps related to mobilization, changes were not as wide spread or strong as in the animal economy.

CRAFT PRODUCTION

As with crop production, the organization of craft manufacture can only be assessed for the Florescent and first part of the Late Period in detail. Here, focus is placed on summary measures of diversity, intensity, concentration, and standardization of various types of crafts. It is expected that these measures will reflect increased centralization during the Florescent Period, although this centralization will affect prestige crafts or those requiring imported raw materials to a greater degree. Changes within finer temporal units in the Florescent Period are also assessed. Primary data for these analyses were presented in Chapter 11.

Diversity

The diversity of various craft classes in the Florescent and Late Periods differ but not to the extent expected if there was a major decrease in the degree of centralization through time (Table 12.11). There is no difference in the diversity of Class 1 crafts; production debris and finished goods (non-perishable) of all types examined are represented. This is expected given the common availability of local raw materials and their domestic use. As discussed in the previous chapter, it is very difficult to distinguish the production of most Class 1 from Class 2 crafts in this assemblage. The only production debris that may be related to manufacture of prestige goods on local raw materials is the horn working debris and perhaps the *Unio* shell pendant that appears to be unfinished, found in Phases 4 and 5 of the Florescent Period respectively. The only examples of finished fine antler/tooth/shell working are also restricted to the Florescent Period. Fineware ceramics are ubiquitous. More detailed analysis of the ceramic assemblage composition is ongoing and further conclusions must await its completion.

Class 3 crafts, utilitarian goods made on imported raw materials, are more difficult to assess since the artifacts in question have not been systematically analyzed for the Late Period and direct evidence for the local production of groundstone is absent. However, working of non-local stone, particularly obsidian, is present in both periods, but appears to be greatly reduced over time (see also trade section).[153]

The range of crafts that have both Class 3 utilitarian and Class 4 prestige components may differ between periods, although to a minor degree. Finished utilitarian and fine groundstone items are ubiquitous but identifying local production is challenging. Metal

[153] There also appears to be low obsidian use in earlier periods as well from the preliminary 2013 data.

production was done at Pecica throughout the occupation and high value bronze items are found in both Florescent and (earlier) Late Period contexts. However, direct evidence for local crafting of fine bronzes has only been confirmed for the Florescent Period via molds. The single gold item, a hair ring, was also found in Florescent Period deposits, but it is not known if this was made locally.

Table 12.11: Diversity measures of craft production

		Florescent Period		Late Period		On Tell		Off Tell	
		Production	**Finished**	**Production**	**Finished**	**Production**	**Finished**	**Production**	**Finished**
Class 1	chipped stone (cobble jasper)	X	X	X	X	X	X	X	
	wood working	X	X	X	X	X	X	X	X
	hide working	X	n/a	X	n/a	X	n/a		n/a
	textiles	X	n/a	X	n/a	X	n/a		n/a
	bone working	X	X	X	X	X	X	X	
	ceramics production (coarse)	X	X	X	X	X	X		X
Class 2	bone working (fine)	X	X			X	X		
	ceramics production (fine)	?	X	?	X	?	X	?	X
Class 3	chipped stone (chert)	X	X	?	?	X	X		
	chipped stone (obsidian)	X	X	X	?	X	X		X
	ground stone (utilitarian)		X		X		X		
Class 4a	ground stone (fine)		X		X		X		
	metallurgy (general/utilitarian)	X	X	X	X	X	X	X	X
Class 4b	metallurgy (fine bronze/copper)	X	X	?	X	X	X	?	
	metallurgy (fine gold)	?	X			?	X	?	
Total # crafts		**11**	**13**	**8**	**10**	**11**	**13**	**4**	**5**
Denisty (# crafts/1000L)		**0.23**	**0.28**	**0.10**	**0.12**	**0.59**	**0.70**	**2.53**	**3.16**

It is difficult to compare the on- and off-tell assemblages in the Florescent Period given the vastly disparate size of excavation areas. The absence of relatively rare craft items, including prestige goods, may not be significant. In fact, the number of crafts represented is greater than expected given the volume. It will be noted that there is a finished obsidian blade, a copper/bronze piece, and metal working debris off-tell. The production of metal, even if at a simple level, therefore was not restricted to the on-tell population. The off-tell inhabitants also had access to imported stone, were making chert chipped stone tools, and were obtaining finished obsidian blades, if not making them themselves.

In sum, diversity measures provide modest evidence for increased centralization of high-value crafts in the Florescent Period. It does appear, however, that local production of fine metal items and non-local chert tools was reduced. Gold items, if produced locally, are also limited to the Florescent Period. These is also some suggestion that the manufacture of fine horn, antler, and shell items was restricted to the Florescent Period, or at least were done at a such a low level in the Late Period to be archaeologically imperceptible, especially considering the much larger excavated volumes in this later occupation. Importantly, while most crafts cannot be compared between contemporary on- and off-tell areas, there is evidence for metalworking off-tell. Metal production, even if for simple domestic goods, was widespread in both space and time and was not a highly controlled activity. It is hoped that further analysis of the metallurgical debris will be able to distinguish between local manufacture of simple versus elaborate items, including those made of gold.

Intensification

Intensification can be measured through the overall density of items related to the production of specific crafts (# items/kL). However, there are changes in the overall intensity of occupation at the site that must be taken into account, as the Late Period is less densely occupied than the Florescent Period. This can be seen in the fewer number of houses and features as well as the overall decrease in artifact deposition per unit volume. This probably reflects fewer individuals per unit area, but it also may in part result from increased loess sedimentation rates in the Late Period that are associated with a drier environment (Sherwood, et al. 2013). As a result, in order to identify changes in craft production debris densities that may be related to decreased occupation intensity rather than organization of crafting, densities of various craft items are compared against fauna density, which is used here as an overall proxy for artifact deposition rates (Table 12.12).

It is apparent that Class 1 and 2 crafts, those made on local raw materials, are strongly and positively related to overall occupation intensity. While production of items that fall into utilitarian (Class 1) or prestige (Class 2) types, cannot always be distinguished, it should be noted that the majority of items fall into the former class. Pot making, textile manufacture, wood working, hide working, and to a lesser degree, bone working follow this pattern. This is not unexpected given that these are predominantly domestic crafts that are unlikely to have been the targets of centralized production, nor could their raw materials be controlled.

Table 12.12: Abundance (density) measures of craft production and relationship to faunal density

Phase	vol (L)	chipped stone (local)	chipped stone (non-local)	chipped stone (all)	wood working	hideworking	bone working	pot making	textiles	metallurgy (all)	metallurgy (no fish plates)	fauna*
1	34813				0.06		0.00					0.06
2	47268				0.08	0.19	0.21	0.15				0.11
3	10916	0.27	0.18	0.37	0.46	0.55	0.27	0.55	0.37	3.85	2.75	0.14
P	23815	0.29	0.17	0.46	0.13	0.13	0.13	0.13	0.25	3.70	1.89	0.11
4	7653	0.52	0.00	0.39	0.78	1.57	0.78	1.18	0.91	2.48	1.31	0.38
5	4588	0.65	0.22	0.65	0.44	0.87	0.87	0.22	0.44	1.31	0.65	0.12
Late**	82081				0.07	0.19	0.21	0.15				0.09
Florescent	46972	0.36	0.15	0.45	0.34	0.53	0.34	0.40	0.22	3.30	1.87	0.16
On Tell	18569	0.38	0.11	0.38	0.59		0.48			5.49	3.02	0.24
Off Tell	1582	1.26	0.63	1.90	0.63		1.26			2.53	1.26	0.27
Total	**129053**	**0.41**	**0.16**	**0.49**	**0.18**	**0.26**	**0.22**	**0.20**	**0.22**	**3.27**	**1.85**	**0.12**
Relationship craft density to faunal density	r	**0.297**	**-0.964**	**-0.434**	0.882	0.893	0.639	0.963	0.976	**-0.180**	**-0.200**	
	r^2	0.088	0.929	0.188	0.778	0.797	0.408	0.928	0.952	0.032	0.040	

*per L (not kL)
**excludes PH 1 when data is not available
note: r values in **bold** indicate crafts tha have little or no relationship to general occupation density as measured by faunal density

Other craft types (Classes 3 and 4) do not show a strong positive relationship with general refuse density, indicating that differences in their density reflect changes in the intensity of production. The densities of finished items, which also can be used as a rough proxy for production, is evaluated in Chapter 11, and for imported raw materials, below. Chipped stoneworking debris has a moderate inverse correlation with occupation intensity, but this differs between raw material types. The density of non-local debitage shows a strong negatively correlation. There is little relationship between local jaspers and occupation density. Overall, there is a greater than expected amount of debitage in the platform (primarily raw cobbles) and in Phase 5. Metalworking, the other craft requiring imported raw materials, is also not strongly related to overall occupation intensity, indicating that other factors are influencing production intensity. Metalworking implements and production debris are far more common than expected in Phase 3 and the platform.

The off-tell materials are not evaluated here in great detail due to the very small volume excavated, which tends to exaggerate the density of common items and rare items are often not encountered. It will be noted that all craft working tools and debris occur at a greater density off-tell except for metallurgy, which does suggest a difference in the intensity of metal production between the central and peripheral population.

Although there are limitations in the data, there does appear to be significant differences in the intensity of craft production for those made from imported raw materials though time, which provides some evidence for changes in the degree of centralization, including within regional exchange networks. Chipped stone manufacture decreases in the latter part of the Florescent Period. At the same time there is a much greater than expected rate of metallurgical production in the later part Florescent Period, peaking in Phase 3. This inverse relationship may reflect replacement of chipped stone with metal cutting tools at this time. Crafts using local raw materials for domestic items track general occupation intensity and do not show any evidence of centralized influence.

Spatial Distribution

Due to small sample sizes, little can be about the organization of crafts among the peripheral population other than that there was not strong restriction in the production of crafts made on imported raw materials, including chipped stone and metals, but metal production appears to have been produced less intensively. There is direct no evidence for prestige items being made off-tell.

However, spatial distribution within the central tell area can be assessed for crafts with sufficient sample sizes and mapping data (see Chapter 11). In general, there is very little evidence for strong spatial segregation of different crafts, with most of the variability related to the size of the production tools and debris, with larger items found outside of the houses, and smaller items found more often within. There is a particularly high concentration of antler working debitage (and denticulates) within and immediately around Structure 2. This may have been a particularly intense locus of crafting, but antler working debris and tools are widespread. There is some suggestion that horn working may have been a specialized craft as horn cores with clear horn sheath removal cut marks have only been recovered from a small area east of

Structure 3 (Phase 4). Other prestige items occur only singly and cannot be systematically evaluated.

In general, it appears that most crafts were done at the household level by most, if not all, families. Potentially higher status families on the tell were not exempt from making their own utilitarian goods. There is also very little evidence for control over production of prestige goods or utilitarian items made of imported materials, as their manufacturing debris and associated tools are also widespread, but there may some asymmetries in the level and types of metal production (and other prestige goods) between on- an off-tell areas.

Standardization

At Pecica, only worked bone and chipped stone items can be assessed for standardization. As discussed in the previous chapter, other than standardization in form directly related to function or raw material properties, there is considerable variation in both bone and stone tools. Bone tools are made on a wide range of elements from a variety of species, often expediently. Antler tools, which allow more latitude in manufacturing methods, also show considerable differences in the size and formal attributes, even within the same type. Chipped stone denticulates and blades also vary considerably in their size, showing little standardization. However, part of the size differences for denticulates may be related to reworking and rejuvenation. Obsidian prismatic blades, on the other hand, are not reworked and have similar coefficients of variation to the chert denticulates.

Summary

The degree of centralized control over craft production is generally low (Table 12.13). Crafts made on local raw materials are made by most, if not all, households with little evidence for changes in the diversity or intensity of production over time. The only exception that can be identified currently lies in the manufacture of fine antler, horn, and shell items. Greater differences are seen in the diversity and intensity of crafts made on imported materials. Stone tool manufacture is more frequent in the Florescent Period as a whole, with little standardization or spatial concentration present. Metalworking peaks in Phase 3 of the Florescent Period. It is also not spatially segregated to any great degree, indicating that there was not elite control over metal production as a whole. However, at this point it is not yet possible to distinguish the manufacture of simple utilitarian items and prestige goods precisely, and there may have been elite sponsorship of high-value metalwork. In general, there does not appear to have been any strong degree of craft specialization, elite controlled or otherwise. However, there are significant differences in access to foreign raw materials over time that affects craft production. This is considered in the following section. There is also a reduction in the manufacture of prestige goods over time and their crafting appears to be limited to on-tell populations. This does indicate some elite influence over the production, and likely distribution and exchange, of sumptuary items during the Florescent Period.

Table 12.13: Test expectations for craft production

Variable	Measure		Flor. Period	Late Period	On Tell	Off Tell*
diversity	# types/volume	Class 1	even	even	even	even
		Class 2	higher	lower	higher	lower
		Class 3	even	even		
		Class 4**	higher	lower	higher	lower
intensity	# items/volume	Class 1	even	even	present	present
		Class 2	higher	lower	present	absent
		Class 3	present	present	present	present
		Class 4**	higher	lower	present	absent
spatial distribution	concentation	Class 1	ubiquitous	ubiquitous		
		Class 2	restricted?	(rare)		
		Class 3	ubiquitous	ubiquitous		
		Class 4**	(rare)	(rare)		
standardization	raw materials/form	worked bone	low	low		
	metrics	chipped stone	low	n/a		

*small samples may affect rare item representation, presence/absence used where appropriate

**based on finished items and metalurgical molds only

shaded cells meet test expections

REGIONAL EXCHANGE

The effects of centralization on regional exchange networks cannot be evaluated to the same degree as craft production given the smaller samples available for analysis, and for some material classes (especially finished goods), difficulties in identifying precise origins. Focus is placed here on raw materials, including their diversity and abundance. Finished goods are similarly considered where data allow.

Imported Raw Materials

There is evidence that the importation of raw materials of different types was organized in different ways over time (Table 12.14). However, systematic data is limited for the Late Period, especially for diversity measures, so most of the observed changes draw on relative abundance within the Florescent Period or use other lines of evidence, particularly craft production.

Chipped stone as a general class occurs at similar densities per unit volume in all periods and is only moderately related to overall occupation intensity. This suggests that there were significant changes in the frequency of chipped stone raw materials that are not just tracking general rates of refuse deposition. This is most clearly seen in the unusually high frequency of obsidian in Phase 3 and the overall decrease in chipped stone of all types (especially obsidian) in the Late Period.[154] Specialist analysis of the unsourced chipped stone may shed additional light on the intensity and direction of regional exchange over time.

It is expected that there would be even stronger differences in ground stone and metal ores as these are used, at least in part, in the manufacture of prestige goods. Unfortunately, Late Period ground stone and ores cannot yet be systematically assessed. In the Florescent Period, both of these classes differ strongly in overall density between phases, but these differences mirror occupation intensity. It is possible that some of the "ores' are actually groundstone and a common pattern is being represented. Further specialist analysis will be able to separate these with greater reliability. More importantly, there may be little identifiable ore gangue remaining after smelting, which is supported by the very high frequencies of slags and other metal production debris in the Florescent Period, especially in Phase 3. This indicates that there must have been more ores arriving to the site at this time than represented in the current assemblage. Given the positive relationship between obsidian and metalworking debris, it is possible that at least some of the ores may have been coming from northern sources in Slovakia. Within the current assemblage, it is not yet known the degree to which other metal sources, including closer ones in the Apuseni Mountains up river, were utilized. However, previous sourcing studies of Pecica's metals (Junghans, et al. 1968) do suggest that most, if not all, of the copper was coming from Transylvanian sources (see also previous chapter).

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[154] Again, this is also seen in Ph 5 and 6+ deposits from 2013, in which no obsidian was found. Only a single piece was recovered from Ph 5 in 2009.

Other import classes are more difficult to assess as it is not always clear whether items were worked locally on foreign raw materials or obtained as finished items. Importantly, a raw nodule of amber was found in 2013 (Phase 5, Florescent Period), providing some of the only evidence for local amber working in the region. It is not yet known if this is Baltic or Romanian amber, but given sourcing studies from other regions, it is more likely to be Baltic.

Table 12.14: Raw material importation expectation testing

Variable	Measure	Class	Florescent	Late	On Tell	Off Tell*
diversity of exotics	# types/volume	chipped stone	n/a	n/a	even	even
		ground stone	n/a	n/a	present	absent
		ore stone	n/a	n/a	present	absent
abundance of exotics	# items/volume	chipped stone	higher	lower	even	even
		ground stone	n/a	n/a	present	absent
		ore stone	n/a	n/a	present	absent
		raw amber	present	absent	present	absent

*absence may be due to small samples

Imported Finished Goods

The organization of exchange networks for finished imported prestige goods can only be assessed at a fairly coarse level given the very small sample sizes and the difficulty in excluding local production of items made on imported raw materials. Other than ceramics, items that are most likely imported as complete items are the shell beads and some of the fine metalwork. Shell beads are present in greater numbers and in a wider range of types in the Florescent Period, but continue to be available in the Late Period (Table 12.15). This suggests that there were well-established trade links with the Mediterranean, or at least intermediary groups to the south, such as Vattina. This is supported by Maros mortuary finds where these beads occur regularly in higher status burials. Amber beads have been found in both Florescent and Late Periods. Ground stone beads and pendants are only present in the Florescent Period. No beads of any type were found in Phase 1, despite the very large volume of earth excavated. None were any found from off-tell areas.

Metalwork also differs greatly between the Florescent and Late Periods in both diversity and abundance. However, an unknown number of these items were made locally. Nonetheless, fine bronze and gold items are among the highest value goods circulating in the Bronze Age and there is a marked decreased in the availability of these items through time. Further, there is no evidence for gold in the Late Period and no elaborate metalwork of any type was found off-tell.

Table 12.15: Test expectations for organization of prestige goods imports

Variable	Measure	Class	Florescent	Late	On Tell	Off Tell*
diversity of exotics	# types/volume	ceramics	n/a	n/a	present	absent
		beads (all types)	higher	lower	present	absent
		fine metalwork**	higher	lower	present	absent
abundance of exotics	# items/volume	ceramics	n/a	n/a	present	absent
		shell beads	higher	lower	present	absent
		other beads (stone, amber)	higher	lower	present	absent
		fine metalwork**	higher	lower	present	absent

*absence may be due to small samples
** all types, may inlcude local items

Summary

At Pecica, the access to imported goods of all types declined sharply over time, as seen in reduced diversities and especially quantities between Florescent and Late Periods. This is particularly acute for prestige goods, including metalwork and other ornamental items. There are no exotic finished items off- tell, including ceramics, which if not reflecting a sampling size issue, would suggest restricted access to these items. This strongly suggests that during the Florescent Period, central tell inhabitants, presumably elites, were participating in regional exchange networks at a greater intensity and were able to establish sustained links with more diverse regions. Minimally, this includes Slovakian obsidian, Baltic amber, and Mediterranean marine shell, and no doubt a much greater number of source regions will emerge with further analysis of the ground and chipped stone assemblage. Metals were likely being obtained from upriver groups in the Apusenis and it is possible that ores were coming in from elsewhere as well. Ceramics vessels reflect interaction with groups to the south (Vattina) and to the east (Wietenberg). Importantly, these differences in abundance, diversity, and spatial distribution meet expectations for more centralized trade networks during the height of Pecica's occupation during the Florescent Period. Preferential elite control over foreign exchange was likely a primary means for economic and political influence both locally and regionally.

CONCLUSIONS

Changes in economic organization at Pecica, in many respects, fit expectations for increasing centralization of production and distribution systems during the Florescent Period. However, different sectors of the economy were affected to different degrees and at different times, suggesting that economic restructuring associated with more centralized political economies took place over a considerable time frame, with individual components gaining or losing prominence over time.

Some of the most dramatic changes are seen in the animal economy, which highlight the need to incorporate zooarchaeological indicators of centralization in studies of emergent complexity. Most notable is the reorganization of husbandry systems to produce very large numbers of horses, likely for export to some degree. They also become central features of ritual feasting and elite identity. Horses are a special case that is considered in more detail below. Other changes in the animal economy during the Florescent Period reflect a greater concern with increased meat production over other products for all species, especially the production of high quality meats. The age structure of off-take also suggests that this in part may be related to increased indirect procurement systems and centralized management of food distribution. There are very strong differences in access to high quality meat between those inhabiting the central tell and peripheral populations, underscoring the level of social inequality at this time.

There is also a strong relationship between animal and crop husbandry systems through the occupation sequence that should be noted. In particular, cattle-rearing is strongly tailored towards the production and maintenance of draft animals in all periods, and only in the Florescent Period do we see the off-take of meat for animals outweigh their use for labor. The large number of traction cattle indicates the use of large-scale and extensive crop production at Pecica rather than (or in addition to) smaller-scale, labor-intensive hand cultivation. In addition, there is weed evidence for the increased use of animal dung fertilizer as a crop intensification method during the Florescent Period, which may be paired with the more intensive animal production that characterizes this period.

However, other aspects of agricultural production do not show much variation over time or between occupation areas. In general, similar farming methods were used. Land use around the settlement was highly structured, as crops appear to have been grown primarily or exclusively on the terrace, leaving the lower floodplain open for pasturage. Crops were also sown predominantly or entirely in the spring. However, in the Late Period, not only does it appear that some less-intensive measures were used, but also that a greater range and proportion of lower-utility or hardy crops were utilized, including more barley and the addition of millet. I suggest that these are related to increased concern with risk mitigation, especially during a period that shows evidence for aridification. The role of environmental change on Pecica's decline must be assessed further. It should be pointed out, however, that concurrent changes in the animal economy do not meet most expectations for adaptations to a drier environment (see also Chapter 13). Rather, they are more strongly linked with social reorganization.

While there are only modest changes within crop production, there are more striking differences in the distribution of plant foods between occupation areas and perhaps over time. In particular, the density of crop remains and storage facilities is much higher within the central occupation than in the periphery, mirroring differences in access to quality meat. This may be related to mobilization of staple goods.

Centralization of the exchange economy is apparent to some degree during the Florescent Period, but is limited to prestige and foreign goods. At this time, the production and importation of prestige goods are more intensive and encompass a wider range of materials. There is also increased manufacture of utilitarian items made on imported raw materials. However, this centralization is not to the extent expected if there were highly specialized or elite attached craft producers, nor is the production of prestige goods spatially concentrated to a significant degree, at least as can be assessed with the available data. Nonetheless, there are asymmetries in production and consumption of high value items that are less likely to occur in strongly decentralized systems.

Within the Florescent Period itself, the primary prestige good was metal. There are especially high production and consumption rates in Phase 3, which may be related to the construction and use of the central platform feature. Obsidian use also peaks at this time. Interestingly, if the new focus on horse breeding at this time is in part related to export production, as current evidence suggests, its intensification reaches its zenith slightly earlier than for metalworking, occurring in Phase 4. It is possible that horse breeding and chariotry were central components of elite production and exchange systems initially, with metalworking becoming increasingly important towards the end of the period.

I argue that horse breeding (and export) was used as a primary means for elites at Pecica to articulate with regional exchange networks and establish regular trade relationships with metal producing areas. The importance of horses is underscored by their use in elaborate feasting events centered on the conspicuous consumption of breeding females. As metal production increased at the site in Phase 3, this also allowed local elites to engage in regional exchange of finished, fine metalwork, which was the principal trade good across the continent at this time. No doubt metals were used within local exchange networks as well to further accentuate socioeconomic and political asymmetries within the settlement and with their immediate neighbors. Horse production declines at this time and horse ritual is abandoned. While horse breeding is still an important sector of the economy, especially compared to the Late Period, it appears to have been overshadowed by metal working. This also may be related to the difficulty in maintaining a monopoly over horse breeding, and potentially chariot production, over the long term, even if horse exchange was limited to geldings.

By the end of Late Period, it appears that the prestige goods economy largely collapses, with a strong decline in both the local production and importation of high value items. This includes horses, which return to being a minor component of livestock production. It is possible that there was a disruption in trade networks at this time that limited access to critical raw materials for the site's inhabitants. These networks were not completely severed, however, but appear to have been greatly reduced in intensity. It will be important to examine changes in the direction of trade networks through time more closely to better understand the nature of interactions with different regional groups.

It should also be noted that Maros culture itself collapses shortly after 1600 cal. BC. In contrast, groups to the east where ores, salt, and other important import resources are found (i.e., Wietenberg) continue to thrive well into the Late Bronze Age. Further work will focus on identifying changing relationships between these two groups and if there was a major shift the regional power dynamics based on control over these raw materials and alternative exchange routes.

CHAPTER 13: REGIONAL TRAJECTORIES—AGRO-PASTORAL SYSTEMS

Having considered the political economy at Pecica Şanţul Mare, it is now possible to compare its development against regional trajectories in order to highlight both common pathways and unique strategies. This chapter examines economic organization at seven other settlements in the Carpathian Basin (Chapter 6), which represent contrasting culture groups, political systems, site types, and environmental settings (Table 13.1). Because of the scope of this analysis and uneven availability of comparable datasets, emphasis is placed on identifying general trends within agro-pastoral systems. Attention is paid to how different internal and external factors have shaped particular economic formations within these settlements, with a focus on distinguishing features that directly reflect processes of centralization (or lack thereof). Analyses used in this chapter follow methods used in previous sections.

Table 13.1: Site summary

Site	Culture	Period	C14 dates*	Regional Organization	Site Type	Hydrology	Dominant Ecozones
Pecica Şanţul Mare	Middle Maros	E-MBA	>2000-1500	unknown	large fortified tell	major river	loess terrace, steppe forest, floodplain
Semlac Şanţul Mic	Middle Maros	E-MBA	2400-1800	unknown	small fortified tell	major river	loess terrace, steppe forest, floodplain
Klárafalva-Hajdova	Lower Maros	E-MBA	2300-1500	autonomous village	small fortified tell	major river	floodplain, marshland
Kiszombor-Új Élet	Lower Maros	EBA	2700-1990	autonomous village	fortified open site	stream	steppe forest
Sarkad-Peckes	Ottomány-Gyulavarsánd	MBA	n/a	simple hierarchy	large fortified tell	tributary to major river	marshland, steppe forest
Tarhos-Gyepesi Átkelő	Ottomány-Gyulavarsánd	MBA	1950-1600	simple hierarchy	small unfortified open site	tributary to major river	marshland
Százhalombatta-Földvár	Nagyrév, Vatya, Koszider	E-MBA	2400-1400	complex hierarchy	large fortified tell	major river	loess terrace, forest, steppe forest, floodplain

*approximate date range, cal. BC

ANIMAL ECONOMY

This regional study of animal economies focuses on the organization of production systems, drawing principally on taxon representation and culling profiles. Body part representation is also considered to assess quality of meat consumption by site inhabitants and evidence for provisioning of meat cuts. Primary data for each of the study sites has been presented elsewhere (Choyke 2000; Duffy 2010; Nicodemus 2009, 2010; Vretemark 2010; Vretemark and Sten 2005). Here, general features of pastoral economies are summarized for each settlement and, where possible, their developmental pathways are evaluated. Inter-site variability is systematically evaluated, including comparisons with Pecica, focusing on determining the relative roles played by ecological conditions and sociopolitical organization in shaping pastoral systems and meat consumption. This study includes all of the selected settlements except for Semlac for which there is not an adequate faunal sample for analysis.

Maros Settlements

Klárafalva Hajdova

Klárafalva is a small fortified tell settlement in the low floodplain of the Maros, spanning the end of the EBA (Early Maros) though most of the MBA (Classic and Late Maros). There are three major phase divisions at the site, Phase 1: c.1800-1500 cal. BC, Phase 2: 2200-1800 cal. BC, and Phase 3: 2300-2200 cal. BC. A comprehensive review of the fauna from this site is presented in Nicodemus (2010), the main points of which are reviewed here. Despite the very long sequence represented at Klárafalva, there are not major changes in the animal economy over time, especially when the three phases are compared (Table 13.2). Overall, Klárafalva's animal economy differs from those of the other study sites in that fish comprise a major part of the diet, forming nearly half of the faunal assemblage. This is no doubt related to its position directly along the Maros River, as well the lack of quality pasture in the frequently inundated land and permanent marshes surrounding the site. For mammals, hunted game makes up about 10% of the fauna, which lies at the upper end of the typical range for the Carpathian Basin Bronze Age. Livestock husbandry systems are focused on ovicaprids and pigs in near equal numbers with many fewer cattle being kept. Horses are rare, averaging only 3% of the fauna.

Table 13.2: Klárafalva faunal summary by layer and phase (%NISP)

	Phase 1						Phase 2				Phase 3	Site
	A	B	C	D	E	Avg	F	G	H	Avg	I-K	Avg
All Fauna Classes												
Mammal	62.5	48.3	55.0	41.1	43.3	**54.6**	39.3	48.3	58.3	**48.4**	**70.9**	**53.4**
Fish	36.3	50.9	43.8	58.1	55.9	**45.9**	60.1	50.4	40.3	**50.5**	**27.7**	**45.6**
Reptile	0.6	0.5	0.5	0.2	0.3	**0.5**	0.1	0.3	0.6	**0.3**	**0.7**	**0.5**
Bird	0.4	0.3	0.2	0.2	0.2	**0.3**	0.3	0.4	0.2	**0.3**	**0.0**	**0.3**
Mollusk	0.2	0.0	0.4	0.4	0.2	**0.2**	0.1	0.5	0.5	**0.3**	**0.7**	**0.3**
Amphibian	0.0	0.0	0.0	0.0	0.1	**0.0**	0.0	0.1	0.1	**0.1**	**0.0**	**0.0**
All Mammals												
Wild Mammal	9.8	11.6	10.0	15.9	6.9	**10.1**	12.5	9.6	14.7	**11.7**	**12.9**	**10.5**
Domestic Mammal	90.2	88.4	90.0	84.1	93.1	**88.9**	87.5	90.4	85.3	**88.3**	**87.1**	**89.5**
Domesticates												
Ovicaprids	37.2	38.1	45.5	40.0	50.5	**40.8**	52.4	48.5	41.4	**46.8**	**45.9**	**42.5**
Pig	41.8	47.0	39.2	40.0	37.6	**41.3**	36.5	38.3	46.5	**40.7**	**32.8**	**40.9**
Cattle	18.1	11.9	12.2	20.0	10.2	**15.2**	9.5	9.5	7.6	**8.9**	**16.4**	**13.6**
Horse	2.9	3.0	3.1	0.0	1.6	**2.7**	1.6	3.6	4.5	**3.6**	**4.9**	**3.0**

Despite the relative stability in the animal economy, there are some important long term patterns that can be seen when examining the fauna at a finer scale. The most striking change relates to the proportion of fish compared to mammals, with fish peaking in frequency in layers D-F, which bracket the transition between Phases 1 and 2. This change is paralleled by an increase in ovicaprids at the expense of larger livestock like cattle and horses. I argued previously (Nicodemus 2010) that this is related to socioeconomic factors rather than any environmental changes[155] and it may be significant that this apparent decline in access to high-value animals occurs when Pecica is at its apex.

The livestock culling patterns are interesting as well.[156] In the earlier part of the occupation, Phases 2 and 3,[157] ovicaprid husbandry is strongly focused on meat production, with about 60% of the animals slaughtered in prime-age, nearly all within the 16-24 month range. A secondary peak is at 2-6 months and few animals were kept past four years. This is similar to the

[155] In short, if shifts in taxon abundance are a response to environmental change, then there should be parallel patterns of change among animals with similar habitat preferences. For example, fauna associated with grasslands would all be expected to increase in frequency during drier periods, while those favoring forests or wetlands would decrease. At Klárafalva, the relative abundances of animals with similar habitat preferences do not co-vary. Rather, it is taxa with similar utility values that vary in parallel.

[156] Demographic profiles use primarily dental data as they can be compared statistically and are more precise than epiphyseal fusion.

[157] Note that in the 2010 analysis, Phases 2 and 3 were combined as an Early-Classic period composite, in contrast to the major Late Period occupation. However, very little of the material represents Early Period.

cull pattern at Pecica at the same time. However, in the final occupation phase (Late Maros), only about 1/3 of ovicaprids are consumed in their prime while half of the animals are maintained into adulthood. 17% of the adult animals are greater than 8 years old, indicating that wool production becomes a major concern over time.

Pig rearing in all phases falls within the range for typical husbandry systems, with most animals being slaughtered before their second year. However, in the earlier occupation (Phases 2-3), the peak cull is of animals 1-2 years old, while in the later period (Phase 1) this shifts to 6-12 months, suggesting the institution of a more rapid-turnover system. Changes in cattle and horse breeding over time cannot be assessed due to small sample sizes in early periods. However, by the Late Period, cattle were being raised in a fairly specialized meat system, with most animals being culled in prime-age (2-4 years), and only about 1/3 being maintained into physical maturity. Draft cattle were not as important at Klárafalva as at Pecica, which may be related to less intensive agricultural practices and limited arable land, which are discussed further below. Little can be said about horses except that animals less than two years old and adults are present in both major occupation periods, suggesting local breeding to some degree.

Table 13.3: Body part representation by utility (%NISP)

	Pecica	Klara.	Kisz.	Sarkad*	Tarhos	Szaz.**
Mammal						
Very High/High	60%	57%	52%	65%	59%	64%
Med/Low	34%	35%	39%	30%	33%	31%
Very Low	6%	8%	9%	5%	8%	5%
Ovicaprid						
Very High/High	50%	51%	49%	62%	43%	55%
Med/Low	48%	44%	46%	35%	50%	42%
Very Low	2%	5%	5%	2%	7%	3%
Pig						
Very High/High	57%	46%	52%	57%	42%	57%
Med/Low	38%	35%	36%	37%	39%	41%
Very Low	5%	18%	12%	6%	19%	3%
Cattle						
Very High/High	30%	39%	30%	31%	46%	49%
Med/Low	48%	30%	34%	43%	17%	40%
Very Low	22%	31%	36%	26%	37%	11%

note: sample sizes for horse bones are too small for intersite comparision
*not collected systematically
**different recording system, converted to approximate other sites

Body part representation at Klárafalva is similar to that of Pecica overall, but there are significant differences as well (Table 13.3). For all taxa considered, there are statistically more of the lowest utility elements present at Klárafalva (Appendix 13.1).[158] This meets expectations for small-scale, self-producing households in which the complete animal is more likely to be fully utilized. For pigs, there are also significantly fewer of the highest-quality meat cuts being consumed.

Kiszombor Új-Élet

Kiszombor is a fortified flat settlement located on elevated loess area about four kilometers away from the main channel of the Maros. It was occupied primarily in the EBA (Early Maros), beginning around 2700 cal. BC, and was abandoned during the transition to the MBA (Classic Maros). There are four major occupation phases that are grouped into two temporal units for analytical purposes. Phases 1-2 span roughly 2300-1990 cal. BC while Phases 3-4 cover a longer period, from roughly 2700-2300 cal. BC. Fauna from this settlement was also presented in Nicodemus (2010).

As at Klárafalva, there are no major changes in the animal economy in terms of taxon representation. The assemblage is dominated by mammals with less than 5% other animal classes present (Table 13.4). The prevalence of mammals is certainly related to its location on dry grasslands distant from major rivers. Game is not a major part of the diet, averaging less than 5% of the mammals. The influence of the dry local environment is also seen within livestock husbandry systems. More than half of the livestock are ovicaprids, followed by pigs and cattle, which are kept in similar numbers (20%). Horses are uncommon (5%). There is a slight increase in the proportion of larger, more valuable livestock over time, but these changes are not statistically significant.

While samples are not large, basic culling patterns have been documented.[159] For sheep and goats, neither occupation period differs greatly from a meat maximization system. Pigs can only be assessed for Phases 1-2, where a rapid-turnover system is in place. The peak cull is of animals between 6-12 months, although there is considerable off-take of age classes on either side of this. Cattle consumption, as a whole, is centered on animals between 3-4 years, but

[158] See Appendix 13.1 for all chi-square statistical tests for body part representation.
[159] See Nicodemus (2010) for primary data.

around 60% are kept into adulthood, suggesting that secondary products, likely including traction, were important in addition to meat. There is no evidence for very young horses at Kiszombor, so it is not clear whether they were being bred locally or not.

Table 13.4: Kiszombor faunal summary by phase (%NISP)

	Ph1/2	Ph3/4	Site Avg
All Fauna Classes			
Mammal	94.4	95.1	94.6
Fish	3.2	3.1	3.2
Reptile	0.5	0.0	0.4
Bird	1.0	0.4	0.8
Mollusk	0.6	1.1	0.7
Amphibian	0.4	0.4	0.4
All Mammals			
Wild Mammal	4.8	3.2	4.4
Domestic Mammal	95.2	96.8	95.6
Domesticates			
Sheep/Goat	52.1	61.4	54.4
Pig	21.8	19.3	21.2
Cattle	20.7	15.3	19.4
Horse	5.4	4.0	5.1

Body part representation at Kiszombor is very similar to that seen at Klárafalva, only differing in that Kiszombor has fewer of the highest utility elements for mammals as a general category (all taxa combined). There is no difference in how individual livestock species are treated. All livestock are represented by more of the lowest meat value elements than at Pecica. This suggests that both Klárafalva and Kiszombor were distributing and consuming meat in similar ways, with household level consumption that utilizes more of the carcass, especially the lower-quality cuts.

Ottomány/Gyulavarsánd Settlements

Tarhos-Gyepesi Átkelő

Tarhos is a small unfortified hamlet situated on a minor tributary to the Körös River in a seasonally flooded wet meadow. It belongs to the Ottomány culture and it was occupied for a significant part of the Middle Bronze Age. The analyzed fauna derives from Layers A and B, which span the period from roughly c. 1750/1700-1650/1600 cal. BC. This corresponds to the

Late Maros and is considered here as a single component. Primary data can be found in Nicodemus (2009), summaries of which are published in Duffy (2010).

As Klárafalva stands out for its great reliance on fish, Tarhos is noteworthy for its use of freshwater mussels (Table 13.5). Because Tarhos is located in an expansive marsh, this high figure is not unexpected. However, there is some question as to what degree these were washed in naturally from seasonal floods or accumulated by human activity, as the settlement is in a low lying, flood-prone area. I would argue that humans are the primary agent as there are deposits that appear to be refuse from concentrated shucking (piles in pits) and the frequency of shell is similar in all contexts, including from within sealed house deposits. Game makes up about 5% of the mammals, similar to Kiszombor. The proportions of livestock fall between those seen at the two Lower Maros settlements and the taxa appear in the same rank order. Horses are very uncommon, comprising less than 1.5% of the livestock assemblage, fewer than seen at the Maros settlements.

Table 13.5: Tarhos and Sarkad faunal summary (%NISP)

	Tarhos	Sarkad
All Fauna Classes		
Mammal	36.4	96.0
Fish	1.3	0.4
Reptile	0.1	0.2
Bird	0.6	0.6
Mollusk	61.6	2.8
Amphibian	0.0	0.0
All Mammals		
Wild Mammal	4.5	11.4
Domestic Mammal	95.5	88.6
Domesticates		
Sheep/Goat	47.7	42.6
Pig	33.1	41.5
Cattle	17.9	15.2
Horse	1.4	0.7

Small sample size must be taken into account for age profiles at Tarhos. Ovicaprids appear to have been raised primarily for meat, except that there is a greater than expected number of juveniles culled when compared against meat-maximization profiles (Payne 1973).

The small samples do not allow precise differentiation, but I would argue that this reflects a system that is maximizing herd security rather than a form of specialized dairy production (e.g., Vigne and Helmer Type B dairy). Pig husbandry shows peak cull of animals between 6-12 months, a typical rapid turnover system. Cattle appear to have been raised in a mixed meat-secondary products system, with half culled in prime-age and half maintained into adulthood. There is no evidence for any juvenile horses present, calling into question local breeding. Body part representation at Tarhos mirrors that seen at Klárafalva and Kiszombor, with significantly more of the lowest utility elements present, which meets expectations for small-scale settlements (Table 13.3).

Sarkad Peckes

Sarkad is a large fortified tell located on the same tributary to the Körös as Tarhos. However, this settlement is located on the edge of the vast marshlands that dominate this region, with larger areas of arable land present. There are no radiocarbon dates for this site, but ceramics indicate that it was occupied for much of the MBA, with its greatest areal extent occurring during the Gyulavarsánd occupation, which corresponds to the Late Maros. Individual contexts have not been correlated with the different occupation phases, so the fauna is considered as a single assemblage. The site was not excavated systematically, so sample bias against smaller species and elements must be taken into account. Primary data are presented in the same publications as for Tarhos.

Taxon representation is shown in Table 13.5. While the assemblage appears to be overwhelmingly dominated by mammals (96%), this figure must be treated with extreme caution as other animal classes are likely to be strongly under-represented because of sampling bias. The frequency of mammalian game and individual livestock species is very similar to Klárafalva, although horses are less common, comprising less than 1% of the domesticates.

Ovicaprid husbandry shows peak culls in animals at 2-6 months and secondarily at 4-6 years. This is an unusual profile, and suggests a strong mix of meat and secondary products use, with the possibility that dairy was particularly important at this settlement. Export production also cannot be excluded. Pig breeding, like other settlements, shows a rapid turnover system with more than half of the animals culled at 6-12 months. Cattle off-take at Sarkad differs considerably from other sites in this study. Half of the animals were culled as juveniles, including significant numbers of neonates and infants. Only 14% were kept into maturity. As seen in ovicaprids, this suggests fairly intensive, and perhaps specialized dairy production. This may also reflect elite consumption patterns, which will be considered more fully below. For horses, most of the elements derive from physically mature animals but at least one juvenile less than two years old is present.

Body part representation is more similar to that seen at Pecica than to the previous sites (Table 13.3). There are no significant differences in element utility for cattle or pigs between Sarkad and Pecica. However, at Sarkad there are more of the highest quality parts and fewer of the moderate value cuts for ovicaprids and mammals as an aggregate category. This may reflect greater access to the choicest meat cuts by Sarkad's population, although it is not clear to what degree that unsystematic collection strategies have affected the sample. Nonetheless, both Pecica and Sarkad show little use of the lowest quality body parts compared to the smaller settlements.

Százhalombatta Földvár

Százhalombatta is a large fortified tell settlement overlooking the Danube. It appears to have been the apex of a multi-tiered settlement hierarchy. It was occupied throughout the Bronze Age with both EBA Nagyrév and MBA Vatya components, as well as LBA and Iron Age deposits. Fauna was analyzed by individual levels (Vretemark and Sten 2005), which were combined into three major E-MBA phases: EBA Nagyrév 2400-2000 BC, MBA-A Vatya 2000-1800 BC, and MBA-B Vatya/Koszider 1800-1400 (Vretemark 2010).[160] The primary data publication (Vretemark and Sten 2005) refers to the MBA assemblage so only general statements can be made considering the EBA drawing from the 2010 summary. The 2005 study also does not include invertebrates or non-mammalian taxa other than birds. The presence of fish is noted (but not quantified) in 2010 and includes cyprinids, sturgeon, and pike. Invertebrates were studied separately by specialists for environmental reconstruction (Sólymos and Elek 2005). As the invertebrate sample was drawn from screen and flotation samples, it is not comparable to the mammalian assemblage, which derives from hand collection. As a result, fauna representation by class cannot be assessed and the proportion of wild game is likely under-represented.

[160] Note that the dates of phasing do not directly correspond between these two publications and it appears that the summary analyses from 2010 draw on additional work done since 2005.

Table 13.6: Százhalombatta faunal summary (%NISP)

	EBA	MBA-A	MBA-B
All Mammals			
Wild Mammal**	8	2*	2*
Domestic Mammal	92	98	98
Domesticates			
Ovicaprids	23	41	45
Pig	13	28	22
Cattle	62	30	32
Horse	2	1	1

note: percentages are approximated from Vretemark (2010) Figure: 6.3
*MBA is combined
**inlcudes non-mammalian vertebrates?

The most significant differences in the animal economy at Százhalombatta are found between the EBA and later MBA occupations, occurring around 2000 cal BC. Wild animals decline in importance and cattle numbers fall by about 50% (Table 13.6). At the same time, smaller livestock become more common, especially ovicaprids. Horses are universally infrequent. The large percentage of cattle, especially in the EBA, fits within a general trend for the western Carpathian Basin and Transdanubia where cattle tend to be the dominant species, which is in contrast to the grassy plains to the east, where ovicaprids (overwhelmingly sheep) are more common (Bartosiewicz 2005; Choyke and Bartosiewicz 1999, 2000). This regional pattern illustrates large-scale influences of environment on herding strategies, as cattle can more readily eat forest fodder than sheep and the latter are better suited to the often dry conditions of the steppe-forest.

Demography also changes over time for ovicaprids.[161] In the EBA, the peak cull is within the juvenile age class (3-9 mo.) with secondary culls throughout prime-age. There is no evidence of animals older than 4-6 years. This reflects a meat-oriented system with the relatively large number of juveniles perhaps related to elite consumption. In the MBA (both phases combined), ovicaprid husbandry is significantly reoriented, with peak culls of mature animals 4-6 years old. Vretemark and Sten (2005) argue that this reflects increased importance of wool production, which is also supported by the fact that nearly a third of the ageable adult bones belonged to males. This is not, however, a specialized wool-maximizing system (Payne 1973),

[161] Note that the age classes used in the Százhalombatta study are different from those used by the author.

as there are no animals older than six years, there is a large but secondary cull of prime-aged animals, and there should be more male whethers present. Note also that the lack of animals over 4-6 years suggests that a provisioning system may be in place, drawing from a wool-oriented flock.

Pig husbandry systems are stable over time. Unlike many of the settlements in this study, the peak cull is not within juveniles, but rather as prime-aged animals between 1.5-2 years of age. This reflects a system in which more emphasis is placed on maximizing the amount of meat per animal rather than rapid turnover or an elite consumption pattern favoring juveniles. Interestingly, about 15% of pigs are older than five years, which is a very unusual pattern as pigs reach sexual maturity and full body size prior to this age. The presence of these old pigs does suggest local breeding.

Cattle demography is only available for the MBA. Around 60% of cattle were maintained into adulthood, including one quarter past eight years. This age pattern, along with the presence of load-bearing pathologies and the relatively high number of adult males (~1/3), indicates the cattle were raised primarily for traction and only secondarily for meat. Note also that there is also evidence for females with traction-related injuries, as at Pecica, which argues against a highly specialized oxen-based traction system.

Horses are almost exclusively older animals and a number of bones show traction pathologies. The 2005 publication indicates that there were only two juvenile bones present, but it is unclear what exact age range these fall into. Nonetheless, there is not the high level of juveniles (including infants and neonates) that would be expected in large-scale local breeding.

Százhalombatta, like Sarkad, shares a similar pattern of body part representation to Pecica (Table 13.3). There are no differences seen in the smaller livestock (ovicaprids and pigs). However, cattle and the combined mammalian assemblage show more of the highest utility elements being consumed at Százhalombatta than Pecica. A similar difference is found between cattle at Sarkad and Százhalombatta. This suggests that while all three of these major tells preferentially consume high-value meat cuts when compared to smaller settlements, Százhalombatta tell inhabitants have greater access to the choicest beef cuts. This pattern is likely related to the cattle-dominated husbandry system at this site. Cattle are far less common at other settlements in this study and at these sites more of the lower utility elements are consumed. At Pecica, there is a strong difference in access to quality beef between central and peripheral inhabitants. Explorations of other settlement sectors at Százhalombatta may also find differential access to high quality beef at this focal site.

Discussion

There is considerable variability in animal production systems in the Carpathian Basin during the Bronze Age. Some of the most striking differences are seen in taxon representation (Table 13.7), but there are also important contrasts in herding strategies reflecting different emphases on animal products and their distribution and consumption. Many of these differences, especially those related to the types of animals utilized, can be related primarily to environmental conditions. However, the influence of political organization and degree of economic centralization can also be seen in several aspects. These are considered below. Importantly, period of occupation does not appear to be a major factor at a larger scale. There are no common patterns of change between Early and Middle Bronze Age occupations within the macro-region. Rather, settlements develop along their own trajectories, adapting to their local ecology while also structuring their animal production systems in parallel with larger economic and political organization.

Table 13.7: Taxon representation summary, all sites (%NISP)

Site	Kiszombor	Klarafalva				Tarhos	Sarkad*	Szazhalombatta**			Pecica			
Period	EBA	EBA***	E/MBA-A	MBA-B	Avg	MBA-B	MBA	EBA	MBA-A	MBA-B	EBA*	MBA-A	MBA-B	Avg
All Fauna														
Mammal	94.6	71.5	48.4	54.6	53.1	36.4	96.0				99.3	89.6	84.8	88.3
Fish	3.2	27.5	50.5	44.4	45.8	1.3	0.4				0.6	0.7	1.6	1.1
Mollusk	0.7	0.3	0.3	0.2	0.2	61.6	2.8				0.0	9.6	13.4	10.5
Other	1.5	0.7	0.8	0.8	0.8	0.7	0.8				0.1	0.1	0.1	0.1
Mammals														
Domesticates	95.6	86.1	88.3	89.9	89.4	95.5	88.6	92.0	98.0	98.0	92.0	86.7	78.8	83.8
Wild Mammal	4.4	13.9	11.7	10.1	10.6	4.5	11.4	8.0	2.0	2.0	8.0	13.3	21.2	16.2
Domesticates														
Ovicaprid	54.4	46.8	46.8	40.6	42.4	47.7	42.6	23.0	41.0	45.0	57.9	34.7	43.4	41.3
Pig	21.2	32.3	40.7	41.1	40.7	33.1	41.5	13.0	28.0	22.0	23.4	26.7	31.5	27.9
Cattle	19.4	16.1	8.9	15.4	13.8	17.9	15.2	62.0	30.0	32.0	16.3	18.9	19.8	18.8
Horse	5.1	4.8	3.6	2.8	3.1	1.4	0.7	2.0	1.0	1.0	2.4	19.7	5.4	11.9

* non-systematic collection, small species under-represented, especially non-mammalian taxa

**percentages are approximated from Vretemark (2010) Figure: 6.3, wild versus domesticates MBA figures combined, no site totals available

***small sample

Environmental Influences

The degree and manner to which local ecology has influenced production systems must be taken into account before assessing the role of sociocultural factors. It is apparent that the environment has played a strong role in the study region, especially among smaller-scale and politically autonomous settlements, as detailed below. In these we see greater concern with risk buffering, more closely tailoring their animal economies to local conditions, both in terms of livestock management and wild resource exploitation.

Environmental influences are most visible in the use of wild fauna. While at most sites, livestock husbandry dominates the animal economy, some settlements place much more emphasis on exploiting readily available wild fauna. This is seen at Klárafalva and Tarhos where fishing and mollusk collection, respectively, are important sectors of their production systems. These two sites have the lowest amount of flood free land for crop production and pasturage, with most of their catchments lying within wetlands of various types. Klárafalva's placement along the main channel Maros River, rich in aquatic resources, made fishing an ideal choice for alternative meat production strategies. Not only are fish abundant in these waters, particularly cyprinids, they also hold very large species that can feed multiple households, including sturgeon and especially wels catfish, which can reach lengths of five meters and weigh up to 300 kg (Maitland 2000:167). Bones of very large individuals have been recovered at this site (and at Pecica). Tarhos, in contrast, lacks direct access to a major waterway and their abundant fish resources. However, the smaller tributary and extensive wetlands would have supported large numbers of freshwater bivalves. While lower ranked than fish in terms of meat per individual and processing costs, their high frequency would have made them an attractive supplemental meat source.

The importance of hunting appears to be related in part to ecological conditions. At all settlements, mammalian game is dominated by red deer. This species is primarily found in deciduous forests but can also adapt to more open woodlands (Chinery 1987). Other wild mammals vary in their frequency in relation to the local environment, with settlements in more open, grasslands having more aurochs, roe deer, and hare while those with greater access to forests (including gallery forests and fens) obtaining more boar, beaver, and woodland carnivores. It is possible that because hunting is strongly centered on red deer at all settlements, those located in areas with little forest have fewer mammalian game overall. This pattern is clearly seen at Kiszombor (grassland) and Tarhos (marsh), where wild species comprise less than 5% of the mammals, in contrast to other settlements in mixed habitats where they generally make up at least 10%. Százhalombatta is a notable exception, where game makes up only 2% of the fauna in the MBA. This low figure may be related to provisioning, which favors livestock production over hunted resources.

Livestock management is also affected by ecological conditions but to a lesser degree than wild resources. Cattle are well adapted to the hilly forests of Transdanubia and occur in large numbers at these sites (30-62% at Százhalombatta by period). Environment also affects the ratio of ovicaprids to pigs, which have contrasting ecological preferences. At Kiszombor, situated predominantly on dry grasslands, this ratio is highest (2.6:1). In contrast, the ratio is around 1:1 at settlements with ample wetlands and woods, such as Klárafalva and Sarkad. The frequency of pigs and fish is directly related, showing the importance of wetland exploitation for both wild and domestic food sources.[162] Other sites fall between these ratios, with the frequency of sheep influenced by the importance of wool production, which is considered more fully below.

Political-Economic Influences

The influence of political economies is most visible in livestock management strategies, aspects of animal economies that can be more directly controlled than wild resources. These effects are seen particularly in sheep and horse, and to a lesser degree, in cattle husbandry. For ovicaprids, when wool production is an important consideration within a settlement (excepting Klárafalva where environmental limitations are particularly apparent), they comprise a larger portion of the total livestock assemblage. Significant sheep/goat secondary product production, especially fiber, is also restricted to tell settlements, although the importance of various products varies by individual site (Table 13.8). At Tarhos, the smallest settlement in this study, a herd security strategy is evident.

[162] r=0.678

Table 13.8: Livestock culling patterns, all sites

Site	Kiszombor	Klarafalva		Tarhos	Sarkad	Szazhalombatta		Pecica		
Period	EBA	E/MBA-A	MBA-B	MBA-B	MBA	EBA	MBA	EBA	MBA-A	MBA-B
Ovicaprid	meat max	meat max	meat-wool	herd security	meat-dairy	meat max	meat-wool	meat-secondary products	meat max	meat max
Pig	rapid turnover	meat max	rapid turnover	rapid turnover	meat max		meat max	meat max	rapid turnover	rapid turnover
Cattle	meat-secondary products		meat max	meat-secondary products	meat-dairy		meat-traction	meat-traction	meat-traction	meat-traction
Horse*	traction	traction	traction	traction	traction	traction	traction	traction	meat-traction-export	traction-meat

*traction is assumed to be the primary use when assemblages are dominated by or exclusively adults

The frequency of cattle is inversely related to both pigs and ovicaprids overall, suggesting that there is a strong distinction between cattle rearing and the production of smaller livestock,[163] regardless of environmental conditions. I would argue that this is related in part to socioeconomic status as measured by relative position in regional site hierarchies (or lack thereof). There is a trend for larger, more central settlements to invest more resources in producing (and consuming) high-value animals. But it is also significant that only at Százhalombatta and Pecica is cattle husbandry strongly geared towards the use of traction animals rather than meat maximization or mixed production systems. This is likely related to more extensive, large-scale agriculture at these two central tells (see also below). Traction cattle were also critical for the transport of bulk goods in local and regional exchange networks.

Compared to those affecting ovicaprids and cattle, the underlying causes that influence variability in pig rearing are less clear. There is a difference between sites and phases in whether meat maximization or rapid turnover systems are in place, but these do not segregate well by any of the study variables. However, meat maximization systems are more likely to be found at the tell settlements.

A second major difference in livestock husbandry practices reflects the number of horses, which distinguishes Pecica (Classic Maros/MBA-A) from all other settlements in the study. While horses are more common at all of the Maros culture sites considered, the very high numbers at Pecica (up to 30% of the livestock) reflects a unique husbandry system that is geared

[163] Cattle-ovicaprid: r= -0.677, cattle-pig: r= -0.747.

to large-scale horse production. Here the breeding of horses is a central pillar of the economy, playing an important role in regional exchange, warfare, and feasting.

The uniqueness of Pecica's horse breeding economy is underscored when compared against a wider range of Early and Middle Bronze Age settlements[164] within the Carpathian Basin (Table 13.9, Figure 13.1). While the vast majority of these sites did not have their fauna systematically collected, the horse to cattle index (HRC) measure (Kanne 2010) [165] can be used to assess the relative importance of large-bodied livestock. As cattle and horses are similar in size, collection bias is minimized, allowing for inter-site comparisons at a larger scale.

At most settlements, horses are only present in small numbers, with 60% of the sites having less than 5% of the livestock comprised by horses, 23% less than 2%, and at four sites they are completely absent.[166] A similar pattern is found using HRC values. With the exception of the Bell Beaker site of Csepel Haros (EBA-A), which may predate Pecica by 500-1000 years, Pecica has both the highest percentage of horses within its livestock assemblage and the greatest HRC value, the latter of which peaks at 63.7 during Phase 4 of the Florescent Period occupation. Only a handful of other settlements have horses comprising more than 20% of the livestock (Csepel Haros, Foeni Gomila Lupului, and Tószeg Laposhalom) and only Csepel Haros and Foeni have HRC values greater than 50. Note that while there is a strong correlation between the percentage of horses and HRC values,[167] there are a few settlements that have HRC values significantly above or below expected values given their respective horse NISP percentages (Figure 13.2). HRC values for Csepel and Pecica (Phase 4) are nearly identical. Csepel Haros and Tószeg Laposhalom have lower HRC values than expected given the frequency of horses overall, which likely reflects collection strategies that are biased against smaller livestock. Again, the relatively high HRC values for all Maros sites can be seen, even when horses do not occur in large numbers.

Clearly, access to horses was highly uneven and I suggest that only a few horse breeding centers existed in the region at any given time. It has long been argued that Csepel was a principal horse breeding settlement in the earliest Bronze Age, helping to usher in sustained and

[164] Including only sites with faunal samples greater than 100 specimens.
[165] HRC=NISP horse/(NISP cattle + NISP horse)*100 (Kanne 2010)
[166] These figures are even greater when including sites with smaller samples and those with only presence/absence data.
[167] r=0.914

Table 13.9: Horse abundance measures for Early and Middle Bronze Age settlements in the Carpathian Basin, total assemblage NISP >100

Site	Country	County	Period	Culture	Citation	NISP*	HRC	% Horse
Csepel-Háros	Hungary	Pest	EBA I	Bell Beaker	Bökönyi 1988	2752	64.1	51.8
Pecica- Phase 4 (Florescent Perod)	**Romania**	**Arad**	**MBA I**	**Maros**	**Nicodemus 2009**	**2782**	**63.7**	**29.2**
Pecica- Florescent Period	**Romania**	**Arad**	**MBA I**	**Maros**	**Nicodemus 2009**	**6803**	**52.0**	**21.3**
Foeni-Gomila Lupului	Romania	Timiş	MBA	Vattina	El Susi 1994	522	50.0	26.1
Pecica- site average	**Romania**	**Arad**	**E/MBA**	**Maros**	**Nicodemus 2009**	**14414**	**40.8**	**13.0**
Tószeg-Laposhalom	Hungary	Jász-Nagykun-Solnok	EBA/MBA	Nagyrév/Hatvan/ Füzesabony	Bökönyi 1959	606	32.8	25.7
Pecica-Şantul Mare	Romania	Arad	MBA	Maros	Haimovici 1968, 19XX	236	28.8	14.4
Dunaújváros-Koszider	Hungary	Fejér	EBA/MBA	Nagyrév/Vatya	Bökönyi 1959	1711	23.1	13.8
Carei-Bobald	Romania	Satu-Mare	MBA	Ottomány	El Susi 2002	2171	20.8	11.8
Pecica- Late Period	**Romania**	**Arad**	**MBA II**	**Maros**	**Nicodemus 2009**	**7611**	**20.7**	**5.0**
Bakonszeg-Kádárdomb	Hungary	Békés	MBA	Gyulavarsánd	Bökönyi 1988	1074	20.4	11.2
Klárafalva-Hajdova	Hungary	Csongrád	MBA	Maros	Nicodemus 2010	10966	19.9	3.8
Klárafalva-Hajdova	Hungary	Csongrád	EBA	Maros	Nicodemus 2010	4927	19.5	2.4
Polgár-Basatanya	Hungary	Hajdú-Bihar	EBA/MBA	Nagyrév/ Füzesabony	Bökönyi 1959	281	17.3	8.6
Mezőkomárom-Alsóhegy	Hungary	Fejér	EBA III	Kisapostag	Choyke & Bartosiewicz 1999	1381	16.8	10.8
Kiszombor Uj-Elet	Hungary	Csongrád	EBA	Maros	Nicodemus 2010	1899	16.2	3.5
Tápiószele-Tűzköves	Hungary	Pest	eMBA	Hatvan	Bökönyi 1959	1007	12.4	6.7
Lovasberény-Mihályvár	Hungary	Fejér	MBA II	Vatya	Choyke & Bartosiewicz 1999	3712	11.9	8.0
Berettyóújfalu-Szilhalom	Hungary	Békés	MBA	Gyulavarsánd	Bökönyi 1988	829	11.0	3.7
Füzesabony	Hungary	Heves	MBA III	Füzesabony	Bökönyi 1959	776	10.9	6.7
Százhalombatta-Téglagyár	Hungary	Pest	MBA	Vatya	Choyke & Bartosiewicz 1999	2138	9.7	4.8
Százhalombatta-Földvár	Hungary	Pest	MBA	Vatya/Koszider	Choyke 2000	3954	8.9	4.2
Százhalombatta-Földvár	Hungary	Pest	EBA	Nagyrév	Vretemark & Sten 2005	250	8.1	3.8
Tarhos 26	Hungary	Békés	E-MBA	Ottomány-(Gyulavarsánd)	Nicodemus 2009	7580	7.8	1.4
Sárbogárd-Cifrabolondvár	Hungary	Fejér	MBA II	Vatya	Choyke & Bartosiewicz 1999	607	7.7	4.0
Tiszaluc-Dankadomb	Hungary	Borsod-Abaúj-Zemplén	eMBA	Hatvan	Bökönyi 1988	4050	7.5	3.4
Békés-Városerdő	Hungary	Békés	MBA	Ottomány-Gyulavarsánd	Bökönyi 1988	6304	7.2	3.6
Ménfőcsanak-Szeles-telep	Hungary	Győr-Sopron	MBA II	Incrusted Ware	Choyke & Bartosiewicz 1999	133	7.2	4.7
Igar-Vámpuszta	Hungary	Fejér	MBA II	Vatya	Choyke & Bartosiewicz 1999	1579	7.1	4.1
Gáborján-Csapszékpart	Hungary	Hajdú-Bihar	EBA	Nyírség	Bökönyi 1988	687	7.1	3.9
Mezőkomárom-Alsóhegy	Hungary	Komárom-Estergom	EBA/MBA	Nagyrév/Vatya	Bökönyi 1988	555	7.1	4.2
Szebény-Paperdő	Hungary	Baranya	MBA	Incrusted Ware	Bökönyi 1988	733	6.9	5.0
Igar-Vámpuszta	Hungary	Fejér	MBA III	Koszider	Choyke & Bartosiewicz 1999	252	5.8	2.6
Süttő-Hosszúvölgy	Hungary		EBA	Magyarád	Bökönyi 1988	971	5.3	3.0
Sarkad-Peckes	Hungary	Békés	MBA	Ottomány-Gyulavarsánd	Nicodemus 2009	5009	4.6	0.7
Százhalombatta-Földvár	Hungary	Pest	MBA	Vatya	Vretemark & Sten 2005	3908	4.5	2.4
Biharugra-Földvárhalom	Hungary	Békés	MBA	Ottomány	Vörös 1978	400	3.8	2.3
Foeni-Cimitirul Ortodox	Romania	Timiş	eMBA	Gornea-Orleşti	El Susi 2001	1514	3.7	2.2
Tiszaug-Kéménytető	Hungary	Jász-Nagykun-Solnok	eMBA	Hatvan	Choyke & Bartosiewicz 2000	764	3.2	2.0
Tiszaug-Kéménytető	Hungary	Jász-Nagykun-Solnok	EBA	Nagyrév	Choyke & Bartosiewicz 2000	2637	2.6	1.4
Igar-Vámpuszta	Hungary	Fejér	EBA III	Nagyrév	Choyke & Bartosiewicz 1999	432	2.5	1.4
Ravazd-Villibald-domb	Hungary	Győr-Sopron	EBA II	Somogyvár-Vinkovci	Choyke & Bartosiewicz 1999	116	2.4	1.1
Ravasd-Villibald-domb	Hungary	Győr-Sopron	EBA III	Kisapostag	Choyke & Bartosiewicz 1999	709	2.1	0.7
Csongrád-Petőfi TSz Homokgödre	Hungary	Csongrád	EBA	Zók	Bökönyi 1988	280	0.0	0.0
Csongrád-Sertéstelep	Hungary	Csongrád	EBA	Makó	Vörös 2001	1141	0.0	0.0
Gornea-Păzărişte	Romania	Caraş-Severin	MBA	Vattina	El Susi 1995	670	0.0	0.0
Szava-Vasúti megálló	Hungary	Baranya	EBA II	Somogyvár-Vinkovci	Vörös 1978	510	0.0	0.0

* NISP all fauna

larger-scale horse husbandry to the Carpathian Basin (Bökönyi 1988). Pecica Şanţul Mare was also one of these centers and may have acted as the principal horse distributer for the greater Maros region during the earlier part of the Middle Bronze Age. Foeni (Vattina) may have competed with Pecica, supplying horses to the south and Tószeg may have been a center for the Körös region. Unfortunately, the fauna at Tószeg was not considered by occupation phase so its temporal placement cannot be firmly established. However, demographic profiles must be used to substantiate this pattern of breeding centers, which are only available for Pecica and Foeni. As discussed in Chapter 8, Pecica has a large breeding population while at Foeni the expected neonatal animals are absent (El Susi 1994).

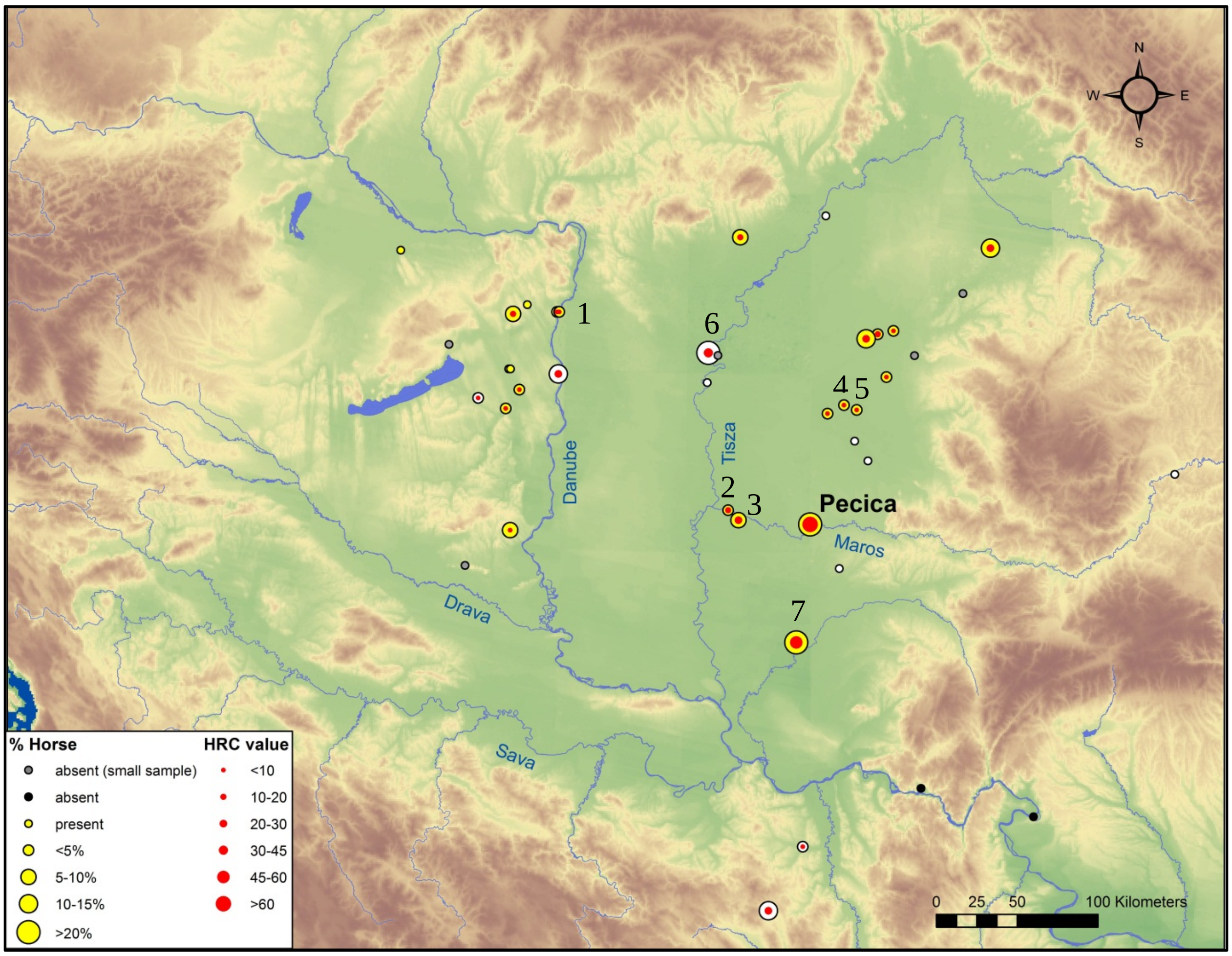

Figure 13.1: Horse distribution Carpathian Basin Bronze Age (EBA-B to MBA-B), %NISP horse/livestock and HRC. Yellow circles: Middle Bronze Age; white circles: Early-Middle Bronze Age mixed. Pecica: Florescent Period (Ph 4), 1: Százhalombatta, 2: Klárafalva, 3: Kiszombor, 4: Tarhos, 5: Sarkad, 6: Tószeg-Laposhalom, 7: Foeni-Gomila Lupului.

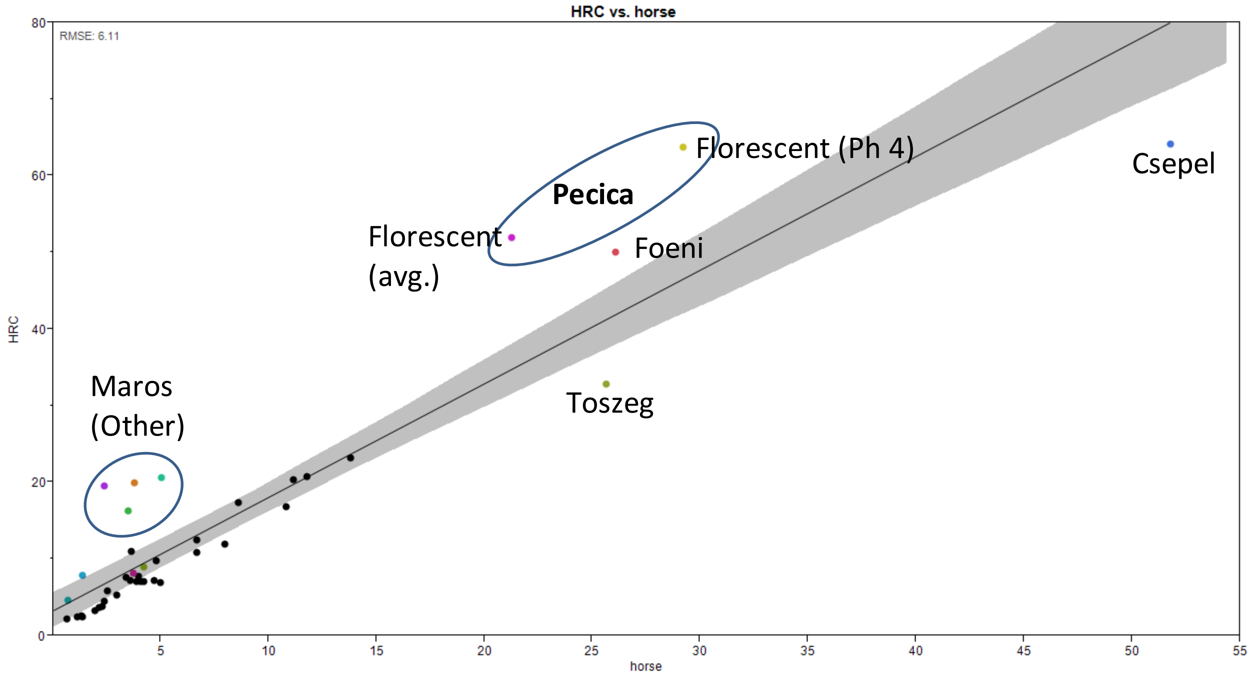

Figure 13.2: Relationship between horse frequency within livestock (%NISP) and HRC

Demographic profiles for livestock show little evidence for provisioning at the comparative study sites, including the larger tells of Sarkad and Százhalombatta. Most species show husbandry strategies that are geared towards mixed usage. However, at the tells there is a greater concern for balancing secondary products and meat output. While this mixed usage is seen in cattle at Pecica, ovicaprid production during its Middle Period occupation stands in contrast to other sites with its strong focus on prime-aged animals and tight culling schedule, which is consistent with provisioning. It is possible that the meat maximization profiles for pigs found at the other tells may be related to intra-site provisioning. It should be noted again that the large number of mature pigs at Százhalombatta is unexpected.

Body part representation provides a different perspective from herd demography. While culling patterns do not show specialized production for centralized provisioning at the comparative sites, there is a strong division between smaller and/or autonomous villages and the larger tells in terms of quality of meat consumed. At Pecica, Százhalombatta, and Sarkad, more select meat cuts of large bodied livestock are being obtained by tell inhabitants. It is possible that, as at Pecica, there was uneven distribution of high-value meat among the settlements' populations related to socioeconomic status, which also may be related to some degree of intra-site provisioning. This pattern clearly applies to beef at the tells and at Pecica this also extends to horse meat.

AGRICULTURE

A basic review of Bronze Age agriculture was presented in Chapter 5. It will be restated here that during the Early and Middle Bronze Ages, agriculture was focused on wheat and barley production, supplemented by a variety of legumes and oil and fiber plants (Gyulai 2010). Little attention has been paid in previous literature to how crop agriculture is integrated within larger economic systems. The following case studies are used to provide a more detailed understanding of Bronze Age farming and its relationship to both environmental and cultural factors. There are considerable differences in primary analytical techniques, level of data presentation, and sample sizes, which affects the range of analyses than can be done. This study includes all study sites except for Sarkad where flotations were not taken.

Case Studies

Semlac Şanţul Mic

Semlac, a small fortified tell located three kilometers downriver from Pecica, provides one of the best comparative assemblages. It was processed and analyzed using identical methods to Pecica as part of the same research program. The 25 analyzed flotation samples from a profile column sample span a period from roughly 2400-1800 cal. BC, covering much of the Early and first half of the Middle Bronze Ages. Primary data and analyses can be found in Oas (2010).

There are few differences in general patterns between Early and Classic Maros occupation periods despite considerable variability between individual contexts. Overall, crops are dominated by einkorn wheat, which appears in 96% of the samples, and comprises 98% of the crop seeds (Tables 13.10, 13.11). This very high proportion reflects two Early Maros house contexts in which large concentrations of wheat were recovered. No other wheat species have been identified, which is unusual. Barely is a secondary crop, occurring in 44% of the flots but only 2% of crop seeds. Millet is found in 24% of the samples, which is fairly high for the region, but note that this only represents a small percentage of individual grains (0.3%). Importantly, in the latter part of Semlac's occupation, barley comprises 12% of the crop seeds and millet 2%, which more likely represents average crop proportions than the Early/Classic Maros sample, in which the grain stores strongly affect representation by NISP. Legumes are infrequent, occurring in 8-16% of the samples, depending on the species (lentil, pea, fava bean, and bitter vetch). Lentils are only found in the EBA while the two vetches are more common in the MBA, but this may be affected by small samples. Overall, legumes comprise only a small number of individual seeds per flot. No fiber or oil seed plants are present.

Table 13.10: Summary of botanicals (NISP) by period

		Pecica			Semlac			Tarhos
Scientific Name	**Common Name**	**MBA-A**	**MBA-B**	**Total**	**EBA**	**MBA-A**	**Total**	**MBA**
Triticum monococcum	einkorn wheat	64.1%	60.3%	63.1%	98.8%	82.5%	97.5%	
Triticum dicoccum	emmer wheat	0.9%	2.6%	1.3%				69.5%
Triticum sp. (new glume)	new glume wheat		+	+				
Triticum aestivum	bread wheat		3.8%	1.0%				
Triticum spelta	spelt wheat							22.7%
Hordeum vulgare	barley	30.0%	28.2%	29.6%	0.7%	11.8%	1.5%	1.6%
Panicum miliaceum	common millet		2.6%	0.7%	0.1%	1.9%	0.3%	
Lens culinaris	lentil	0.9%	1.3%	1.0%	0.3%		0.3%	
Pisum sativum	pea	0.9%	1.3%	1.0%	0.1%	0.4%	0.1%	
Vicia faba	fava bean	3.1%		2.3%		1.1%	0.1%	
Vicia ervilla	bitter vetch				0.0%	2.3%	0.2%	

+ ID by chaff only

Wild seeds show a general similarity to Pecica in terms of family representation and number of species from major habitat types (Table 13.12), which is expected given their proximity. By NISP, Semlac has fewer pasture and woodland plant seeds but more from floodplain and salt-affected grasslands, which suggests some differences in land use. Wild species that are typically used as indicators of season of planting are uncommon overall, with the exception of white goosefoot (*Chenopodium album*), which is also a common ruderal and may have been harvested. Notably, there are very few seeds (n=1) that are winter crop indicators, as at Pecica. The vast majority of the ruderal/segetal species are either spring weeds and/or indictors of more intensive farming practices. Compared to Pecica, there are fewer weeds that are associated with high nitrogen levels, which, along with the higher proportion of weed to crop seeds, argue for less intensive farming practices being used.

Crop processing at Semlac is well documented. Overall, chaff (spikelet forks and glume bases) comprise 5% of wheat remains[168] and was found in 64% of the samples. There is no evidence for by-products for earlier stages of processing. This indicates that primary threshing

[168] 2% in the EBA (including in house, cleaned grain stores), 28% in the MBA.

took place away from the habitation area and that partially processed grain was brought into houses for storage. There is evidence for end-stage cleaning (sieving and sorting) within households, the remains of which were often disposed of in hearths (chaff and small weed seeds). There is a storage pit that contained a clean cache of einkorn wheat, a rare example of *in situ* storage. This also suggests that crops were not grown as maslins (mixed crops).

Table 13.11: Summary of botanicals (ubiquity), site totals (all periods)

taxon	Pecica	Semlac	Tarhos	Szaz.
einkorn wheat	87%	96%	0%	91%
other wheat**	15%	0%	89%	+
barley	64%	44%	22%	78%
millet	4%	24%	0%	+
domestic legume	13%	12%	0%	85%*
grass	77%	88%	0%	+
chenopod	64%	72%	44%	87%
carnation	34%	32%	0%	+
mint	32%	4%	0%	+
clover/wild legumes	28%	12%	0%	+
elderberry	21%	24%	0%	+
buckwheat	19%	28%	0%	63%
sedges	19%	32%	0%	+
dewberries/rose family	15%	0%	0%	+
nightshade	11%	0%	0%	
total flots (BA)	47	25	9	

*pits only

** ID to species only, exlcudes Non-ID wheat grains

Table 13.12: Botanical comparison MBA-A Pecica versus Semlac (NISP, %NISP)

	Pecica	Semlac	Pecica	Semlac
einkorn wheat	229	217	56%	60%
other wheat*	127	97	31%	27%
barley	41	31	10%	9%
millet		5		1%
domestic legume	10	11	2%	3%
Total crop seeds	*407*	*361*	*100%*	100%
chenopod	72	161	35%	34%
grass	67	222	33%	46%
carnation	21	27	10%	6%
clover/wild legumes**	11	12	5%	3%
mint	9	2	4%	0%
sedges	6	10	3%	2%
nightshade	5		2%	0%
buckwheat	4	16	2%	3%
dewberries/rose family	4		2%	0%
elderberry	3	10	1%	2%
mustards	2	17	1%	4%
other	2	1	1%	0%
Total wild seeds	*206*	*478*	*100%*	*100%*

*all wheat species and non ID wheat seeds

** inlcudes non ID pulses

note: MBA-A (Classic Maros) only

Klárafalva Hajdova

The archaeobotanical remains from Klárafalva have not yet been fully published (Jones, et al. in prep). While the raw data are not available, this preliminary report does provide a basic overview of crop husbandry and processing practices. Unlike most Bronze Age sites, barley is the most common grain recovered at Klárafalva, followed by einkorn. The extensive use of barley, which is a faster-growing, hardy grain compared to wheat, may be related to the extensive floodplains and marshes around the settlement, as it can be planted after the annual floods and withstand a range of unfavorable growing conditions. Emmer, bread, and new glume wheat are found in very low quantities and the authors suggest that that may have been contaminants in the einkorn. Only a single millet grain was identified, originating in the latest occupation phase. There are a range of pulses present, mostly lentil, but also pea, grass pea, and bitter vetch. Jones et al. (in prep) argue that lentils may have been grown as a maslin crop with other legumes.

The weed species are dominated by white goosefoot, as is typical for the region. There are weeds representing both fall (*Agrostemma githago* and *Centaurea cyanus*) and spring (*C.*

album, B. convolvulus, and P. aviculare) planting.[169] And while the most common weeds are associated with dry soils, indicating that fields were predominantly on areas of higher elevation, there is also a number of species associated with wetter conditions (Cyperaceae, *Scirpus spp.*, *Carex spp.*, *P. lapathfolium*, and *P. persicaria*), suggesting that crops may have been grown in low parts of the floodplain around the settlement as well, although to a far lesser extent. The authors do note that these wetland seeds may not have arrived on the site as crop weeds. Nonetheless, the weeds do suggest a diverse planting strategy in terms of season of planting and perhaps field location as well. There is no evidence for any significant changes in crop husbandry practices over time.

Most samples contained evidence of late-stage wheat processing within the settlement, indicated by chaff and small-seeded weed species. Interestingly, there is evidence from discrete contexts for the storage of cleaning by-products, perhaps for use as daub temper or fuel. In one pit feature such a chaff store was found within a vessel, along with separate vessel caches of barley and einkorn. The grain was partially cleaned with the majority of weed seeds being large species like common corncockle (*A. githago*), a winter weed that requires hand sorting to remove, which is the final processing stage.

Kiszombor Új-Élet

The botanicals from Kiszombor derive primarily from the EBA (Early Maros). This assemblage was evaluated as part of the same study as Klárafalva by Jones et al. (in prep). Far fewer flots were taken at Kiszombor so the analysts were not able to include a discussion of husbandry strategies or processing stages. In addition, botanicals do not appear to have been as well preserved. Compared to Klárafalva, a smaller range of crops were found, but the absent species are those that are typically rare and may reflect the smaller sample size. Einkorn is the most common cereal, followed by barley. Emmer and bread wheat are rare and there are small quantities of millet. The pulses are represented by a single pea. Jones et al. (in prep) suggest that bread wheat and millet were more important at Kiszombor than at Klárafalva. Greater use of millet, which requires less water, may be a response to the drier soils in the area around the site. Its frequency in the Early Bronze Age is also notable as it often does not appear at sites until the Middle Bronze Age.

[169] Note that winter weeds were also found in barley, which is unusual since this is typically a spring sown crop.

Tarhos Gyepesi Átkelő

Ten flotation samples from Tarhos (MBA/Ottomány) were analyzed by Berszényi, the results of which are presented in Duffy (2010). These flotations derive primarily from a house and the area immediately external to it. The range of crops is completely different from those found at Maros settlements. The assemblage is dominated by emmer wheat, which is found in all but one of the Bronze Age flots, and comprises 70% of the crops seeds. Secondary in importance is spelt wheat (23%), found in half of the samples. Only two grains of barley were recovered and there is no evidence of millet or legumes. Two weed species were recovered, *C. album* and *C. hybridum*, both associated with spring-sown crops and high nitrogen levels. There are few chaff remains present, suggesting that much of the grain cleaning was done away from the house. Most of the cereal grains came from the house floor, where it appears that a pot with cleaned grain was spilled and charred when the house burnt down. There are also two grinding stones and a storage pit within this house.

Százhalombatta Földvár

The botanicals from the large Vatya tell Százhalombatta were also studied by Berszényi (unpublished), which has been summarized in Vretemark (2010). Einkorn is the dominant crop, found in 91% of the analyzed samples, followed closely by barley, identified in 78% of the flotation samples. New glume and emmer wheat were of secondary importance, and spelt, bread wheat, and millet were uncommon. Unlike most sites in this study, pulses are relatively abundant at Százhalombatta, occurring in 85% of the pit samples and comprising more than 10% of the crop seeds in the majority of seed-rich flots. Lentils are the most common pulse, followed by pea and bitter vetch. Fava beans are infrequent. Of note is the range of oil seeds, including gold of pleasure, poppy, flax, and safflower, albeit in low numbers. The number of species present, including rare varieties, may be related to the large number of flotations analyzed. Evidence for crop-processing tailings on the tell is abundant, with over 80% of the wheat remains being chaff rather than seeds. Most of the chaff was recovered from pits, where charred remains were disposed of. Some of the einkorn grains also show evidence of coarse grinding, perhaps for bulgar production.

Weed seeds indicate that both fall and spring sowing of wheat was practiced, but spring weeds are by far dominant. This includes white goosefoot (*C. album*) and black bindweed (*P. convolvulus*), which are found in 87% and 63% of the flotations, respectively. The chenopods are also associated with more intensive farming practices and their high numbers may also reflect this. In general, the weeds (mostly ruderals and grassland species) are common to well-drained, fertile soils that would have been abundant on the loess terrace on which the settlement was located, but there are also a number of species that are indicative of less fertile sandy soils. There are few species associated with animal fodder or dung, suggesting that livestock was kept away from the settlement. Most of the wetland seeds are from species used in construction or weaving.

Discussion

A comparison of archaeobotanical remains among the six study sites shows a general similarity in crop production in terms of the relative importance of different species, with the notable exception of Tarhos (Tables 13.10-13.13). These differences in part reflect local environmental conditions, namely the relative abundance of wetter versus drier soils and soil fertility. At most sites the dominant crop is einkorn followed by barley. However, at Klárafalva, barley is most frequent, which likely reflects the poor agricultural conditions in this marshy region. Barley also occurs in greater proportions at Kiszombor and Százhalombatta than at the Middle Maros settlements of Pecica and Semlac. Most settlements also have a variety of other wheats present in low numbers, which for the Middle and Lower Maros sites may be contaminates in einkorn. Spelt is also absent in the Maros region. Non-einkorn wheats occur in greater proportions at Százhalombatta and emmer is the dominant crop at Tarhos. Tarhos also stands out for its complete lack of einkorn, very low frequency of barley, and relatively high percentage of spelt. This regional pattern of einkorn versus emmer growing areas was noted previously by Nováki (1969), who argued that settlements on the eastern Plain preferred emmer while those to the west favored einkorn. From new research on Maros culture settlements, it appears that these groups also favored einkorn, in contrast to their northern neighbors. To date there has been no functional explanation for this division and may be related to cultural preferences or historical contingencies. Millet is present at most sites, usually in very low numbers. It does however occur with some frequency at Kiszombor and Semlac, especially by ubiquity (presence/absence per sample), which may reflect greater emphasis on risk-buffering strategies, tailored to the dry soils around these settlements.

Table 13.13: Relative abundance of crop plants

		Pecica		Semlac		Klárafalva	Kiszombor	Tarhos	Százhalom.
Scientific Name	**Common Name**	**MBA-A**	**MBA-B**	**EBA**	**MBA-A**	**E-MBA**	**EBA**	**MBA**	**MBA**
Triticum monococcum	einkorn wheat	**XXX**	**XXX**	**XXX**	**XXX**	XXX	**XXX**		**XXX**
Triticum dicoccum	emmer wheat	X	X			X	X	**XXX**	XX
Triticum sp. (new glume)	new glume wheat	X	X			X			XX
Triticum aestivum	bread wheat		X			X	X		X
Triticum spelta	spelt wheat							XX	X
Hordeum vulgare	barley	XX	XX	XX	XX	**XXX**	XXX	X	XXX
Panicum miliaceum	common millet		X	X	X	X	X		X
Lens culinaris	lentil	X		X		XX			XX
Pisum sativum	pea	X	X	X	X	X	X		XX
Lathyrus sativus	grass pea					X			
Vicia faba	fava bean	X			X				X
Vicia ervilla	bitter vetch			X	X	X	X		XX
Linum usitatissimum	flax								X
Camelina sativa	gold of pleasure								X
Carthamus tinctorius	safflower								X
Papaver somniferum	poppy								X

Note: XXX = dominant (bold is most frequent species), XX = secondary, X = uncommon/rare

Pulses, especially lentils and peas, are present at all settlements except for Tarhos, which may be related to small sample size. They are infrequent at most sites, but are unusually abundant at Százhalombatta. This settlement is also unique in its evidence for a variety of oil and fiber plants, but this may also be due to the large number of samples from this site as these plants are very rare during this period. However, as these are also high-value, specialty crops, their abundance may also be due to the site's apical position in a regional hierarchy and its association with elite occupants and perhaps intensive textile production.

At all settlements, spring planting crops are dominant, and in the case of Tarhos and the Middle Maros settlements, nearly exclusive. At Lower Maros sites and at Százhalombatta, winter crop seeds are more frequent, suggesting more diversified planting systems at these sites. Interestingly, it has been argued that spring sowing would have been utilized in the lowland regions as a response to spring flooding that would have disrupted fall planted crops. However, spring planting is most frequent at all sites, even those where crops are planted on terraces well above the affected floodplains. In fact, at Lower Maros sites, fall sowing is more common than at Middle Maros settlements, despite the fact that the Lower Maros region (and around

Klárafalva in particular) is largely floodplains and backwater wetlands. It is possible, as Jones et al. (in prep) suggest, that in these flood prone areas fields may have been located some distance from the settlement on areas of higher ground. In this case, the settlement's proximity to the Maros River (trade, transportation, etc.) outweighed the need to have access to abundant flood free land in the area immediately adjacent to the occupation. In sum, the preference for spring planting of both traditional spring planted crops as well as wheats can only be explained in part by flooding issues. Rather, it may reflect seasonal labor constraints. And while a staggered season of planting was used to some degree at a number of settlements, it does not appear to have been used as a primary risk buffering strategy.

As alluded to above, land use for agricultural production was very similar between settlements, despite the high level of variation in their ecological settings. From the weed seed assemblages, it appears that fields were preferentially placed on elevated, dryer areas, as seen by the dominance of segetals, ruderals, and grassland species versus wetland taxa. There does not appear to have been much utilization of floodplains or other ecozones for farming, arguing against a risk mitigation strategy that favors high diversity in land use. I instead suggest that this reflects a highly structured land use pattern in which dryer, fertile, grassy areas on chernozems were reserved for crop production, while floodplains, seasonal marshes, woodlands, and other habitats were used primarily for pasture in a well-balanced agro-pastoral system.

Other aspects of farming strategies remain hazy because of small samples or lack of comprehensive publication of wild plant taxa. A few general observations can be made, however. Perennials and other wild species that are intolerant of high levels of disturbance are universally uncommon. This suggests fairly intensive farming practices were widely used, as opposed to low-maintenance extensive farming in which perennials would be more frequent. Weeds associated with high nitrogen levels are most abundant at Pecica, followed by Semlac and Tarhos. Of the twelve most common wild species at Százhalombatta, none are species that belong to the most nitrogen loving taxa and there are significant numbers of plants indicative of poor quality soils. However, the full weed list is not presented and many of the most frequent species tolerate a wide range of growing conditions.

In terms of crop processing, a very interesting pattern emerges. We would expect there to be a lower chaff to wheat grain ratio at the larger sites where there is more likely to have been indirect procurement or provisioning of central populations. In contrast, at smaller subsidiary or autonomous villages, there should be more chaff since they are self-producing. The archaeobotanical assemblages from the study sites show the opposite pattern (Table 13.14). The greatest frequencies of chaff are found at Százhalombatta and Pecica, with much lower quantities at Semlac[170] and especially Tarhos. This may reflect several phenomena. The low quantities at the latter two sites are in part reflecting that the majority of wheat grain was recovered from burned houses where cleaned grains were stored in vessels and spilled on floors. Chaff is more commonly found in pit and other refuse disposal areas, which form a lower percentage of the flots at these sites. This pattern may also be due to lower occupation density at these sites, where there would be more open areas away from houses where grains could be processed. However, the high levels of chaff at the central settlements also may be related to its use in other activities that would have been more intensive at these sites, for example in pot making, daub construction, or as Gyulai (2010) suggests, as fuel for metallurgy. The importance of its secondary usage is perhaps underscored by the possible chaff store found at Klárafalva (Jones, et al. in prep).

Table 13.14: Relative abundance crops, chaff, and weed seeds per site (NISP, MBA only)

	Pecica	Semlac	Tarhos	Szaz.*
crop seeds	66%	43%	93%	
wild seeds	34%	57%	7%	
wheat seeds	54%	72%		15%
wheat chaff	46%	28%	"very small"	85%

note: excludes all non ID seeds (cereals and wild)

*Százhalombatta chaff % based on einkorn counts only, approximate value

CONCLUSION

Animal economies vary considerably between study settlements. This is in part related to ecological differences, especially in terms of the quantity and range of wild resources consumed as well as the proportion of pigs versus ovicaprids, and to some extent, cattle. However, of greater interest are the differences that are related to larger economic and sociopolitical organization. These are equally striking and show different ways in which political economies, or lack thereof, can shape animal husbandry systems.

[170] Note that Table 13.16 is for the MBA Semlac occupation. If the entire settlement occupation is combined, then the percentage of wheat remains that are chaff drops to 4%.

One of the most distinctive features is the trend towards diversified, lower-risk production systems in smaller settlements, including both those that would be characterized as autonomous and those that may be part of simple regional hierarchies. Here greater focus is placed on smaller, less resource-intensive species such as pigs and ovicaprids. Management systems are also geared towards diversified production, rather than any specialized resource, especially secondary products. There is also greater use of low-ranked wild fauna and more complete use of the animal in terms of body part representation.

In contrast, at tells, especially central settlements, there is more emphasis placed on high-value animals and exchangeable products, including livestock themselves. At Százhalombatta, for example, the animal economy is centered on cattle and there is a shift towards wool production over time. At Pecica, we see a different pattern. Here horses are a central pillar of the economy during the height of its occupation. Horses were consumed in great numbers, especially in feasting contexts, and were important for elite display, transportation, and warfare, including chariotry. At the same time, husbandry practices for smaller livestock shift towards meat production with some evidence for elite provisioning, especially for sheep. This is also supported by differential access to high-quality meat by central tell inhabitants. The importance of cattle as draft animals should also be noted and is likely tied to extensive, large-scale farming and perhaps regional exchange of bulk goods.

Farming practices by Bronze Age groups in the Carpathian Basin share many features. While there is variability within and between settlements, there do not appear to be highly diversified farming practices related to risk mitigation in terms of field placement or staggered cropping. Land use is similar despite ecological setting, with fields being placed primarily on drier, grassy areas which are associated with the distribution of rich chernozem soils. The majority of crops also are planted in the spring, even in flood prone areas. More variation is seen in the range of crops utilized, even when sample size is taken into account. Most notable is the focus on emmer and, secondarily, spelt at Tarhos, which has been identified as a general pattern in eastern Basin groups. There is no functional explanation for this currently, and it appears that cultural preferences may have played a strong role. Other differences are responses to environmental parameters, especially with regards to barley and millet. Barley is more common at sites in wetter areas while millet is commonly used at smaller sites in drier areas, albeit in low frequencies overall, as a risk buffering strategy. Farming practices are fairly intensive at all sites, but more nitrophilous species are found at Pecica, which may be related to manuring as an intensification strategy. Central sites also have high percentages of chaff, which may reflect its secondary usage. There are no indications that elite populations were receiving cleaned grains indirectly. However, at Százhalombatta there are more specialty crops (oil, fiber), which may in fact represent an elite directed diversification strategy. Overall, the agricultural sector is not as strongly affected by centralization as are animal production systems.

CHAPTER 14: REGIONAL TRAJECTORIES—CRAFT PRODUCTION AND REGIONAL EXCHANGE

CRAFT PRODUCTION

Given the scope of the regional study, evaluation of craft manufacture focuses on those that can be best understood given the available archaeological record. This requires crafts with large samples of materials directly reflecting the organization of production, including raw materials, facilities, tools, debitage, and other by-products. Evaluation also targets crafts that span a range of classes, from those made primarily for domestic use to those being made for specialized use or elite consumption. This includes crafts that use locally available raw materials and those requiring imported goods. This allows variability in production organization stemming from these variables to be systematically assessed.

The following study is centered on bone working (Class 1/2 craft), chipped stone tool production (Class 3 craft), and metallurgy (Class 3/4 craft). The spatial organization, intensity, and diversity of production are evaluated using the same methods employed at Pecica to allow inter-site comparisons. Full data are not available for all of the settlements in the study sample. As a result, this study focuses primarily on Klárafalva, Kiszombor, and Tarhos, representing production systems within two autonomous villages and a small, possibly subsidiary, hamlet. These offer strong contrasts to Pecica in terms of sociopolitical organization. Basic evaluations of craft production are made for other sites where possible.

Bone Working

Klárafalva Hajdova

The worked bone assemblage at Klárafalva is diverse despite the relatively small sample size (n=24), although all of the types represented can be found at Pecica and most other settlements as well (Tables 14.1-14.2). The vast majority of the items are completed tools (91%) with only a single piece of antler debitage and one unfinished heavy-duty beam tool present. Most of the finished items are made from bone rather than antler (64%) and no worked shell or teeth were recovered. The most frequent class of tools is scrapers of various types, including rib scrapers and a number of beveled gouges made from long bones. Of interest is a scraper made on the margin of a dog atlas. Other tools include antler hammers and picks, a bone awl, a bird bone needle, and three antler harpoon heads. Harpoon heads are generally uncommon and their frequency is related to the strong emphasis on fishing at this site.

Because of the low number of unfinished pieces and debitage present, little can be said concerning the organization of bone working as a craft other than that the excavated area was not a primary locus of production, at least for antler items. However, from the finished items it is apparent there are not significant differences in manufacturing techniques or in the range of utilitarian items present compared to the other settlements in this study. On the other hand, there is no evidence of finely worked antler, bone, tooth, or shell pieces, which separates Klárafalva from Pecica and the other tell sites in this study.

Table 14.1: Worked bone assemblages by site

Type	Pecica	Klara.	Kisz.	Tarhos	Sarkad	Szaz.*
hammer/flat end antler**	5	2				13
adze/oblique end antler	1					2
hammer/adze antler	4	1				
antler pick	1	2			1	
planer	1					
scraper (flat end-rib)	8	6		6		33
scraper (flat end-other)	6	1			2	54
scraper (gouge)	5	5		1	2	
smoother (antler tine)	10					
smoother (flat, bone)	2			1		
awl/punch	9	1	2	2	12	37
needle/pin	3	1	1			
"skate"	1					3
harpoon/toggle	2	3				
double points						18
cheek piece	1					5
drilled teeth					10	+
drilled metapodia						11
worked shell	5					
debitage (antler)	26	1			1	n/a
debitage (horn)	2					+
unknown type	23	1	2		4	
Total	115	24	5	10	32	176

*not all types all listed in the table from which these data derive, including debitage

**some of these are socketed and may be part of composite tools

Kiszombor Új-Élet

Only five worked bone items were found at Kiszombor. Two of these are awls/punches made on long bones. There is also a large needle and two indeterminate worked bones. No worked antler, teeth, horn, or shell were recovered nor any pieces of debitage or unfinished items.

Tarhos-Gyepesi Átkelő

The worked bone from Tarhos resembles the assemblage from Kiszombor. All of the worked items (n=10) are finished tools and none were made on antler, teeth, or shell. Most of the tools are scrapers (predominantly large mammal rib scrapers). Long bone awls and a smoother are also present. These all were recovered from within and immediately adjacent to a single excavated house.

Sarkad Peckes

Worked bone and related materials are relatively common at Sarkad, approaching numbers seen at Pecica in terms of the percentage of worked items within the total faunal assemblage (0.6%, n=32). However, antler items are uncommon (7%) compared to bone and no worked shell or horn has been identified. Most of the worked bones are awls/punches. A variety of scrapers and an antler pick are also present. Only a single piece of antler debitage was recovered. Of interest is the very large numbers of worked teeth (31% of the worked materials), which have not been found at the other study settlements besides Százhalombatta and Pecica to date, although they are found at other sites in the Carpathian Basin, including within burial assemblages of the Maros culture. At Sarkad, these are all made from domestic pig teeth except for one from a wild boar. They are mostly the lower incisors but split and polished canines are also present. Their frequency suggests that tooth ornaments may have been a special craft at Sarkad, but given the lack of manufacturing tools or debris in available collections, this cannot yet be supported empirically.

Százhalombatta Földvár

The complete worked bone assemblage from Százhalombatta has not yet been systematically evaluated, but preliminary results from Poroszlai's excavations in the 1990s and more recent work by the international collaboration are available (Choyke 2000; Choyke, et al. 2004; Sofaer 2010), as well as basic descriptions of the non-systematically collected items from Kovács' excavations in the 1960s (Choyke 2000). The assemblage derives primarily from the MBA Vatya and Vatya-Koszider occupation (n=155), but some materials from the EBA Nagyrév phase are included as well (n=21) (Choyke, et al. 2004:Figure 8). Note that there are worked items that are not listed in this reference table that are described in the text, so the table data must be treated as approximated values. In addition, there are no quantitative data for debitage.

The assemblage contains all of the most common worked bone classes from the region, with particularly large numbers of scrapers and awls, suggesting that hide working was a particularly important craft. Detailed descriptions of raw materials used are not available, but cattle ribs and ovicaprid long bones appear to be frequent elements, as at other sites. Antler items are less common than at Pecica and Klárafalva, but it should be noted that these include five horse harness pieces and a range of composite tools. Aside from these more complex items, the less frequent use of antler is related to the low numbers of red deer at the site (Table 14.4). There are also two artifact classes that deserve special attention as these are not found at the other sites included in this study: double points and perforated small mammal long bones. The double points are often thought to be fish gorges but Choyke et al. (2004) suggest that these may have been used for personal decoration or an unknown special task. The perforated long bones are primarily made from hare metapodia, but a dog metapodial and a beaver humerus are also present. The same authors also argue that these unusual items may be used as identifying markers for the inhabitants at Százhalombatta (Choyke, et al. 2004:187). Perforated dog and pig teeth are also present, which have a wider distribution regionally.

Unfortunately, primary data for debitage are not presented so it is not possible to discuss the organization of bone working in any detail. However, local manufacture of osseous materials is attested by the presence of antler debitage, including boxes of antler rough-outs that have been recovered from house contexts, thought to be caches of raw materials for future production (Sofaer 2010:199). This may be analogous to the cut antler beam group found in a pit associated with Structure 2 at Pecica. Choyke (2000) also mentions two cattle horn cores that show cut marks indicative of sheath removal, providing the only other evidence for horn working at the study sites apart from Pecica. There is no mention of worked shell in these publications.

Discussion

Spatial Organization

Little can be said concerning the spatial organization of production at most settlements, unfortunately, due to limited sample sizes of debitage and lack of precise locational data in publications. However, it must be pointed out that at Pecica and Százhalombatta antler debitage (and possibly horn at Pecica as well) tends to be concentrated in particular loci that may represent specific crafting areas. As detailed in Chapter 11, much of the antler working debris is found in clusters associated with specific households or external working areas, but is not limited to these locales. At Százhalombatta, the presence of stored antler rough-outs within particular houses suggests that some households were producing more or specific types worked antler items. While it does appear that not all households were equally engaged in crafting bone, which suggests some level of specialized production, the working areas are in fact within households (and generalized habitation debris) rather than in any formal workshops.

Abundance

Abundance measures show that bone working was more intensive at central tell settlements that at other sites. Worked items comprise a much larger proportion of the faunal assemblages at these principal settlements (Table 14.2).[171] This not only reflects more intensive manufacture of the bone items themselves, but potentially also for the other crafts for which these tools are used (e.g., hide working, weaving, carpentry, etc.). There is a significant contrast in the presence of manufacturing debris, with more debitage being found at the tells, including the autonomous tell village Klárafalva, and especially at Pecica (see also Chapter 11). However, the range of raw materials used must be taken into account as antler working produces more visible and abundant debitage than does bone working proper.

There is a strong relationship[172] between frequency of debitage and finished antler items within the assemblages and clearly sites with no finished antler items (i.e., Kiszombor and Tarhos) lack antler debitage. There is a lower than expected amount of antler debitage at Klárafalva given the number of finished items, especially when compared against values seen at

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[171] Only a small percentage of the collected fauna (n>150,000) from Százhalombatta has been analyzed to date and the complete worked bone inventory is not available. It does appear that worked items represent a greater range of contexts than does the refuse fauna. Again, there are no data for debitage.

[172] $\rho = 0.973$, $p=0.005$

Pecica.[173] This again underscores the importance of antler working at Pecica, including for fine ornaments and composite tools.

Table 14.2: Summary worked bone composition by site

	Pecica	Klara.	Kisz.	Tarhos	Sarkad	Szaz.*
NISP worked items	115	24	5	10	32	176
% total fauna worked	0.6%	0.1%	0.2%	0.1%	0.7%	
debitage vs. finished items						
finished tools	56.3%	91.3%	100.0%	100.0%	96.3%	
debitage	43.8%	8.7%	0.0%	0.0%	3.7%	
raw material, all worked specimens						
bone	40.2%	60.9%	100.0%	100.0%	92.9%	
antler	54.3%	39.1%	0.0%	0.0%	7.1%	
shell	5.4%	0.0%	0.0%	0.0%	0.0%	
raw material, finished items only						
bone	54.7%	63.6%	100.0%	100.0%	96.3%	88.6%
antler	37.5%	36.4%	0.0%	0.0%	3.7%	11.4%
shell	7.8%	0.0%	0.0%	0.0%	0.0%	0.0%
finished worked types, identifiable only						
heavy-duty antler tools	17.2%	22.7%	0.0%	0.0%	3.7%	8.5%
scrapers	29.7%	54.5%	0.0%	70.0%	14.8%	49.4%
smoothers	18.8%	0.0%	0.0%	10.0%	0.0%	0.0%
awl/punch	14.1%	4.5%	66.7%	20.0%	44.4%	21.0%
ornaments	14.1%	0.0%	0.0%	0.0%	37.0%	6.3%
other	6.3%	18.2%	33.3%	0.0%	0.0%	1.7%

*no data for debitage, some artifact classes not listed

Lastly, the overall density of worked osseous materials also varies considerably between sites (Table 14.3). Worked materials as a whole (finished items and debitage) occur at similar densities as calculated by the number of items per unit volume. The exception is at Kiszombor, where they are far less abundant. However, overall occupation intensity must be taken into account as there are significant differences in habitation and refuse density between settlements. Using density of faunal remains as a general measure of occupation intensity, finished work bone is under-represented at Klárafalva and Tarhos compared to the presence of general debris. Debitage, again, is over-represented at Pecica.

[173] χ= 5.1357, df=1, p=0.02

Table 14.3: Density (#/1000L) and diversity of worked bone by site

	Pecica	Klarafalva	Kiszombor	Tarhos	Sarkad	Szaz.*
density finished items	0.43	0.47	0.06	0.53		
density debitage	0.35	0.04				
density faunal refuse	176.9	579.3	27.2	553.3		
density finished items/ density refuse	0.24	0.08	0.23	0.10		
density debitage/ density refuse	0.20	0.01				
# types of worked bone	15	9	2	4	5	11
# types/ # worked bone NISP	0.13	0.38	0.40	0.40	0.16	0.06
# types/ 1000L	0.31	0.32	0.02	0.29		

*incomplete data set, # types minimum value

Diversity

The range of items produced also sheds light on the organization of production (Tables 14.2, 14.3). There is a logarithmic relationship between the number of worked bone types and the overall sample size. While there is a greater diversity of items in larger assemblages, these additional types occur infrequently. The most common types (scrapers and awls) are found at most sites. By unit volume, there is little difference in diversity, with the exception of Kiszombor, where occupation density is much lower than the other settlements.

Nonetheless, when looking more closely at the specific types of artifacts represented, there are significant contrasts. First is the number of antler items in the assemblages (Table 14.4). As described above, worked antler is far more common at Pecica than other sites, followed closely by Klárafalva. However, antler was probably not equally available to all settlements as the frequency of red deer in the local habitat and the importance of hunting within subsistence economies must be considered.[174] There is a strong positive relationship between the number of worked antler items and the proportion of red deer bones in the general faunal assemblage. This suggests that antler was a preferred raw material and was used when it was available, but it should be kept in mind that different tool types were made from bone and antler as well. Again, the amount of worked antler at Pecica is particularly high given the overall frequency of red deer in household refuse.

[174] Of course, shed antler can be collected without hunting of red deer themselves.

Table 14.4: Frequency antler working compared against red deer bones in faunal assemblage

	Pecica	Klara.	Kisz.	Tarhos	Sarkad	Szaz.
% unworked red deer in mammalian assemblage	10.6%	7.1%	3.2%	1.2%	6.5%	0.8%
% worked antler as raw material type	54.3%	39.1%	0.0%	0.0%	7.1%	n/a
% finished antler items	37.5%	36.4%	0.0%	0.0%	3.7%	11.4%
% worked antler of total red deer	8.2%	5.5%	0.0%	0.0%	1.9%	n/a
correlation % antler items: % total red deer r=	0.75031					

Second, worked teeth, horn, and shell are only found at major tell settlements (Pecica, Sarkad, and Százhalombatta), although differences in area excavated and overall sample sizes must be considered as well. Worked teeth are particularly common at Sarkad while and horn working debitage have only been described to date at Pecica and Százhalombatta. Worked shell may be limited to Pecica.[175] The uneven presence of marine shells may reflect differential access to these long distance trade goods (see below). It should again be underscored that it is not yet clear whether or not the marine shells were being worked locally or imported as finished items.

Crosscutting raw material types is the difference in the number and range of finely worked items between sites. These include composite tools and various ornamental items such as jewelry (pierced and polished bone, teeth, and shell), horse gear, and figurines/models. These types of artifacts also have only been found at Pecica, Sarkad, and Százhalombatta, again highlighting the differences between these central tells and smaller hamlets and/or autonomous villages.

Summary

Bone working as a craft differs substantially between the study settlements, which can be seen in the intensity, diversity, and spatial organization of production. The greatest contrasts are found between large tells and the autonomous villages or hamlets. The overall intensity of bone working is greater at central tells, particularly at Pecica, in terms of abundance and density of manufacturing debris and finished objects. There are also considerable differences in the range of items produced between settlements, both for raw materials and the types of items manufactured. The greater range of items at tells includes more finely worked and complex

[175] It is possible that shell was not stored or evaluated with the general fauna assemblages and therefore not listed in the same publications (e.g., Százhalombatta) or given to the author for analysis (Sarkad).

artifacts (Class 2 crafts), especially those made from antler, horn, teeth, and shell. This pattern has also been noted in other regions of the Carpathian Basin by Choyke and Bartosiewicz (2009).

Differential crafting of these item classes, I would argue, reflects differences in the sociopolitical standing of these central settlements. This stems from several factors which together shape the organization of production. First, primary tells, especially those within regional hierarchies, would have housed a larger and more socially distinct elite who would have had the incentive and economic means to preferentially procure prestige items for display. As a result, there would have been increased demand for finely worked pieces, fostering increased production and a wider range of artifact types.

Unequal access to raw materials also plays a role. This is particularly the case for those requiring imported materials, such as marine shell. Worked shells are found at central tells, which I would correlate with their being loci of elite sponsored long distance exchange networks. Antler also may not have been equally available, but this is tied, at least in part, to local ecological conditions and red deer population. It is not a material that could have been centrally controlled to a strong degree. But its preferential use for finely crafted items appears to have increased procurement rates at certain tells, especially at Pecica.[176] Other raw materials would have been equally available and the differential crafting of horn and teeth at tells likely reflects demands for social display (and perhaps social prohibitions). Utilitarian bone items show little difference between settlements and their crafting remained within general domestic production. In short, other than marine shell, access to osseous raw materials could not have been easily restricted by a central authority and was unlikely to have been an elite controlled craft.

Similarly, there is little means for centralized control over bone working on the production side. It is not a craft that requires specialized facilities or a skill set that could be monopolized by elites. While there are certainly differences between the level of artistic and mechanical ability between individuals, the basic techniques are not beyond most producers.

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[176] As Choyke and Bartosiewcz (2009) point out, antler debitage typically comprises less than 5% of modified osseous materials at Bronze Age sites in the Carpathian Basin. This pattern is seen at Klárafalva, Sarkad, Százhalombatta[?], and Tarhos. Pecica stands out in its very high percentage of debitage and finished items. Here, worked antler of all types makes up 54% of the assemblage with debitage comprising 24%. A similar figure has only been found at Jászdózsa–Kápolnahalom, where antler working debris comprises 21-25% of the worked bone by period and overall worked antler at 63-67%, providing an interesting comparison to Pecica. Here, Choyke and Bartosiewicz argue that red deer hunting and items made from them, including worked antler and hides, may have been specialized activities, perhaps for export. Red deer also make up a very large proportion of the overall faunal assemblage (16-39%), which is in part related to the site's forested location. Red deer bones are common in the food refuse at Pecica as well, comprising 11% of the identified mammalian fauna.

Sofaer (2010:199-200) argues that antler working, especially fine decoration, requires specialized metal tools that may not have been available to everyone, supporting the idea of specialist production of these items. However, I suggest that the metal tools in question are likely fairly simple bronze knives, awls, and related tools that may not be as restricted in distribution as once thought (see also below).

While I do not support the idea of fine working of osseous materials as being a craft directly controlled or monopolized by elites through the restriction of raw materials (except possibly marine shell), tools, or knowledge, I do argue that increased elite demand for such items creates a semi-specialized niche that a skilled carver may fill. The differential distribution of raw antler and working debris, at least Százhalombatta and Pecica, does point to working loci within particular households.[177] However, this is likely to have been only part time given the evidence for a variety of crafts being undertaken in any given area, including those with antler concentrations. It is possible that there were semi-attached or sponsored artisans at central settlements. Sofaer et al. (2013:485) also have suggested the presence of part-time specialists at this time. On the other hand, Class 1 worked bone, those utilized primarily for domestic activities, remain solidly within the domestic sphere.

Choyke (2005) notes that compared to earlier periods, in the Bronze Age there is a stronger distinction between the two ends of the bone manufacturing continuum, between simple domestic items (Class 1) and finely carved ornamental objects (Class 2). I argue that this new division reflects both increased elite demands for display objects as well as increasingly specialized production of Class 2 items. This is part of a larger trend towards specialized crafting in this period as well as more formalized social distinctions.

[177] Again, at Jászdózsa–Kápolnahalom, Choyke and Bartosiewicz (2009) note that most of the antler debitage at Jászdózsa was found in the central tell area and antler working may have been a specialized craft by this part of the settlement's population. At Pecica, antler working debris has been found in both on- and off-tell areas and it does not appear to have been a restricted craft in general. However, the concentration of debitage and "blanks" with particular households at Pecica (and at Százhalombatta) does suggest that while antler working was practiced as part of the domestic economy (Class 1 craft), some level of specialized production may have been present, especially for elaborate ornamental items (Class 2 craft).

Stone Tool Production

Klárafalva Hajdova

The chipped stone assemblage from excavations at Klárafalva has undergone preliminary sourcing and typological study by K. Biró (forthcoming) (Table 14.5). Five additional pieces were documented from a private collection, which are not included in the density calculations. UMMA excavations produced 20 lithics, 55% of which are finished tools. The tools, as at Pecica, are dominated by denticulates (54%), although there are a wider variety of tool types present than at other sites. These include a blade, borer, burin, side scraper, and two end scrapers. The remainder are unmodified flakes. No cores or preforms were recovered from excavations, which is unusual (Biró forthcoming), although there is a large prismatic blade core from the private collection. The ratio of debitage to finished items is 0.92:1, which is similar to Pecica (1.05:1). Because a number of the raw materials have not been precisely sourced (see also below), it is not clear to what extent local versus imported stone was being treated differently. It is apparent, however, that a wide range of raw materials were being utilized, with some preference for Carpathian radiolarite varieties. There does not appear to be a strong distinction in the degree of curation and rejuvenation of tools by type or raw material as there is a similar range and frequency of materials present in the debitage and tool assemblages.

Kiszombor Új-Élet

There is a small chipped stone assemblage from Kiszombor (n=7), which has also be evaluated by K. Biró. There are three flakes, one core, and three tools, all of which are denticulates. The ratio of debitage to finished tools is 1.33:1. As at Klárafalva, despite the small sample there is a considerable range of raw materials present. The majority are Carpathian radiolarites.

Tarhos-Gyepesi Átkelő

18 chipped stone items and raw materials were collected from excavations at Tarhos and an additional flake was identified from survey. These have been analyzed by T. Márton and published in Duffy (2010). Six of these are unmodified quartz and quartzite pebbles.[178] There

[178] Note that unmodified quartz and quartzite pebbles were not included in the chipped stone assemblages for Maros settlements as these materials were not used for chipped stone tools at these sites (they were, however, used as

are four modified flakes one core, and the rest are unmodified flakes of unspecified types. The ratio of debitage and cores to worked items is 2.25:1, higher than at the other sites considered here. This large ratio may be related to the frequent use of low quality raw materials (local quartzites), as suggested for Százhalombatta (Sofaer 2010). While most of the raw nodules and cores are quartzites, the majority of flakes and worked items are made on non-local materials of higher quality. A similar pattern of local versus non-local material use is found at Pecica.

Table 14.5: Summary table lithic assemblages

Measure	Pecica*	Klárafalva	Kiszombor	Tarhos	Száz.
core/raw nodule	7	1	1	7	16
debitage (flakes and shatter)	11	11	3	9	125
preform-- sickle/denticulate	1				40
sickle/denticulate	11	7	3		75
prismatic blade	8	1			12
end scraper		2			
side scraper		1			
borer		1			7
burin		1			
point					1
modified flake				3	
indeterminate	3				
total # lithics	41	25	7	19	276
% finished items	41.5	52.0	42.9	21.1	34.4
% preforms	2.4	0.0	0.0	0.0	14.5
% debitage/cores	56.1	48.0	57.1	78.9	51.1
debitage: finished items	1.05	0.92	1.33	2.25	1.91
density finished items	0.41	0.45	0.04	0.29	
density debitage	0.43	0.37	0.05	1.02	
density finished items: density refuse (*100)	0.23	0.08	0.14	0.05	
density debitage: density refuse (*100)	0.24	0.06	0.18	0.18	
minimum raw material types	11	14	5	5	47
# raw material types/ # lithics	0.27	0.56	0.71	0.26	0.17
density raw material types	0.23	0.50	0.06	0.36	
density raw material types: density refuse (*100)	0.13	0.09	0.23	0.07	

*Phases 3-5 (Late Maros), on- and off-tell combined

burnishing stones in some cases and are included in the groundstone assemblages when there is clear evidence for use).

Százhalombatta Földvár

There is a sizable chipped stone inventory from Százhalombatta (n-=276), which has been published by Horváth (2005) and summarized by Sofaer (2010). It has also been considered in terms of craft specialization by Priskin (2013). This collection is considered here as a single assemblage as the 2005 data publication is divided by year of excavation rather than stratigraphic context or period. Items that are clearly Late Bronze Age are excluded. 35% of the assemblage are finished items, and like other settlements, are dominated by denticulates (also termed "saws"), which comprise nearly 80% of the tools. Blades, borers, and points are also present. Százhalombatta stands out in its large number of denticulate preforms, which make up 15% of the total 2005 lithic assemblage. The remainder are flakes and cores. The ratio of debitage, cores, and preforms to finished items is 1.93:1, which is higher than the Maros settlements and approaches figures seen at Tarhos. Horváth (2005) notes that the degree of local manufacture is quite high, as evidenced by the large number of preforms and debitage. However, the large proportion of waste flakes may also reflect the low quality of the nearby Buda chert, which comprises the greatest part of the assemblage (Sofaer 2010). While most finished items are made on raw materials in similar proportions to the cores and debitage, the blades are preferentially made on higher quality materials obtained from more distant sources. This is similar to the pattern seen at Pecica, where blades are exclusively made on obsidian while other tool classes are made on local jaspers and other non-obsidian materials.

Horváth (2005) argues that raw materials are imported to the site as "lumps" with decortification and core preparation being done at the settlement. This is also seen at Pecica, where there are large numbers of primary reduction flakes and raw nodules, at least for the local cobble jaspers. The denticulates show evidence of extensive reworking, suggesting a fairly high level of curation.

Sofaer (2010) suggests that the chipped stone industry is widespread and small-scale, with only moderate investment in their production. Items range from technically simple to more complex and utilize a range of raw materials from local, regional, and long-distance sources. However, the majority of items are low quality. She also argues that the more complex items may have been made by specialists and there is some suggestion that lower quality materials were used for domestic production and finer materials reserved for more talented knappers. It is unclear on what basis this assertion is made. In contrast, Priskin (2013) argues that while

Százhalombatta may have had greater access to long distance raw materials (see below), there is no evidence for specialized production.

Discussion

Spatial Organization

At settlements where spatial data are available, there is no indication of specialized workshop areas for chipped stone manufacture. Debitage and cores tend to be diffuse within occupation debris and there have been no caches of raw materials or flaking tools recovered. However, there is a higher density of debitage in the areas within and immediately around houses, at least at Pecica (see Chapter 11), but this is found within a range of other domestic refuse and activity areas. There is little indication that particular households were producing more or different types of chipped stone tools than others. Unfortunately, the spatial organization of production cannot yet be systematically accessed for Százhalombatta. The unusually high numbers of denticulate preforms at this site may suggest some level of specialized crafting, or at least production in excess of domestic needs.

Abundance

All settlements are producing lithics locally, but there are differences in the intensity of production as measured by the ratio of finished items to cores, preforms, and debitage as well as the overall density of production debris (Table 14.5). The relative frequency of working by-products and raw materials is higher at Százhalombatta and especially Tarhos than at the Maros settlements. The relatively low proportion of raw materials and cores was noted by Biró (forthcoming) for the two Lower Maros settlements. However, quality and availability of raw materials must be taken into account. For example, the larger proportion of debitage at the non-Maros settlements may be tied to the lower-quality of the local sources. In contrast, the cobble jaspers used predominately at Pecica (and the Lower Maros settlements) are fairly high-quality. On the other hand, at Százhalombatta this category includes a large number of sickle blade preforms. In this case, there does appear to be a greater intensity of chipped stone production at this settlement.

In terms of density of raw materials and waste products, there are some visible differences. The highest density is found at Tarhos,[179] which is twice that seen at Pecica and Klárafalva. Very low densities are found at Kiszombor. When compared against the density of general habitation refuse, the differences between settlements are not as pronounced. Similar densities are found at Tarhos and Kiszombor and slightly higher at Pecica. Low densities of working debris are found at Klárafalva.

In sum, there is not strong evidence supporting differences in chipped stone manufacture intensity between settlements that is tied to sociopolitical organization. An exception may be Százhalombatta, with a high level of sickle preform production.

Diversity

It is difficult to access diversity in the chipped stone industry as there is only a limited range of items being produced during the Bronze Age. The vast majority are denticulated sickle blades followed by prismatic blades. Other forms, such as scrapers, borers, and points, are infrequent. All of these are fairly simple utilitarian items that do not require highly specialized tools or facilities nor a skill level beyond what can be attained by most members of the community (with varying degrees of proficiency). Considering the relatively small sample size, there are a wider range of tool types at Klárafalva, particularly scraping and boring/engraving tools. While a number of factors may be at work, I would suggest that this may reflect the substitution of stone tools for metal equivalents. There is also a relatively high proportion of prismatic blades at Pecica compared to other settlements. As these are all made on obsidian, this may be related in part to Pecica having greater access to this imported raw material than the other study sites (see below).

Summary

Chipped stone manufacture, like bone working, shows much similarity across the region. All settlements also have evidence for local manufacture, with raw nodules, cores, preforms, and debitage comprising at least half of the lithic assemblages. There is also a similar range of finished items being produced. There is little difference in the intensity of production between

[179] Again, most of these are unmodified quartz and quartzite pebbles which may or may not have been intended for chipped stone manufacture.

settlements, especially when raw material quality and general occupation density is taken into account. There is also little indication of any specialized production as working debris and tools are widespread in habitation areas and highly co-mingled with other refuse. Chipped stone crafting does not seem to be highly structured or occurring disproportionately at particular sites. As suggested by Duffy (2010:299) for Tarhos, there is nothing that suggests chipped stone production is anything other than a household industry. Százhalombatta may be an exception with high levels of sickle preform production which may have been exchanged locally or even regionally. Additional spatial and density data are needed to evaluate this possibility more thoroughly.

It should be noted that the ubiquity of chipped stone manufacture indicates that this was not a centrally controlled craft. Access to raw materials may have been a bottleneck that could have been exploited by particular individuals or groups. However, there is no evidence for unequal access to raw materials between households within individual settlements, including long distance stone.[180] Even at Pecica, obsidian is being worked by both on- and off-tell populations. While it is possible that the long distance trade routes through which some of these stone sources obtained were disproportionally controlled by a few elites, there does not appear to be any access restriction within the community. It is also possible that stone, a relatively lower value commodity, may have been more freely exchanged at a regional level, especially when compared against metals, amber, marine shell, etc. Differences in access to lithic raw materials at an inter-settlement level are explored in more detail below.

Metallurgy

The organization of metal production is examined through the abundance and diversity of metal working tools, by-products, and to a lesser extent, finished items. Samples of slags from Klárafalva, Kiszombor, Tarhos, and Sarkad are considered in terms of their composition. This draws on work by Papalas (1992, 2008), who characterized slags using x-ray diffractometry, particle induced x-ray emission, and optical and electron microscopy, shedding light on smelting techniques and ore types. Unfortunately, slag densities cannot be estimated with the current

[180] Note that Sofaer (2010) suggests that at Százhalombatta chipped stone production may have been a two-tiered craft as we have seen in other crafting classes. She argues that high quality stone resources may have been reserved for specialized artisans.

data. Százhalombatta also cannot be evaluated in any detail, so this study is focused on the Maros and Körös valley settlements.

Klárafalva Hajdova

Klárafalva, like all of the study sites, shows evidence for local metallurgical production (Table 14.6). There are smelting tools present, albeit in low numbers. Excavations have produced a tuyère and a fish plate crucible. No molds have been found. There were a number of slags recovered, principally found in association with two thermal features that are likely furnaces. Twelve of these slags underwent compositional analysis by Papalas (1992, 2008) and details concerning slag typologies can be found in these works. These slags show that the copper was smelted from silica/shale and limestone hosted ores in similar proportions. It is possible that the latter slags may also reflect the use of shell fluxing. The sources for these ores have not yet been determined (see also below). There is a relatively high proportion of refractories (75%) within the sample, which indicates that either very pure ores were being used or that scrap metal was being recasted.

Finished items recovered from UMMA excavations include six bronze fragments of undetermined type. These are assumed to be small scrap pieces as no detailed descriptions are available. An additional four pieces are in a private collection, including a wire, knife/razor(?) fragment, an ornamental pin, and a halberd blade. Note that these include both utilitarian objects as well as finer metalwork. Currently, there is no evidence that any complex metal working was being done at Klárafalva. It is not clear to what degree finished items, especially the ornamental pieces and weaponry, were being crafted locally or imported. But clearly some level of metallurgy was being undertaken.

Kiszombor Új-Élet

Kiszombor has two metalworking tools present, similar to Klárafalva. A tuyère and a crucible were recovered, along with slag samples from two furnace complexes. Nine of these slags were analyzed in Papalas' studies.   There is an equal proportion of silica/shale and limestone hosted copper present, as at Klárafalva. However, the slags show greater typological diversity and only two refractories are present. Papalas suggests that Kiszombor may have had access to a greater range of ores, albeit of more variable quality. On the other hand, he also points out that given the differences in occupation periods between these two settlements, the differences may instead reflect changes in smelting technology over time, which at a regional level shows a trend towards more sophisticated methods. In terms of finished items, there is little copper/bronze at Kiszombor. Only a single piece has been identified, a chisel/awl fragment. No ornaments or weaponry has been recovered nor any molds.

Tarhos-Gyepesi Átkelő

Tarhos stands out in its very large slag assemblage which covered a substantial area of the site. Nearly 1000 pieces were recovered, but unfortunately none of these were from sub-surface deposits. Because the settlement is single component, it is assumed that these date to the Bronze Age, but debris from a later occupation cannot be conclusively excluded. No metal working tools or facilities were identified from the limited excavations at this settlement. The only finished metal item is a fish hook.

23 of the slags recovered from surface deposits were analyzed by Papalas. As at other settlements, these are highly diverse. There is a fayalitic slag present, which are the most "modern" slag types in terms of smelting processes. Again, as this site falls relatively late in our sequence, this may reflect the implementation of more refined techniques over time (Papalas 2008:151). However, most of the slags fall into categories indicative of less sophisticated techniques, especially the gehlenites.

Sarkad Peckes

Sarkad is only considered briefly here as excavations were not systematic and it is likely that a range of inconspicuous metallurgical items were not collected. Therefore, the density measures must be treated with caution. There have been no metalworking tools described to date nor is it apparent if any possible furnaces were encountered. However, Jankovits and Medgyesi (n.d.) did recover four finished metal items, including a needle and a bronze pendant. The other pieces are small fragments of indeterminate type. No molds were recovered and it is not known if prestige metals were being produced locally.

Surface collections from Sarkad include seven slags that were analyzed by Papalas. It must be stated that the Sarkad site cluster includes post-Bronze Age occupation and there may be some contamination. These slags are less diverse than at Tarhos and the most frequent class is the modern type fayalites. The most primitive slag class, the gehlenite group, is not represented. It is possible that this is reflecting more skilled metalworking at this large tell, but the limitations of this sample must be kept in mind.

Százhalombatta Földvár

Little can be said concerning the organization of metal production at Százhalombatta as primary data has not been published. There are bronze fragments, molds, slags present, although they do not occur in large numbers (Sofaer 2010). These have been recovered from a variety of contexts, so while workshops are thought to be present, metal working does not appear to be restricted to them (Poroszlai 2000; Sofaer 2006:139). The available information does suggest that metal working at Százhalombatta included the production of complex items and prestige goods, perhaps by some level of specialist at workshops, but other forms of metallurgy were more widespread.

Discussion

Spatial Organization

The very low density of metalworking remains at most sites precludes any detailed discussion about the spatial organization of production within settlements. Slags are often found in association with thermal features, which is expected. Thermal features themselves are often found in clusters, being rebuilt in the same area over considerable periods of time. In most cases, these working areas do not appear to be any sort of formal workshop, as seen at Lovasberény-Mihályvár (Kovács 1977:36) and perhaps at Százhalombatta. At the Maros settlements, these potential furnaces are not particularly elaborate and share many features with domestic ovens. It is possible that these thermal features were multi-purpose. Nonetheless, the data we do have indicate that many of the metallurgical tools, potential ores, and slags are found in a variety of contexts and that metal working was likely occurring widely, even at a small-scale, at settlements. Again, at Pecica, slags were recovered from diverse areas at the settlement, including off-tell.

At this point is it difficult to discern intra-site spatial differences between simple, smaller-scale metal working and the production of more elaborate items like ornaments and weaponry. However, at a regional scale, some differences are apparent. While tuyères and crucibles of various types are fairly common (but by no means ubiquitous), the distribution of molds is more restricted. In the study sample, these have only been recovered from Százhalombatta and Pecica. It should be restated here that the number of molds found at Pecica is particularly high. Thirty-four have been described from previous excavations (Gogâltan 1999:100-101) and two additional molds, one stone and one clay, have been recovered from recent UMMA excavations. It is not known how many have been found to date at Százhalombatta, but at the tells examined in Duffy's (2010) study of lower Körös region, only two produced molds, each only having a single specimen. It the latter case, these also tend to correspond with settlements having high numbers of finished bronzes as well.

Abundance

The relative abundance of finished metals and metal working tools supports the above argument that there were significant differences in the intensity of metal production between settlements (Table 14.6). The density of both artifact classes is higher at Pecica than at the other study sites, especially during the Classic Maros occupation. This holds both for general density (# items per cubic meter) and the adjusted measure taking overall deposition rates into account (density metal items/density faunal refuse*100). Pecica clearly stands out as a center for metal production. For Lower Maros settlements, when taking occupation density into account, Klárafalva does not differ greatly from Kiszombor. This supports low level metal production at both of these two autonomous villages. The position of Tarhos is unclear given the small area excavated, but it appears to fall along the lower end of the spectrum. Counter to this is the very large abundance of slags found in surface deposits. Finished metal items at Sarkad fall into an intermediate range, but given non-systematic recovery procedures, these figures are likely under-estimates.

Table 14.6: Summary table metallurgical assemblages

Measure	Pecica Late	Pecica Flor.*	Pecica Total	Klarafalva	Kiszombor	Tarhos	Sarkad†	Száz.
total finished metal (bronze), in situ only	9	24	31	6	1	1	4	n/a
prestige items (all contexts)	1	7	8	2**			1	n/a
molds/crucibles/tuyeres (tools)	7	17	26	2	2			X
slag	X	X	X	X	X	X***	X	X
possible furnaces	X	X	X	X	X		?	X
density finished items	0.11	0.45	0.24	0.22	0.01	0.07	0.03	n/a
density tools	0.09	0.36	0.20	0.07	0.02			n/a
density tools (no fish plates)	0.02	0.21	0.09	0.04	0.02			n/a
density finished items: density refuse*100	0.12	0.28	0.19	0.04	0.05	0.01	0.09	n/a
density tools: density refuse*100	0.10	0.22	0.16	0.01	0.09			n/a
density tools (no fish plates): density refuse*100	0.03	0.13	0.08	0.01	0.07			n/a

*on tell only
**from private collection, not systematic UMMA excavations, not inlcuded in density calculations
***from surface deposits only
†Sarkad not systematically excavated
note: densities per 1000L

Diversity

The diversity of finished metal items, tools, and debris also differs considerably between settlements. The range of finished prestige items is related in part to the total number of metal objects recovered. However, I do believe that the concentration of fine metalwork at tells is relevant. Even more so are differences in the range of metallurgical tools, particularly the number and diversity of molds, as discussed above. Again, these are concentrated at primary tell settlements. The slags are also interesting. While some of the differences reflect changes in smelting technologies over time, there is some suggestion that more sophisticated techniques were being used at tells. Analysis of slags from Pecica and Százhalombatta are needed to further evaluate this hypothesis.

Summary

Metal working as a craft is widespread during the Bronze Age. However, the abundance, diversity, and spatial distribution of metal items and production indicators indicate that there are important regional differences. There is strong evidence that production of more complex pieces was concentrated at certain settlements, especially large, principal tells. This suggests a two-tiered metal production system, as has been argued by others (Earle 2002; Papalas 2008; Wells 1996). In this case, access to ores and basic smelting technology was not restricted by central settlements. However, it appears that the skills needed to craft high quality items was a bottleneck that could be exploited by elites. It is not yet known the exact nature of this relationship, particularly the degree to which these specialized artisans were attached to elites or operating independently. Nonetheless, the strongly asymmetric distribution of both molds and finished fine metalwork does indicate some degree of centralized control over the production, distribution, and consumption of elaborate metal items.

Conclusions

The above study of bone working, chipped stone production, and metallurgy highlight several key conclusions concerning the organization of craft production during the Bronze Age. First, it is necessary to take a more nuanced approach to the study of craft specialization, separating components of production that require different skill levels and investment in labor, tools, facilities, and raw material procurement. In most cases, these correspond to the types of objects being produced, separating those for domestic, utilitarian use and those for display or specialized tasks, including warfare. These variables were used in this study to divide crafts into different classes (Classes 1 to 4) in order to better evaluate organization of production. I have shown these to differ between, and in some cases, within settlements. These differences are generally tied to sociopolitical organization, often in different ways.

Bone working is an interesting case study. There is no evidence for any differences in the production of Class 1 type items, those made from common raw materials and for domestic use. However, Class 2 items, those which are more complex and are typically display items requiring more labor and/or skill, do differ between settlements. Here we see concentration of both debitage and fine finished items at central tells. Osseous raw materials are not easily restricted,[181] so the supply side of production was not likely to have been directly controlled by elites. Nor is the skill set required for their production sufficiently complex to require a full time artisan or specialized knowledge. In short, this is not a craft that would be able to be monopolized by elites. However, I would suggest that differences in socioeconomic organization between settlements, related to political formations, create increased demands for such items at central settlements. This creates a niche that a skilled artisan could fill. The current data do not, however, support any form of full-time or attached bone working specialist.

[181] Although the availability of antler is to some degree related to the size of local red deer populations.

Chipped stone crafting is also an interesting case study. It is a Class 3 craft, which requires imported raw materials in the manufacture of fairly simple, utilitarian items. The potential bottleneck here is obtaining the requisite raw materials. As with Class 1 crafts, the data do not show strong differences in the production of chipped stone items, either within or among settlements. The only potential exception is the large number of sickle preforms at Százhalombatta. Differences in the proportion of debitage to finished items appear to be more sensitive to the quality of raw materials rather than the organization of production. However, as discussed further below, there are some differences in access to higher quality, long-distance raw materials that does affect the range of items being manufactured. But as many raw material types are interchangeable, it does not appear to affect the intensity of production in any substantial way. In short, there is little evidence for centralized control over lithic raw materials that would affect the organization of production at a household level.

Lastly, metal working is considered. It is a Class 3 and Class 4 craft, requiring imported raw materials but differing in the type of items being produced. The former are simpler, utilitarian items while the latter are more complex, often prestige goods, that demand a greater skill set as well as more specialized tools and facilities. As with bone working, there are clear differences between the different classes of production. Class 3 metal working is ubiquitous and it does not appear that metal production in general was centrally controlled. On the other hand, evidence for the manufacture of fine items, such as weaponry and ornaments, is strongly concentrated at central tell settlements. Metal production in general also is more intensive at these sites. As with lithics, it does not appear that elites had any tight control over raw materials.[182] Rather, they had differential access to the knowledge, or skilled artisans, to make these prestige goods. The degree of specialized production is not yet clear, however, and it is premature to assume that full-time, elite-attached metallurgists were present. Nonetheless, central tells do appear to have had the ability to restrict access to the means of production for high-quality metalwork.

In sum, it is difficult to make a case for high levels of craft specialization during the Bronze Age in this region. Most crafts were produced at the household level and few raw materials were tightly controlled by local elites or regional centers. The exceptions, as discussed below, tend to be rare, extra-regional materials with no utilitarian use. Importantly, copper does

[182] An exception may be gold, as discussed below. Unfortunately, tin exchange is not well known.

not appear to be one of these materials as metalworking was widespread. Differences between settlements at different ranks within regional hierarchies, and those lacking regional political centralization, are seen most strongly in the production (and consumption) of prestige goods. There is little evidence for elite control over the manufacture of prestige goods made from more common raw materials. However, the production of objects requiring high skill and specialized tools and facilities does appear to have had some level of centralized control, even if by purely economic means via patronage. During the Bronze Age, there is clearly an increase in the level of specialized production of valuable goods. However, there is no evidence of full-time, attached specialists that are typically associated with strongly centralized systems.

It is a common mistake in Bronze Age studies to confuse the presence of finely made items with specialist producers. It is also easy to dismiss the influence of centralized political economies on crafts by considering them monolithically. I use the above study as a case in point, demonstrating differences in organization of craft production using several independent variables. Most important is the need to consider direct evidence of production, including the tools, facilities, and raw materials used in their manufacture, as well as crafting by-products and debris. This requires detailed consideration of the spatial distribution, abundance, and diversity of these indicators. To date, few excavations in the region have either collected or published data with which these variables can evaluated systematically. It is hoped that the utility of this approach will encourage these data classes to be incorporated in future studies. Only then can the issue of Bronze Age craft specialization can considered fully.

REGIONAL EXCHANGE

Assessing differences in the intensity and organization of long distance exchange networks among settlements is a challenging task, one that requires sufficient samples and well sourced materials. Given the limitations of the study site assemblages, regional and extra-regional exchange is focused primarily on presence/absence of major import classes, drawing on sourcing data where available. As with craft production, Klárafalva, Kiszombor and Tarhos are used as principal cases to compare against Pecica. Százhalombatta and Sarkad are included where possible. Imported item classes considered here are chipped stone, metals, amber, and marine shell.

Chipped Stone

Chipped stone raw material types represented by settlement are listed in Table 14.7. Because the analyses were done by several different researchers, the level of detail and methods for description varies substantially, as does the degree to which specific varieties could be sourced. Physical characteristics for unsourced materials were provided for Pecica (author), Klárafalva and Kiszombor (Biró forthcoming), and Százhalombatta (Horváth 2005; Horváth, et al. 2000), allowing more detailed separation of variants. At Tarhos, unsourced types are only described as general material classes (Duffy 2010:Table 9.3). The number of materials represented per settlement is an estimate. For Tarhos, these may be under-estimated given lack of distinction between materials (if present) within the same general class. It is also likely that the some of the differences seen in the color, luster, texture, and inclusions within unsourced classes may fall within the range of variability for a particular deposit.[183]

Klárafalva Hajdova

While the lithic assemblage at Klárafalva is not particularly large (n=25), there is a considerable range of raw materials present, which was noted by Biró (forthcoming). There is not one clearly dominant type represented and given the long period that this assemblage represents, changes in lithic sources over time may be a factor. The most common classes are radiolarites (n=8) and limnoquartzites (n=7). There is some ambiguity in their specific assignments, however, as sources outside of Hungary other than the northern varieties of flint were not systematically assessed. For example, the "possible Ércelő-type limnoquartzite" is a river cobble variety that appears to resemble the yellow-brown variety of metalliferi jasper used at Pecica. Similarly, purple-red radiolarite may be the cobble jasper variant seen at Pecica as well. Biró suggests that all of the radiolarites, including the blue "silex" variety, are from eastern Carpathian sources and were collected from Maros river gravels. Given the distribution of lithic sources upriver (Crandell 2008, 2009), I would agree and suggest that these are in fact jaspers, with the exception of the blue "silex" variety. If her assessment of river cobble sources for these materials is correct, then at least 40% of the lithics are being collected locally.

[183] For example, at least 16 color variants have been described for Buda hornstone at Százhalombatta (Horváth 2005).

Table 14.7: Lithic raw materials for chipped stone

			Pecica		Klárafalva		Kiszombor		Tarhos		Százhalombatta	
Class	**Type**	**Source**	**# types**	**# pc**	**# types**	**# pc**	**# types**	**# pc**	**# types**	**# pc**	**# types**	**# pc**
Obsidian	C1a	Slanské Mountains, IWC, SK	1	5								
	Untested			5	1	2				4		
Limnoquartzite	Ercelo type?**	Maros River gravels			**1**	**2**						
	Hron Valley	IWC, Slovakia									1	3
	Other/Unspecified				4	5	3	3		4	7	10
Radiolarite	Carpathian, red-purple**	Maros River gravels			**1**	**4**	**1**	**1**				
	Carpathian, "blue silex"	Maros River gravels?			**1**	**4**	**1**	**3**				
	Szentgal	Bakony Mnts, Central Transdanubia, HU			1	2					1	2
	Other/Unspecified											
"Silex"/Flint	Csesztve gray transluscent	Cserhát Mountains, IWC, Northern HU			1	1						
	Volhynian/Prut flint	Outer Carpathian Depression, RO/UA/MO			1	1				1		
	Other/Unspecified				1	1					9	9
Jasper/Jaspilite	Metalliferi	Maros River gravels	**2**	**19**								
	Other/Unspecified										5	5
Hornstone	Buda "chert"	Buda Hills, Northern HU									**16**	**221**
Hydroquartzite	Other/Unspecified										3	5
Quartz/Quartzite	Rock crystal?	Alps, Austria?									1	1
	Other/Unspecified	Körös River gravels								**13**		
	Other/Unspecified										2	8
Silicified Wood		Bükk/Tokaj-Zemplín Mountains , IWC, Northern HU?								1	1	1
Lydite	Gray	Banat?									1	1
Unidentified*			8	12	2	3						5
Total			**11**	**41**	**14**	**25**	**5**	**7**	**5**	**23**	**47**	**271**

* non-obsidian
**"yellow brown Ercelo-type limnoquartzite?" and "purple-red Carpathian radiolartite" may be the yellow and purple Jasper varieties from Maros River
note: types seprated by color, texture, luster, and inclusion distinctions where specific source not identified
total number of types is estimated, for Szazhalobatta and Tarhos no detailed descriptions are given, number of types maybe underestimated
items in bold are available locally

Other types occur in low frequencies, generally with only a single specimen represented. These include Szentgál type radiolarite from the Bakóny Mountains of central Transdanubia, Csesztve silex from the Cserhát Mountains northeast of Budapest, and Volhynian/Prut with outcrops in northeastern Romania, Moldova, and the Ukraine. While no obsidian was recovered from systematic excavations, there are also two obsidian flakes from the private collection, as mentioned above. These have not been chemically sourced but likely derive from the obsidian rich region of northeast Hungary/southeast Slovakia.

Kiszombor Új-Élet

Like Klárafalva, the small assemblage at Kiszombor is quite diverse and overlaps greatly in terms of raw material types. All of the lithics are radiolarites and limnoquartzites, as determined by Biró. Again, most of these (57%) fall into classes that are from Carpathian sources, likely collected from local river gravels. There are also three limnoquartzite varieties that are unidentified. No items fall within classes that clearly derive from long distance sources, although it is possible that the undetermined variants are imports. No obsidian was recovered.

Tarhos-Gyepesi Átkelő

The Tarhos assemblage is similar in size to Klárafalva (n=23), but shows far less diversity. The majority of the items (57%) are low quality quartzes and quartzites from local river gravels. There are four unspecified hydro-/limnoquartzites, four obsidian pieces, and single representatives of Volhynian/Prut and possible silicified wood. Fossilized wood is found near the Hungarian and Slovakian obsidian sources as well as in the Bükk mountains north of Budapest and in the Trascău Mountains of Transylvania.

Százhalombatta Földvár

The chipped stone assemblage from Százhalombatta (Horváth 2005) differs greatly from the settlements of the eastern Pannonian Plain. The chipped stone is dominated by nearby Buda hornstone (82%), located 10-30 km north of the site (Sofaer 2010:197). At least 16 color variants are described and it is not known how many locales this variety spans. However, 84% of the Buda hornstone is of the typical gray translucent type. Other raw materials are used in low frequencies. These represent eight classes with 31 variants, the vast majority of which occur singly. These include a range of unspecified/unsourced forms of limnoquartzite, silex/chert, quartz/quartzite, hydroquartzite, jaspilite/jasper, and silicified wood (in descending order). All of these can be found in the northern mountain ranges in Hungary (Biró 2002). Sourced materials include silex from the Hron Valley, Slovakia, Széntgál radiolarite from central Transdanubia, and possibly lydite from the Banat (Romania) and rock crystal from the Austrian Alps. It is not clear if the dark varieties of chert/silex are from Poland or the Prut Valley. No obsidian was found in the EBA-MBA sample to date, at least through the 2005 publication.

Discussion

The range of lithic raw materials clearly differs between settlements. While many of the materials could not be precisely sourced, there is a strong positive relationship between sample size and the range of materials present.[184] At each settlement, locally available sources, even if of lower quality, are the most commonly used material class (40-82%), which is not unexpected. As discussed above, the high frequencies of local stone at Százhalombatta partially reflects the low quality of the raw material, producing more waste flakes during reduction. All settlements also have access to longer distance raw materials, albeit in different quantities and from different sources. Tarhos has a particularly low level of diversity present for its sample size, which may reflect the inability of this site's inhabitants to establish wide ranging exchange relationships.

Of particular interest is the frequency of obsidian, which can be considered a long-distance and very high-quality import for all settlements in this study, and a material that is well sourced. Pecica has a particularly large obsidian assemblage (24%), deriving from the C1a source in the Slanké Mountains of Slovakia (see Chapter 11). Obsidian is infrequent or absent at the Lower Maros sites. There are only two pieces from Klárafalva (8%), none of which were recovered from the systematic UMMA excavations. No obsidian was found at Kiszombor, although the total sample size is very small. This is interesting as, if river borne trade routes are assumed, obsidian likely travelled down the Tisza and up the Maros River to Pecica, moving past the Lower Maros settlements of Klárafalva and Kiszombor. It is also possible that these may have been imported to Pecica more directly via overland routes. In either case, Pecica appears to have had differential access to this very high-quality raw material.

Compared to the Maros region, obsidian is more common on average to the north among the Körös River valley groups (Duffy 2010: Table 9.3), although not reaching levels seen at Pecica. This at least in part reflects their closer proximity to obsidian sources. At Tarhos, obsidian comprises 17% of the lithics and averages 15% for the settlements in his regional study. Interestingly, there is no obsidian from Early-Middle Bronze Age contexts at Százhalombatta, despite the very large sample. This underscores differential orientation of exchange networks for chipped stone resources between groups in the eastern and western Carpathian Basin.

Because of the differences in distance to different raw material sources (of varying qualities), it is challenging to assess unequal access to imported stone among settlements at a macro-regional scale. There appears to have been cultural boundaries influencing the direction of trade networks, as seen between eastern and western groups. I would argue, however, that the very high levels of obsidian use at Pecica compared to other Maros (and Körös?) sites is

[184] $\rho=0.738$, $p=0.054$

indicative of Pecica's inhabitants' ability to maintain more sustained and intensive trade for this high quality resource from southeast Slovakia. It is possible that this obsidian travelled along the same exchange networks as for metals from this region. Recently, Priskin (2013) also suggested that compared to smaller settlements in the Benta Valley region, Százhalombatta had greater access to long distance raw materials.

This does strongly point towards the dominant tell settlements, such as Pecica and Százhalombatta, having differential access to high quality import materials, indicating asymmetries in regional exchange networks. Nonetheless, smaller settlements were also able to procure these materials, albeit at a smaller scale, so central settlements were not monopolizing high quality stone. Unfortunately, at this time it is not possible to characterize the nature of trade relationships to a great degree. Nonetheless, the greater number and variety of imported materials at central settlements does suggest that lithics exchange was not organized in a simple "down-the-line" system, at least in the Maros and Benta Valleys.

Metals

Metal sourcing in the Carpathian region is still in its infancy. To date, only a relatively small number of slag samples have been analyzed.[185] This includes samples from Klárafalva, Kiszombor, and Tarhos (Papalas 1992, 2008). For these three sites, copper from slags was not able to be sourced to a specific locale as there is much overlap in their chemical signatures and further work is need to assess to effects of the smelting process on composition. It should be noted, however, that copper sources from the Körös drainage tend to contain natural tin, those from the Maros have trace arsenic, and sources from the southern Banat are fairly pure. Analysis of finished metal objects and slags from Lower Maros sites tend to be fairly pure copper although there are several specimens that do contain tin or arsenic (Junghans, et al. 1968; Papalas 2008). Papalas (2008:216) suggests that these groups may have been obtaining their copper primarily from these more southern Romanian sources, which are also the closest and can be easily transported via the Maros River. It is also possible that some metals were imported from northern sources along the same routes as obsidian and other high-quality stone, or from the

[185] There have been a range of sourcing studies done on finished objects, but these must be treated with caution as these items have may been casted using raw materials from multiple sources and/or recycled metals, which limits their use in identifying specific ore sources. Further, many of the sources, especially those in the Eastern Carpathians, have not been systematically evaluated.

south along with marine shell. As discussed in the previous section, there does appear to be differences in the purity of ores used, or perhaps that some sites were using more recycled materials rather than primary smelting. This is the case for the tell settlement Klárafalva, compared to Kiszombor and Tarhos.

It is not known at this point how many of the finished items found at the study sites were imported. It is more likely that prestige metalwork would have been imported than simple utilitarian items, the latter of which characterize materials found at Kiszombor and Tarhos. While not recovered from systematic excavations, Klárafalva does have a range of more complex bronze items, including a pin and a halberd from the private collection. Pecica stands out in the number and range of finished metal pieces, which includes a variety of ornamental pieces and weaponry. Again, it is not yet possible to ascertain which of these were made locally. While metalworking tools, facilities, and/or debris have been found at all settlements, the only direct evidence for more complex metal working is from Pecica and Százhalombatta given the presence of fine groundstone molds, as discussed above.

While copper is ubiquitous at the study sites, access to tin and gold must also be considered as well. There have been no tin ores found at the study settlements to date, but clearly settlements must have had access to this metal to craft true bronzes.[186] Of course, the use of recycled metals would obviate the need for tin. Previous compositional analysis of finished metalwork from Lower Maros sites showed that most of these items were fairly pure copper, but some did contain tin or arsenic as well (Junghans, et al. 1968:Table 1). As discussed in Chapter 4, the source(s) of tin used in the Carpathian Basin is a matter of much debate and there have been no securely identified sources from archaeological materials at this time. The sources most often suggested are those from the Erzgebirge and Fichtelberge Mountains in Germany and the Czech Republic. However, the use of alternative sources should not be discounted, including deposits in the Dinarides, within the greater Carpathian region itself.

Gold is also problematic. It is difficult to identify local smelting as it does not produce diagnostic slags as does copper. Few finished items from the Early and Middle Bronze Age have been the subject of compositional analysis in the region so it is not yet possible to establish

[186] There is one stone sample from Klárafalva (KF 764.3) that is a granitic pegmatite, a known host rock for tin. However, this sample did not contain any tin content, but it cannot be excluded that the tin had already been removed (Papalas 2008:252).

regional patterns of gold source use in any detail.[187] There is also debate about whether primary sources were being mined at this time or if only alluvial placer deposits were exploited (Ciugudean 2012). It must be restated here that while the most productive sources lie in the Metalliferous Mountains of the Apusenis (Western Romanian Carpathians) and the Slovakian Ore Mountains (Inner Western Carpathians), there are numerous deposits throughout the Carpathians that may have been exploited prehistorically (see Chapter 4).

That being said, of the study settlements in question, gold items have only been recovered from Pecica.[188] A single gold hair ring fragment was found in Classic Maros deposits on the main tell. Given their rarity, it cannot be excluded that their absence at other sites is a result of smaller excavations and sample sizes. This is also not to say that other regions did not have access to gold at all. For example, gold ornaments were found at several Lower Maros cemeteries, including Mokrin, Szöreg, Pitvaros, and Óbéba. These occur in relatively low frequencies (<3%) with the exception of gold hair coils, which were found at 20% of the burials at Óbéba (O'Shea 1996:Table 5.5). As there have been no Middle Maros cemeteries found to date, it is not possible to compare burial deposition rates between these two regions.

In the Lower Körös region, gold is found only three of the ten tells in Duffy's (2010) study, and again, none from Tarhos. He found the highest gold index at Vărşand, which also has the highest bronze index by far. Clearly, gold (and bronze) is not equally distributed between settlements in this region. However, Duffy (2010:213) suggests that these differences are not great enough to argue that these metal rich sites were supplying metals to other settlements. Rather, he proposes that since metal is found in greater densities in the southeastern part of his study area, closer to the Transylvanian ore sources, this may reflect some level of down-the-line exchange. Further work is needed to clarify these patterns.

Minimally, the distribution of finished metal items of both copper/bronze and gold indicates that there are asymmetries in access to metals. These may reflect down the line exchange networks to some degree. Within local regions with possible site hierarchies, I would suggest that central tells had greater access to metals, in terms of both quantity and range of materials, as seen with stone. Importantly, despite these differences, all settlements in question had access to metal. Central tells were not monopolizing metal exchange, although it does

[187] A notable case study showed that gold from a hair ring in the EBA Tauteu horde (Bihor County, Romania) was from Transylvanian alluvial placer deposits (Constantinescu, et al. 2010).
[188] It is not known if gold has been recovered from Százhalombatta.

appear that they had more intensive trade relationships with ore producing regions. It is not yet clear whether metals were being funneled exclusively through these central tells then exchanged within local groups or if smaller settlements were able to procure metals independently. It is possible that both systems were operating simultaneously. I have argued above that fine metalwork may have been a fairly specialized craft largely restricted to central tells. The circulation of these prestige items, rather than ores, may have been more tightly controlled.

Amber

Amber is an interesting case. It is a quintessential Bronze Age trade good, one that was exchanged across the European continent. And while most is assumed to originate from the Baltic region at this time, further work is needed to exclude the exploitation of other sources, including those from Romania (see Chapter 4). Excluding Százhalombatta, for which there is no data, amber has only been found at Pecica. Here a single bead was found in Late Maros deposits. Two more possible amber beads were found during the 2013 excavation campaign in Classic Maros deposits, as well as a substantial lump of raw amber. This indicates that local amber working was taking place. It should also be noted that not only was amber not found at the Lower Maros settlements, it does not appear to have been used extensively in mortuary ritual at this time (O'Shea 1996). Amber is also not common in the Körös valley, but has been recovered from Foeni and Battonya (Bader 1978:112; Szabó 1999:20).

The very low frequency of amber in assemblages from the eastern/southeastern Pannonian Plain makes regional comparison difficult. Nonetheless, access to amber does not appear to be equally available to all settlements. In the Maros River Valley, I would argue that the presence of amber at Pecica is significant, representing differential access to this prestige good.

Marine Shell

Marine shell, like amber and gold, is also unevenly distributed, but again, small samples from settlements must be taken into account as these are low frequency finds. For the study settlements, excluding Százhalombatta, again for which there are no data, marine shell has only been found at Pecica. This includes five *Columbella* beads and a fragment of a polished *Cardium* shell.[189] Both of these genera are found in the Black Sea and the Mediterranean.

As with gold, this does not mean that other groups were unable to procure marine shell, since these were important elements in composite ornaments in Lower Maros burials (O'Shea 1996). It can be argued, however, that the greater rate of deposition at Pecica is a reflection of their greater abundance at this settlement. Middle Maros burial data would help to clarify this pattern.

Discussion

The organization of long distance exchange networks traditionally has been a primary focus of Bronze Age studies. However, in the Carpathian Basin, such work is strongly affected by small samples, non-systematic data collection, dearth of sourcing studies (especially beyond national borders), and lack of comparative materials in many regions. That being said, the data that are available begin to shed light on the organization of trade networks.

Among the study sites, there is preliminary evidence for unequal participation in long-distance trade networks between central tells and smaller and/or autonomous settlements (Table 14.8). For chipped stone raw materials, Pecica and Százhalombatta have access to a greater range and quantity of high-quality stone within their respective regions. While these sites appear to have more intensive (and extensive) exchange relationships, other settlements were also able to procure these materials, albeit to a lesser degree. It should also be noted that the strong differences in orientation of trade networks between regions, especially between those in the eastern and western parts of the Pannonian Plain.

Table 14.8: Presence/absence imported items

Import Good	Pecica	Klara.	Kisz.	Tarhos	Szaz.
chipped stone	X	X	X	X	X
copper	X	X	X	X	X
gold	X				n/a
amber	X				n/a
marine shell	X				n/a

[189] Note that one *Columbella* bead and the *Cardium* shell were recovered from 2013 excavations.

Copper also was not monopolized by central settlements, although the differential rates of metal production between sites does suggest that large tells also had greater access to these ores. Excluding Százhalombatta, for which there are no data, gold, amber, and marine shell have only been found at Pecica. This may indicate unique trade relationships; however, several factors must be taken into account, not the least of which is differences in volume excavated/artifact sample sizes. It should also be pointed out that marine shell and gold are found in burial goods at Lower Maros cemeteries. Consequently, these artifact classes are unlikely to have been exclusively obtained by Pecica, but an argument can be made for greater availability to them at this site. Amber, however, may have been uniquely procured at Pecica compared to Lower Maros villages.

Overall, there is limited evidence for any imported items being exclusively obtained (and retained) by inhabitants at central tell settlements. It appears to be more reflective of differences in the intensity of participation in regional exchange networks, with central sites having preferential access to rare and/or high valuable import goods. Despite these asymmetries, it is not yet possible to ascertain whether importation of these goods was centrally controlled by these regional centers, then exchanged locally to smaller and/or subsidiary settlements, or if these smaller settlements were able to directly procure them on a smaller scale. Regardless, these differences do underscore unequal economic power between settlements at this time.

CONCLUSIONS

The organization of both craft production and long-distance exchange networks are principal aspects of the economy that are expected to differ between settlements having contrasting degrees of economic centralization. Where centralization is more pronounced, we would expect to see more intensive, specialized, and elite-attached craft production, especially for high-value goods for which the means of production can be controlled. Similarly, the importation of high-value goods, both raw materials and finished items, would be differentially procured by central settlements.

Among the groups analyzed in this study, such regional differences are apparent (Table 14.9). The intensity and diversity of high-value craft production are greater at large, central settlements compared to smaller hamlets and autonomous villages. For some crafts, especially those for which raw materials are not easily restricted by a central authority, their differential production may be more related to elite demands rather than direct control. Some level of specialization, even if part-time and independent, is likely present. However, for crafts for which there are additional requirements of specialized knowledge, facilities, and tools, as well as imported raw materials, there is greater opportunity for elite monopolization. This can be seen especially in the production of complex and prestige metalwork, which to date, is restricted to apical tells.

Access to high-value import goods in general also follows this pattern, with central settlements having preferential or perhaps exclusive access to these items. This is seen most notably with gold, amber, and marine shell, but also within high quality chipped stone at central sites within their respective regions. Copper and lower-quality stone do not appear to have strongly regulated.

Table 14.9: Degree of inter-site differences in craft production and import good procurement

Craft Production	Regional Differences
Class 1 bone working (utilitarian)	low
Class 2 bone working (fine)	high
Class 3 chipped stone production	low
Class 3 metallurgy (utilitarian/simple)	moderate
Class 4 metallurgy (fine/complex)	high
Imported Goods	
chipped stone	moderate
copper	low-moderate
gold	high
amber	high
marine shell	high

While it is not yet possible to draw specific exchange relationships among individual settlements, the asymmetries present in the acquisition and production of high-value goods reflect economic differentials that likely mirror political relationships as well. A complete monopoly over these items is not necessary to create unequal power relationships. The ability for elites at central settlements to secure disproportional access to these high value and symbolically charged goods, and their subsequent distribution (or retention), would have been an important means to exert influence over other members of their communities as well as neighboring settlements. The bestowal or restriction of these items allows the creation of social and economic debts and obligations that can be manipulated by leaders and transformed into political power. This, along with changes in agro-pastoral systems, was critical to the creation of political economies and regional, hierarchical political systems that emerged among some groups during the Bronze Age, including those of the Middle Maros region.

CHAPTER 15: CONCLUSIONS

THE RISE AND FALL OF PECICA ŞANŢUL MARE

Pecica Şanţul Mare has proven to be an ideal case study for the development of political economies within Bronze Age societies of the Carpathian Basin. Data from recent systematic excavations allow changes in economic organization over time to be detailed to a degree seldom possible. Here we see the influence of centralization affecting separate sectors of the economy to different degrees. In addition, while at a larger time scale, most economic alterations occur within the same period, suggesting widespread, inter-related organizational changes, at a finer scale, there are key differences in the timing and intensity of this restructuring that have important ramifications for the specific pathways of economic centralization. Together, these can be used to create a more nuanced understanding of critical organizational changes that allowed this settlement to act as a central site in the Middle Maros region.

Exchange economies and local craft production are strongly linked, at least for crafts that require imported raw materials and those that can be considered prestige items. The frequency and range of import goods of all types, except ground stone, differ considerably between Florescent and Late Periods, with a substantial decline in access to high-value foreign items over time. During the height of Pecica's occupation in the Florescent Period, regional and extra-regional linkages are more intensive, bringing in a greater number and types of imported raw materials. This can be seen in the frequency of high-quality lithics, especially obsidian, as well as ore stone, marine shell, and amber. Changes in the import economy are paralleled by changes in the organization of some crafts. Metallurgical production is greatly increased at this time, with output peaking during Phase 3, the latter part of the Florescent Period. The frequency of other prestige goods also is greater, including ornaments made from horn, antler, and teeth, as well as ornamental ground stone. Importantly, other crafts, particularly utilitarian items and those made from local raw materials, do not show any significant changes over time, with most domestic items continuing to be made within individual households at a similar intensity.

These patterns meet expectations for increased economic centralization during the Florescent Period, with the elaboration of foreign trade networks and intensified production of high-value goods, especially metalwork, but also other prestige items. The degree to which the production and distribution of prestige items within the settlement was directly controlled by elites is still somewhat hazy, as greater areal exposures are required to compare spatial distribution more detail. It can be said, however, that elites did not have a complete monopoly on these goods. For example, the production of most crafts, including metalworking, is widespread and found among peripheral site inhabitants as well. Nonetheless, while samples are not large, there is preliminary evidence that there are quantitative and qualitative differences in access to high-value goods (and their production) between the site's populations that likely represented central elites versus peripheral commoners. What is lacking is any clear indication of specialized, elite-attached workshops. However, the spatial differentiation in craft production areas does suggest that not all households were equally engaged in producing certain crafts, especially high-value goods. But these items were manufactured along with a range of other domestic items, arguing against full-time craft specialization by individual households. Further work is needed to determine whether these artisans were independent or working under elite patronage. In any case, an increased demand for prestige items is evident during the Florescent Period, the production of which was facilitated by the expansion and intensification of long-distance trade networks.

Within the agro-pastoral sector, there are changes that mirror those within trade and crafting, but other aspects remain relatively stable. In all periods crop production was large-scale and fairly intensive, with extensive use of cattle-drawn plows and probably manuring. The basic agricultural system remains in place over time, but there is evidence for greater use of hardy, secondary staple crops over time, suggesting more concern with risk buffering, perhaps related to increasing aridity. There is also evidence that more intensive production methods were in place during the Florescent Period as seen in the weed assemblage, with lower weed to crop seed densities overall but greater proportions of nitrophilous species. There is no indication of differential access to types of plant foods between central and peripheral inhabitants, but the on-tell population did maintain larger food stores. The even distribution of crop harvesting and processing tools demonstrates that all households were engaged in farming activities.

More striking patterns are found in the pastoral sector, some of which are central to economic changes defining the Florescent Period. Meat production is strongly intensified during the Florescent Period, shifting from more generalized husbandry systems to those either specializing in meat or strongly increasing meat output compared to secondary products This focus on meat output in part is related to indirect procurement systems, with some degree of elite provisioning evident, especially for mutton. There are also very strong differences in access to high-quality meat between central and peripheral populations, underscoring substantial social differentiation at this time. Most significant is the restructuring of animal husbandry systems to incorporate intensive horse breeding. Their dramatic increase on-tell is also tied to feasting and chariotry, being powerful elite symbols of wealth and status. I would also argue that Pecica acted as a center for horse breeding in the greater region, with export production being an important means for wealth generation and alliance building. Importantly, the development of specialized horse production predates the intensification of metal production within the Florescent Period. I suggest that large-scale horse breeding was used by elites at Pecica to create an economic advantage over their neighbors and to articulate more strongly with regional exchange networks, particularly those with metal. Over time, these economic asymmetries were strengthened as local metalworking became increasingly important for export production.

REGIONAL TRAJECTORIES

The economic changes occurring at Pecica can be better understood when situated within a regional context. We can see some parallel developments with other culture areas, which highlight important general trends within the Bronze Age. But there is also a unique suite of characteristics that help to structure regional variability at this time. Pecica stands out from the laterally-organized Lower Maros settlements in a number of critical ways. While Lower Maros settlements, including Klárafalva and Kiszombor, were engaged in regional exchange networks, they were not able to establish the same range of contacts or import items with the same frequency. Local production of prestige goods is less intense and there does not appear to be any major differentiation between settlements indicative of asymmetrical relationships. Lower Maros agro-pastoral economies are more concerned with risk buffering, having diversified production systems that are strongly tailored to local ecological conditions. There is no evidence of specialized production and higher-value plants and especially animals are far less common than at Pecica.

In the Körös region, there is greater differentiation between settlements, as can be seen between the small hamlet of Tarhos and the large Sarkad tell. As in the Lower Maros region, all settlements were able to obtain import goods to some degree, but there appear to be significant differences in the quantity and quality of these items, especially fine metalwork, between major tells and smaller villages. While local craft production cannot be assessed systematically, it will be noted here that within the two study sites, prestige worked bone items are limited to Sarkad, where tooth ornaments are particularly abundant. And while metalworking was not limited to tells, Duffy's (2010) regional study shows that molds are found predominantly (if not exclusively) at tell settlements, suggesting a qualitative difference in metal production between these sites. There are also striking contrasts in animal production systems that underscore regional differentiation. While Tarhos, like the Lower Maros settlements, practices small-scale, diversified husbandry systems that are geared to risk buffering, at Sarkad there is much greater emphasis placed on high-value livestock, especially young cattle. In addition, at Tarhos there is much greater use of low-ranked wild resources, as seen at Klárafalva and the off-tell occupation at Pecica. Horses are rare at both Körös region sites.

Százhalombatta and the Benta Valley region cannot be compared directly in many cases given differences in available data. However, it is clear that this apical settlement resembles Pecica in a number of ways. Preliminary assessments indicate that Százhalombatta had greater access to imported materials, such as stone, than other sites in the region in terms of quantity and diversity, suggesting that it acted as a major hub in regional exchange systems (Priskin 2013). There is also evidence for local production of a range of prestige crafts, including fine metalwork and bone. Differences in animal production systems between Százhalombatta and settlements on the Plain are particularly interesting, which are only in part related to local ecology. Cattle are dominant at Százhalombatta, which is typical for this region, and meat quality shows that tell inhabitants had access to high-value meat cuts, especially beef. Horses were not a primary component of livestock production. Instead, over time there is a reorganization of ovicaprid husbandry systems to increase fiber yield at the expense of prime meat. It appears that textile production became an important export commodity during the settlement's expansion from the Early to Middle Bronze Age.

COMMON PATTERNS AND UNQIUE PATHWAYS

Among the study sites, there are a number of common patterns that differentiate central tells from smaller settlements and autonomous villages. First, large central sites have disproportional access to import goods, especially rare, high-value items. The range and proportion of items vary to some degree by orientation of trade networks. The strongly asymmetric representation of these items between site types indicates that central settlements had greater economic power than their neighbors. Local elites were actively seeking to obtain these foreign goods and were able to establish more wide-ranging and intensive trade relationships with external regions. And while elites may not have been able to secure monopolies on these items, differential access to them (and their distribution) were important for accentuating social inequalities that can be transformed into political power.

Second, the local production of high-value crafts is concentrated, and in some cases restricted, to central settlements. Again, while metal production is ubiquitous, the manufacture of complex items like jewelry and weaponry is strongly associated with central settlements and was likely sponsored by elites. Elites may not have been able to restrict access to the necessary raw materials, at least for copper. This is not to say, however, that they did not have disproportional access to ores, especially for tin or gold. But more importantly they were able to exploit a production bottleneck as crafting of fine metalwork requires specialized knowledge, tools, and facilities. Control over raw materials may have been more critical in the production of marine shell beads and amber, the latter of which is evident at Pecica. Other prestige crafts, especially those made on local raw materials (e.g., antler, horn, textiles), also are more common at central settlements. In these cases, there is little means for elite control over production. They may have been commissioned or made by independent artisans to meet elite demands.

Third, aside from differences in crop production that appear to be culturally related (e.g., the use of emmer in the Körös region versus primarily einkorn elsewhere), there are some important contrasts in the range and frequencies of crop species. This is particularly evident between Lower and Middle Maros groups, where the former utilized a much greater proportion of hardy, faster-growing crops, which is typical in systems tailored to risk mitigation. The presence of specialty crops, namely oil and fiber plants, at Százhalombatta is also notable.

Lastly, there are strong differences in animal economies between central settlements and autonomous villages or smaller hamlets. These largely stem from differences in the degree of risk buffering versus resource maximization, with smaller settlements having more generalized, low-risk production systems that are tailored to local ecology. In these there is much greater use of low-ranked wild resources and a focus on smaller-bodied livestock. Husbandry practices also show more generalized production systems, balancing multiple resources, and in some cases, herd security. In contrast, central settlements place more emphasis on high-value, high-cost livestock, especially cattle and/or horses. Greater secondary products production is seen at tells, including fairly specialized wool and perhaps dairy production at some sites. Tell inhabitants also had disproportional access to high-quality meat cuts, regardless of species, indicative of significant socioeconomic differences.

Despite these common trends, there are striking differences in the way economies are structured at these central settlements. This is most strongly seen in animal production systems. For example, at Százhalombatta, fiber production becomes intensified over time and textiles were likely important locally produced exchange goods. In contrast, at Pecica wool production is more important in early periods, shifting instead to an intensive meat production system over time, which also shows features of indirect procurement systems in its highly structured off-take program. Increased meat production at the expense of other products is seen across all taxa during Pecica's peak occupation. At the same time, there is a fundamental restructuring of livestock husbandry to greatly intensify horse breeding, which is linked to their use in chariotry and ritualized feasting. The exceptionally high level of horse production at Pecica is also likely tied to export production, with the settlement acting as a key distributor of horses in the region.

In sum, intensification of long-distance exchange networks and local prestige good production are common practices at emerging central settlements in the Carpathian Basin, with some difference in the range of items produced related to specific orientation of trade networks, given different trading partners and access to overland and riverine transportation routes. Elites at central settlements in more hierarchically organized regional polities, such as Pecica and Százhalombatta, were more successful in establishing longer-range and sustained extra-regional contacts. The degree to which agro-pastoral systems are influenced by increased economic centralization varies strongly between regions. Among Middle Maros groups, elites were more actively involved in animal husbandry systems, where intensified production of meat was likely used to provision central populations, and more importantly, specialized horse breeding was a primary means for wealth generation and social display.

What factors contributed to these significant regional differences? There are some common features that more hierarchical groups share. They are found in regions with high agricultural potential. The less centralized and autonomous village societies in this study all lie within largely marginal environments, particularly marshlands. Minimally, there needs to be the potential to produce sufficient and predictable agro-pastoral surpluses. This is necessary to sustain larger, concentrated populations at central settlements, but also has important implications for the extent of resource mobilization, elite provisioning, and maintenance of other non-producing specialist groups possible with staple goods.

Central settlements also tend to be located on major rivers, allowing them ease of access to water-borne trade as well as the ability to control the movement of people and goods along principal exchange routes. Interestingly, it is apparent that these focal settlements do not need direct access to or control over raw material sources as most are located in lowlands some distance from mineral and ore-producing areas. Rather, these settlements are in a position to facilitate the exchange of complementary resources from lowland and highland regions. They also have the potential to act as gateway communities for exchange with settlements away from the main trade routes as well as those further along the rivers themselves.

Clearly, other factors must be in play as many settlements meet these baseline criteria and do not develop into regional centers. Historical contingencies are certainly a factor, as relative position to other settlements within localities as well as to other cultural groups at a larger scale help to shape the direction and nature of interaction. But how do some settlements rise to prominence at the expense of their neighbors? How do local elites extend their influence beyond their community? This is where some of the regional differences can shed some light on these questions.

Across the region, local elites are competing for access to foreign raw materials and finished prestige goods. However, there needs to be local surplus production of desirable goods that can be exchanged for these sought-after foreign valuables. I would argue that successful elites were able to do so by exerting increased centralized control over local production and distribution systems, including the mobilization of staples and production of prestige crafts. It is apparent that there are different pathways that elites may take, for example intensified textile production at Százhalombatta or horse breeding at Pecica. I would also argue that the difference between risk-averse and maximizing plant and animal husbandry systems between central and peripheral sites is strongly related to surplus production for exchange, both locally and regionally, including through centralized mobilization. Animals in particular are intrinsically valuable commodities that can be easily transferred on the hoof. Horses stand out as their breeding, maintenance, and especially training require significant resource and labor investment as well as specialized knowledge, which makes horse breeding amenable for elite control. Differential access to high-quality and well-trained horses, coupled with chariotry technology, also has important implications for rapid transport of people, goods, and information, as well as warfare.

What emerges is a Bronze Age landscape in which successful elites, those who were able to extend their influence regionally, harnessed productive potential in multiple economic sectors. I suggest that the ability to exert centralized influence over the production and distribution of staple goods, animals, and their products provided the necessary economic advantage to expand and intensify participation in regional exchange networks for these lowland groups. Indeed, at Pecica, restructuring of the animal economy predates intensified metal production, although it follows shortly. Securing disproportionate access to critical foreign raw materials served to heighten local economic asymmetries through the dominant settlements' ability to produce a greater amount and range of economically valuable and symbolically important prestige goods, including weaponry, horse gear, and various ornamental items. No doubt public display of foreign items served to reinforce the dominant position of these emergent regional elites.

While martial and ideological realms are not the focus of this study, they are intimately linked with these economic changes. This is clearly evident at Pecica. Among the suite of economic changes that characterize its peak occupation is a dramatic increase in the production of horses and metal, both central to Bronze Age warfare. It should be underscored here that the majority of molds from Pecica are for weapons, including axes, daggers, and spearheads, rather than tools or ornaments (Gogâltan 1999). The widespread construction of fortifications, including the triple-ditch ramparts at Pecica, attests for the ubiquity of violence at this time.

Also of note is the evidence for ritual at Pecica. In general, ritual activities, other than those surrounding mortuary practices, have left little archaeological trace in the region.

Figurines tend to comprise the majority of the ritual paraphernalia recovered. These include zoomorphic figurines of various types as well as model wagons (including disk wheels) and occasionally spoked chariot wheels, speaking to the value of animals for their labor and in transportation. Chariot wheels also have been found at Pecica, as well as numerous disk wheels. More important are Pecica's ritual features that, to date, are unique. These include the patterned deposits of feasting remains, predominantly bones from prime-aged female horses, which encircle a very large, burned platform on which rites and activities related to food took place. The feasting deposits correspond to the peak periods of horse production at the site and the symbolic value of horses is strongly demonstrated by these ritual remains. They were created over several occupation phases, culminating in the platform construction. Significantly, these ritual features ceased to be used in the latter part of the occupation, corresponding to a decline in prestige goods production and consumption and the dis-intensification of agro-pastoral systems.

A final point is the inherent instability of these more centralized political configurations. Where we have absolute dates, the prominence of particular central settlements, as well as larger regions, is often fairly short-lived. For example, Pecica had a period of rapid expansion during its economic plateau, coinciding with the abandonment of the nearby Semlac tell. However, this peak appears to only have lasted for just a few generations, roughly 100-150 years, then rapidly diminished. There is no evidence for catastrophic destruction at this time or during its final depopulation. Rather, Pecica's decline may reflect the inherent instability of prestige goods economies, as new settlements and elites vied for control over foreign exchange networks. While Maros prominence collapses shortly after 1600 BC, groups in other regions maintain their regional influence, including those in ore-producing regions upriver.

THE CARPATHIAN BASIN AND BRONZE AGE COMPLEXITY

The Carpathian Basin Bronze Age is a microcosm reflecting trends that characterize Bronze Age Europe writ large. Rather than a steady march towards complexity that traditionally has been envisioned for this period, we see a rich mosaic of societies with vastly different organizational forms. While some groups develop into regional, centralized polities, others do not, maintaining a laterally-organized tribal society for centuries, if not millennia. In addition, regions where centralized formations form may not maintain this complex structure, with groups rising and falling in influence over time. This cycling occurs at multiple scales, from the individual settlement to larger geographic regions.

In several aspects, traditional explanations for Bronze Age complexity as being driven by metal production and extra-regional exchange are evident in the Carpathian Basin. Central settlements do have more far-reaching and intensive trade connections and are disproportionately manufacturing and consuming metal and other prestige goods. However, this is not the whole story. Regionally prominent settlements couple this wealth finance system with significant changes in their agro-pastoral economies. The ability to stimulate and harness increased productive capabilities within crop and animal production is essential for the establishment and maintenance of regional economic and political asymmetries. There are different pathways that this reorganization may take, but all share increased and targeted production of locally and regionally exchangeable goods, especially via animals and their products.

It is critical to Bronze Age studies, and research on the origins of complexity more generally, that agro-pastoral systems be given equal attention. The traditional focus on prestige goods, in particular, on metals in the Old World, has strongly overshadowed the perceived role that these other economic sectors have played in the development of more complex political formations (or lack thereof). This study has provided an approach and set of methods through which critical differences in production and distribution systems can be identified, including means to differentiate small-scale, risk-averse practices from those that maximize output of a variety of products.

It is also necessary to evaluate more systematically the organization of craft production. In many cases, specialized craft production (and its associated political implications) is assumed based solely on the presence of what is perceived to be “complexly made” items. There is rarely explicit examination of production facilities, tools, or by-products that shed far more light on the organization of production. For example, in the Carpathian Basin there is little evidence of specialized, elite-attached workshops, for metalwork or otherwise. And while the production of high-end metal items like weaponry and fine ornaments may be concentrated at large, central settlements, bronze working itself is widespread within and between communities. It is important to more clearly distinguish and independently examine different types of crafts as they vary greatly in the raw materials, tools, facilities, labor, and knowledge required for their production. Manufacturing bottlenecks that can be exploited by a subset of the population need to be examined in more detail. It is through these that elites can gain disproportionate control over production and distribution of economically valuable and symbolically potent items that can be used to expand alliance networks, buy loyalty, or coerce compliance, all of which can be used to strengthen political power.

APPENDIX 4.1: Carpathian Stone Resources

This appendix presents a more detailed review of economically useful stone from the Carpathian Region as well as major imports from neighboring areas. It should be noted that this discussion is strongly biased towards Hungary and the Apuseni Mountains of Romania, where most of the stone sourcing work has been done, and should not be considered comprehensive. Given the very large number of materials available in the greater Carpathian Region,[1] only the major stone categories and geographic regions are presented in the text.

Unfortunately, there is much ambiguity in the literature concerning the nomenclature and taxonomy of useful stone. This discussion will largely follow the system devised by Biró (1998, 2002, 2009, 2011), who has created the most systematic typology and sourcing database for the region, supplemented by (Crandell 2008, 2009) for sources in the Apuseni Mountains and Rapp (2009) for general geologic considerations.

Cherts and related materials

This category contains the microcrystalline quartzes, which are siliceous stones forming as precipitates within sedimentary (primarily limestone) rocks, those typically classified as cherts and closely related materials.[2] These include chert *sensu stricto*, flint, radiolarite, lydite, hornstone, porcellanite, chalcedony, agate, japser, and plasma. Chert and flints will be considered together here as many of the "flints" should be considered chert geologically. Cherts have a widespread distribution in the greater Carpathian region, including numerous sources in the Western Romanian Carpathians and the Bakony Mountains of Transdanubia (Table 4.1A). There are also very important chert sources found just outside the Carpathian Region to the north

[1] Biró (1993) has identified 80 classes of material in Hungary an adjacent regions to the north and west alone!

[2] Microcrystalline quartzes suffer from the most problems concerning standardized nomenclature, particularly in the use of silex, chert, and flint. Chert is a micro- or cryptocrystalline quartz with nearly equidimensional crystals. Flint is often used synonymously with chert, but this term should be used only for very dense cherts with high organic content, which gives them their dark color. Chalcedony differs from chert in that it has a fibrous crystalline structure that gives it a greasy luster. Silex is also used generically for any rock with high quartz content, especially in the French literature (Rapp 2009).

and south that were imported prehistorically. The so-called “northern flints” largely refer to the extensive chert outcrops of the Outer Carpathian Depression (Biró 1998; Crandell 2008; Domański and Webb 2000).[3] Southern sources primarily refer to the high quality Balkan flints of the Moesian Platform along the southern bank of the Danube in Bulgaria (Biagi and Starnini 2011).

Radiolarite[4] is a common stone in the western Carpathian Region and was one of the most important lithic raw materials in Hungary prehistorically. It also has a fairly widespread distribution, found in Transdanubia, the Outer Western Carpathians, and the Northern Limestone Alps near Vienna (Elburg and van der Kroft 2008). Lydite[5] is found in Cserhát Mountains (IWC) and the Gerecse Mountains of Transdanubia (Biró 2002, 2009, 2011). Hornstone[6] is another frequent microcrystalline stone in the region. The most extensive outcrops are found in Transdanubian Mountains. Other sources are found in the Cserhát and Bükk Mountains (IWC) and the Outer Western Carpathian Depression (Biró 2002, 2009, 2011). The Central Beskids (OEC) produce menelite hornstone (Elburg and van der Kroft 2008).

There are also a number of related materials that are located in comparatively isolated areas and in smaller quantities. Chalcedony is found in the Slanské Mountains and the Matras (IWC) as well as in the Gerecse and Mecsek Mountains of Transdanubia. There are also small quantities of chalcedony and agate[7] in the Trascău Mountains (WRC). There are a number of jasper[8] outcrops in the Northern Hungarian Mountains (IWC) and in the Apusenis (WRC) as well as in the Maramureş region of northern Romania. Plasma[9] is found in southern Moravia, southwest of Brno (Biró 2002, 2009, 2011; Crandell 2008, 2009; Elburg and van der Kroft 2008).

[3] Note that some of these Polish varieties may be considered true flints given their very dark color and density, particularly the chocolate flint.
[4] Radiolarite is a siliceous rock formed in deep water oceanic conditions from bodies of radiolarians, which are amoeboid protozoa.
[5] Lydite is typically a green banded stone that forms from a compressed radiolarite, but can become dark if thermally altered.
[6] Hornstone, also called hornfels, is formed in sedimentary rock in contact zones with hot intrusive igneous masses.
[7] Agate is a chalcedony variety formed in volcanic rocks.
[8] Jasper is a high quality, typically reddish chalcedony with high iron oxide content.
[9] Plasma is a green variety of chalcedony with yellow spots.

Table 4.1A: Locations of major chert (and related stone) sources in the Carpathian Region. Sources in *italics* are outside of the study area but frequently imported.

Resource	Range	Region	Important Locales
Sümeg chert	Transdanubian Mountains	Bakony Mountains	
Tevel chert	Transdanubian Mountains	Bakony Mountains	
Lower Jurassic chert	Transdanubian Mountains	Bakony Mountains	
Nummulitic chert	Transdanubian Mountains	Gerecse Mountains	
Cserhát chert	Inner Western Carpathians	Cserhát Mountains	
Other cherts	Western Romanian Carpathians	Metalliferous Mountains	
	Western Romanian Carpathians	Trascău Mountains	
	Western Romanian Carpathians	Strei River	
	Southern Carpathians		
	Dinaridies		
Jurassic-Cracow flint	*Outer Carpathian Depression*		
Chocolate flint	*Outer Carpathian Depression*		
Banded flint	*Outer Carpathian Depression*		
Gray-white spotted flint	*Outer Carpathian Depression*		
Volhynian/Prut/Miorcani flint	*Outer Carpathian Depression*		
Balkan flint	*Moesian Platform*		
Szentgál radiolarite	Transdanubian Mountains	Bakony Mountains	
Urkút-Eplény radiolarite	Transdanubian Mountains	Bakony Mountains	
Tata radiolarite	Transdanubian Mountains	Gerecse Mountains	
Other radiolarites	Transdanubian Hills	Mecsek Mountains	
	Outer Western Carpathians	Slovak-Moravian Carpathians	Vlára Pass
		Western Beskids	Podhale Basin
			Peieniny Mountains
			Čergov Mountains
	Northern Limestone Alps		Wien-Antonshöhe
Lydite	Transdanubian Mountains	Gerecse Mountains	
	Inner Western Carpathians	Cserhát Mountains	
Hornstone	Transdanubian Mountains	Balaton Highlands	
		Keszthely Mountains	
		Buda Hills	
	Inner Western Carpathians	Cserhát Mountains	
		Bükk Mountains	
	Outer Eastern Carpathians	Central Beskids	Ondava Highlands
	Outer W. Carpathian Depression		*Krumlovský Les*
			Stránská Skála
Porcellanite	Transdanubian Mountains	Bakony Mountains	
Chalcedony	Transdanubian Mountains	Gerecse Mountains	
	Transdanubian Hills	Mecsek Mountains	
	Inner Western Carpathians	Matras	
		Slanské Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Agate	Western Romanian Carpathians	Trascău Mountains	
Jasper	Inner Western Carpathians	Matras	
		Rudabánya Mountains	
		Tokaj-Zemplín Mountains	
	Western Romanian Carpathians	Metalliferous Mountains	
		Trascău Mountains	
Plasma	*Moravia*		*Boskovštejn*

Quartzites, opalites, and related materials

This group entails a variety of rocks formed under disparate geological conditions, typically through metamorphic or post-volcanic processes, and are largely comprised of opaline silica (Rapp 2009).[10] In the study region, these are generally related to hydrothermal activities during Tertiary volcanism in the Inner Carpathians (Biró 2002).

Quartzites are common in the Carpathian region and fall into two categories based on formation conditions (Table 4.2A). Metaquartzite is metamorphosed sandstone while orthoquartzites are sandstones that have been cemented by nearly pure silica from groundwater. Metaquartzite (generally referred to as just quartzite) is found in the Hungarian Foothills of the Eastern Alps, Outer Western Carpathian Depression, Szendrő Mountains (IWC), and Velence Mountains of Transdanubia. Orthoquartzites include hydro- and limnic quartzites and are found throughout the Northern Hungarian Mountains (IWC). Limnoquartzites are the most commonly utilized raw materials in the Pannonian Plain behind obsidian (Biró 1993, 2002, 2009, 2011; Elburg and van der Kroft 2008; Šarić 2002). Related quartzite sandstones are located in the Trascău Mountains (WRC) and the Cerna Valley across the Maros to the southwest (Figure 4.7) (Crandell 2008, 2009).

Opal and opalites are formed in the same general geologic conditions as the orthoquartzites[11] (Rapp 2009) and follow their distribution. They are located widely throughout the southern arc of the Northern Hungarian Mountains and in the Trascău Mountains. Geyserite (or sinter) sources are found in Matras and in the Metalliferous Mountains and there are siliceous shale outcrops in the Trascău and Poiana Ruscă Mountains.[12] Other miscellaneous silicified materials include "volcanics" (Börzsöny Mountains, IWC) and tuffs, magnesites, and marls from unspecified sources in Serbia[13] (Biró 2002, 2009, 2011; Crandell 2008; Elburg and van der Kroft 2008; Šarić 2002).

[10] These are often grouped together as "porcellanite rocks," which are less dense than micro-crystalline cherts (Rapp 2009).
[11] Opals and opalites are amorphous sub-microcrystalline cristobalites. During late stages of volcanism, hot groundwater precipitates low density colloidal silica into the cavities of volcanic or sedimentary rocks, especially sandstone. Its internal structure of silica spheres in cubic or hexagonal lattices causes light to diffract, particularly in its precious gemstone form. The largest opal deposits in Europe are found in Hungary (Rapp 2009).
[12] Note that the Poieni siliceous shale from the Poiana Ruscă Mountains is often incorrectly called "Banat chert" in the literature.
[13] These are commonly referred to as "white stone of different origins" in the Serbian literature (Šarić 2002).

Table 4.2A: Locations of other major stone sources in the Carpathian Region

Resource	Range	Region	Important Locales
Metaquartzite (Quartzite)	Hungarian Alpine Foothills		
	Transdanubian Mountains	Velence Mountains	
	Inner Western Carpathians	Szendrő Mountains	
	Outer W. Carpathian Depression		
Hydroquartzite	Inner Western Carpathians	Börzsöny Mountains	
		Matras	
		Tokaj-Zemplín Mountains	
Limnoquartzite	Inner Western Carpathians	Matras	
		Bükk Mountains	
		Tokaj-Zemplín Mountains	
		Slanské Mountains	
Quartzitic sandstone	Western Romanian Carpathians	Trascău Mountains	
		Cerna Valley	
Opal	Inner Western Carpathians	Cserhát Mountains	
		Matras	
		Bükk Mountains	
		Tokaj-Zemplín Mountains	
		Slanské Mountains	
Limnic opalite	Inner Western Carpathians	Matras	
Wooden opalite	Inner Western Carpathians	Bükk Mountains	
		Tokaj-Zemplín Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Geyserite/Sinter	Inner Western Carpathians	Matras	
	Western Romanian Carpathians	Metalliferous Mountains	
Siliceous shale	Western Romanian Carpathians	Poiana Ruscă Mountains	
Silicified volcanics	Inner Western Carpathians	Börzsöny Mountains	
Silicified tuff	Serbia (unspecified)		
Silicified magnesite	Serbia (unspecified)		
Silicified marl	Serbia (unspecified)		
Quartz crystal	Central Eastern Alps		Vienna
	Inner Western Carpathians	Matras	
	Dinaridies	Vardar Zone	Rudnik Mountain Region
Obsidian	Inner Western Carpathians	Slovakian Highlands	(type C4)
		Tokaj-Zemplín Mountains	(types C2a,b and C5)
		Slanské Mountains	(types C1a,b)
	Inner Eastern Carpathians	Vihorlat-Gutin Area	(type C3)
	Dinaridies	Vardar Zone	Rudnik Mountain Region
Felsitic porphyry	Inner Western Carpathians	Bükk Mountains	
Rhyolite	Inner Western Carpathians	Tokaj-Zemplín Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Andesite	Inner Western Carpathians	Bükk Mountains	
		Matras	
		Cserhát Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Microgranite	Western Romanian Carpathians	Trascău Mountains	
Basalt	Western Romanian Carpathians	Trascău Mountains	

Volcanics

Perhaps the best known lithic resource of the Carpathians is obsidian, a volcanic glass,[14] which supplied large regions of Europe in prehistory. It was the most frequent raw material used

[14] Obsidian is a volcanic glass that is generally a high silica rhyolite containing less than 1% water (Rapp 2009).

from a single source area in Hungary, particularly on the Pannonian Plain (Biró 1993). There are a number of chemically distinct varieties in the Carpathians (Table 4.4), all formed during Miocene volcanism (Rosania and Barker 2009; Thorpe, et al. 1984). The Inner Western Carpathians house obsidian in the Slovakian Highlands and to the east in the Slanské and adjacent Tokaj-Zemplén Mountains (Figure 4.9). There are also sources in the Vihorlat-Gutin Area, Ukraine.[15] The Slanské and Tokaj areas are the two most important obsidian sources. The Slovakian Slanské sub-types are older, higher quality, more glassy and transparent, and found in larger nodules than the Tokaj varieties (Biró 2002). Note that obsidian from the Slovakian Highlands is of too low of a quality to be used for chipped stone manufacture (Nandris 1975; Williams and Nandris 1977). The Ukrainian materials are primarily volcanic bombs rather than flow deposits (Rosania and Barker 2009) and are of unknown suitability for working. A Serbian obsidian source has also been suggested as pebbles were found in the Onjega Valley near Rudnik Mountain in the Dinaridies (Šarić 2002).

In addition to obsidian, there are several other important volcanics used in chipped and ground stone technologies. Andesite,[16] rhyolite,[17] and related materials were also widely utilized prehistorically, primarily for groundstone items in post-Paleolithic periods, as their crystalline formation generally does not facture as well as finer grained materials. These rocks are found in large areas of the region hosting volcanic activity, especially in the inner ring of the Carpathians and the Apuseni Mountains (Brezsnyánszky and Haas 1989). In the Northern Hungarian Mountains, rhyolite is found in the Tokaj region and andesite in the central ranges (Biró 1998, 2002, 2009). Rhyolite, andesite, microgranite, and basalt are all found in the Trascău Mountains (Crandell 2008).

[15] The Ukrainian obsidians grade into the Romanian perlite zone of the zone of the Oaş-Tibliş Range. Perlite, a hydrated obsidian, is low quality and friable, unsuitable for working. The Romanian "obsidian" sources often mentioned in the literature are actually perlite (Nandris 1975).
[16] Andesite is an intermediate volcanic rock with 52-63% silica.
[17] Rhyolite has a larger silica component, over 69%, containing primarily quartz and feldspar, and similar in composition to granite.

APPENDIX 8.1: Faunal coding form and sample entries

Lot	Context	Taxon	Element	Portion	Count	Side	Age	Modification	Measurements	Other Comments
6-181	F2	Sus scrofa	pelvis	ilium	1		fetal			photo taken
8-108	C5	Unio spp.	valve	umbo	1	l		burned		
8-147	C5	Sus scrofa	MC III	prox epi and shaft	1	r		gnawed		
8-386	D0	Large Mammal	thoracic vertebra	centrum fragment	1		f	calcined		
8-498	E	Ovicapridae	ulna	olecranon/shaft	1	r	su	gnawed, worked	gl 103.8 gb 17.6	awl, tip at radial articulation polished, olecranon gnawed
9-244	Ea1	Sus scrofa	mandible	M2	1	r	1yr		M2l 22.6 wa 13.0 wp 13.2	M2:a, M3: V/E
9-304	Ea1	Ovis aries	1 phalanx	complete	1	r	jf		glpe 42.1 bp 13.3 bd 12.2 sd 10.5	
9-369	F171	Equus caballus	mandible	ascending ramus	1	r				pathology: arthritic lipping condyle, 4 pc, likely assoc. with l mand
9-369	F171	Medium Mammal	long bone	shaft fragment	12			5 gnawed		
9-382	E ash	Cyprinus carpio	opercular	fragment	1					large cyprinid

APPENDIX 8.2: Ceramic coding attribute list

Variable	Codes
Internal Color	1 = Brown (brown)
	2 =Yellow
	3 =Orange
	4 = Black
	5 = Gray
	6 = Tan
Interior Surface Treatment	1 = Plain
	2 = Coarse Burnished
	3 = Burnished
	4 = Polished
	5 = Brushed/Combed
	6 = Rusticated
	7 = Smooth
	8 = Reburned
External Color	1 = Brown (brown)
	2 =Yellow
	3 =Orange
	4 = Black
	5 = Gray
	6 = Tan
External Surface Treatment	1 = Plain
	2 = Coarse Burnished
	3 = Burnished
	4 = Polished
	5 = Brushed/Combed
	6 = Rusticated
	7 = Smooth
	8 = Reburned
Sooting	1 = Interior
	2 = Exterior
	3 = No Soot
Ware	1 = Fine
	2 = Coarse
	3 = Wheel Turned
<u>Things to Note:</u>	
Type of exotic	
Suspension Holes	

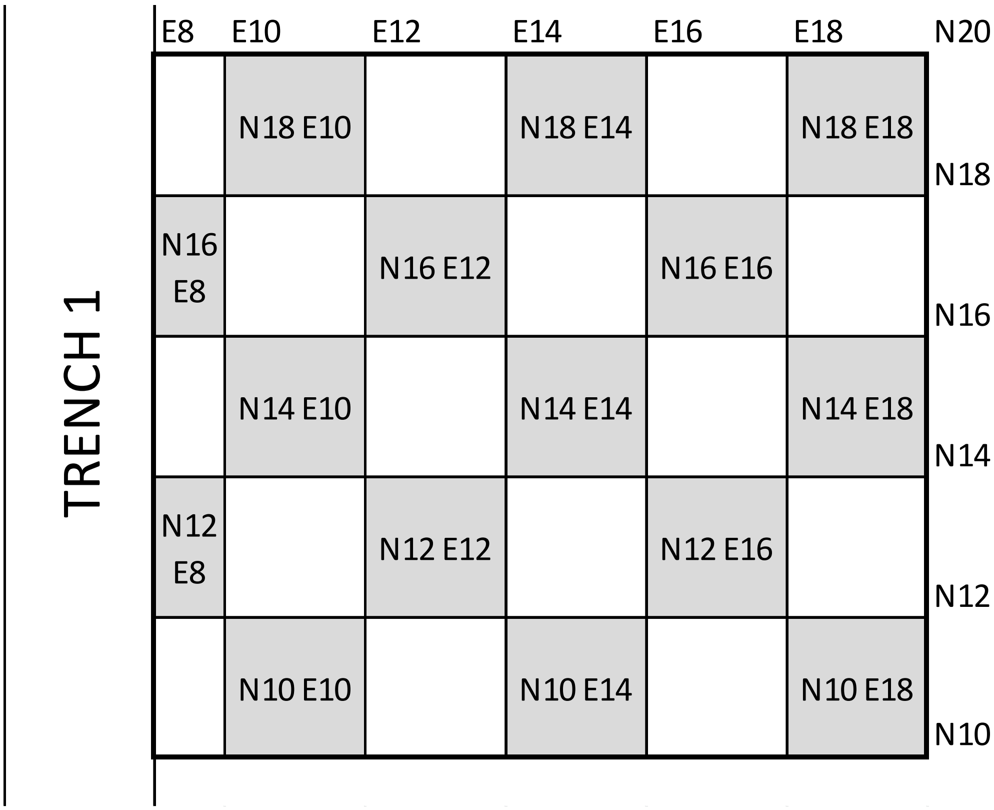
Variable	Codes
Presumed Vessel Type	1 = Cup
	2 = Jar
	3 = Pitcher/Jug
	4 = Bowl
	5 = Plain Cooking Pot
	6 = Lid
	7 = Strainer
	8 = Brazier
	9 =Miniature
	10 = Fish Plate
	11 = Wheel
	12 = Spindle Whorl
	13 = Other
Part	1 = Rim
	2 = Base
	3 = Handle
	4 = Shoulder
	5 = Body Sherd
	6 = Other
Exotic	1 = Yes
	2 = No (Maros)
Thickness 1 (rim)	in mm
Thickness 2 (lip)	in mm
Diameter	in cm
% Present	
Lip Shape	1 = Rounded
	2 = Tapered
	3 = Beveled
	4 = Square
	5 = T-shaped
Rim Orientation	1 = Everted
	2 = Straight
	3 = Inverted
	4 = 90 degrees
Odd Tempering	
Non-Round Orifice Shape	
Handle Attachment Below Rim	

Variable	Codes
Handle XS	1 = D-shaped
	2 = C-shaped
	3 = Oval
	4 = Flat
	5 = Rounded
	6 = Triangular
Handle Surface	1 = Plain
	2 = Coarse Burnished
	3 = Burnished
	4 = Polished
	5 = Brushed/Combed
	6 = Rusticated
	7 = Smooth
	8 = Reburned
Handle Decoration	1 = Yes
	2 = No
High Arch Handle	1 = Yes
	2 = No
Kantharos	1 = Yes
	2 = No
Handle Form	1 = Loop
	2 = Tab
	3 = Double Tab
	4 = Lug
	5 = Double Lug
Handle Width	in mm
Base XC	1 = Flat
	2 = Hollow (Concave)
	3 = Footed
	4 = Rounded
	5 = Dimpled
	6= Pedestal
Base Profile	1 = Simple
	2 = Inflected
Base Diameter	in cm
Exterior Decoration	1 = Yes
	2 = No

APPENDIX 8.3: Sample ceramic coding form

Lot #										
Object #/Piece Plot #										
Reference #										
INT Color										
INT Surf										
EXT Color										
EXT Surf										
Sooting										
Ware										
Pres. Vessel Type										
Part										
Exotic										
Thickness 1 (rim)										
Thickness 2 (lip)										
Diameter										
%										
Lip Shape										
Rim Orientation										
Handle XS										
Handle Surface										
Handle Decorated?										
High Arch Handle										
Kantharos										
Handle Form										
Handle Width										
Base XC										
Base Profile										
Base Diameter										
Decoration										
Channeled										
Trailed										
Incised										
Engraved										
Punctated										
Bossed										
Tick										
Node										
Arch										
Hatch										
Triangular										
Encrusted										
Chevron										
Pinched Fillet										
Pinched lip										
Pin. fillet even w/ lip										
Prow										
Applique										
Finger nail impressed										
Other										
Notes										

APPENDIX 9.1: Pecica Excavation Block Sampling Grid



Note: Fauna from general fill layers was analyzed in shaded cells only (50% sample)

APPENDIX 9.2: Chi-square tests, bone modification by phase, period, and context

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
	Ph 5	Ph 4	Ph 3		Ph 5	Ph 4	Ph 3		Ph 5	Ph 4	Ph 3				Ph 5	Ph 4	Ph 3
Weathered	11	10	1	22	2.44205	12.6546	6.90331	22	29.9906	0.5569	5.0482	35.5957			**5.48**	-0.75	**-2.25**
Animal Modified	70	491	210	771	85.5827	443.488	241.93	771	2.8372	5.0902	4.2141	12.1415			-1.68	**2.26**	**-2.05**
Burned/Calcined	31	220	86	337	37.4077	193.846	105.746	337	1.0976	3.5287	3.6873	8.3136			-1.05	1.88	-1.92
Butchery Marks	6	17	15	38	4.21808	21.858	11.9239	38	0.7528	1.0797	0.7936	2.6260			0.87	-1.04	0.89
Worked	1	12	10	23	2.55305	13.2298	7.2171	23	0.9447	0.1143	1.0731	2.1321			-0.97	-0.34	1.04
Unmodified	447	2183	1278	3908	433.796	2247.92	1226.28	3908	0.4019	1.8751	2.1814	4.4584			0.63	-1.37	1.48
	566	2933	1600	5099	566	2933	1600	5099	36.0249	12.2449	16.9975	**65.2674**	10	**0.000**			

	Ph 2	Ph 1		Ph 2	Ph 1		Ph 2	Ph 1		df	p	Ph 2	Ph 1
Weathered	0	6	6	4.24792	1.75208	6	4.2479	10.2991	14.5471			**-2.06**	**3.21**
Animal Modified	321	40	361	255.583	105.417	361	16.7433	40.5944	57.3377			**4.09**	**-6.37**
Burned/Calcined	126	17	143	101.242	41.7578	143	6.0543	14.6787	20.7329			**2.46**	**-3.83**
Butchery Marks	14	11	25	17.6997	7.30031	25	0.7733	1.8749	2.6483			-0.88	1.37
Worked	23	0	23	16.2837	6.71629	23	2.7702	6.7163	9.4865			1.66	**-2.59**
Unmodified	4719	2072	6791	4807.94	1983.06	6791	1.6454	3.9892	5.6346			-1.28	**2.00**
	5203	2146	7349	5203	2146	7349	30.5890	74.1634	**104.7525**	5	**0.000**		

	Early	Flor.*	Late		Early	Flor.*	Late		Early	Flor.*	Late		df	p	Early	Flor.*	Late
Weathered	12	22	6	40	3.50601	15.8319	20.6621	40	20.5783	2.4031	10.4044	33.3859			**4.54**	1.55	**-3.23**
Animal Modified	60	814	361	1235	108.248	488.809	637.943	1235	21.5050	216.3406	120.2261	358.0717			**-4.64**	**14.71**	**-10.96**
Burned/Calcined	12	413	143	568	49.7853	224.813	293.402	568	28.6778	157.5291	77.0983	263.3051			**-5.36**	**12.55**	**-8.78**
Butchery Marks	26	42	25	93	8.15147	36.8091	48.0394	93	39.0813	0.7320	11.0496	50.8629			**6.25**	0.86	**-3.32**
Worked	0	24	23	47	4.11956	18.6024	24.278	47	4.1196	1.5661	0.0673	5.7530			**-2.03**	1.25	-0.26
Unmodified	1137	4316	6791	12244	1073.19	4846.14	6324.68	12244	3.7941	57.9933	34.3826	96.1699			1.95	**-7.62**	**5.86**
	1247	5631	7349	14227	1247	5631	7349	14227	117.7560	436.5642	253.2283	**807.5485**	10	**0.000**			

	On Tell	Off Tell		On Tell	Off Tell		On Tell	Off Tell		df	p	On Tell	Off Tell
Weathered	11	0	11	10.1045	0.89552	11	0.0794	0.8955	0.9749			0.28	-0.95
Animal Modified	730	22	752	690.779	61.221	752	2.2269	25.1268	27.3536			1.49	**-5.01**
Burned/Calcined	370	38	408	374.784	33.2156	408	0.0611	0.6891	0.7502			-0.25	0.83
Butchery Marks	33	0	33	30.3134	2.68656	33	0.2381	2.6866	2.9247			0.49	-1.64
Worked	23	2	25	22.9647	2.03527	25	0.0001	0.0006	0.0007			0.01	-0.02
Unmodified	3651	365	4016	3689.05	326.946	4016	0.3925	4.4292	4.8217			-0.63	2.10
	4818	427	5245	4818	427	5245	2.6055	29.3986	**32.0041**	5	**0.000**		

note: statistically significant values in **bold**

*Classic Maros excludes the platform

APPENDIX 9.3: Chi-square tests, taxon representation, Florescent Period

	Observed Values					Expected Values					Chi Square Values					df	p	Standardized Residuals			
	Ph 3	Platform	Ph 4	Ph 5		Ph 3	Platform	Ph 4	Ph 5		Ph 3	Platform	Ph 4	Ph 5				Ph 3	Platform	Ph 4	Ph 5
Mammal	1407	2199	2590	535	6731	1404.93	2243.964	2576.9	505.204	6731	0.0030	0.9010	0.0666	1.7573	2.7279			0.06	-0.95	0.26	1.33
Mollusk	161	312	248	28	749	156.335	249.6998	286.748	56.2172	749	0.1392	15.5439	5.2359	14.1631	35.0821			0.37	**3.94**	**-2.29**	**-3.76**
Fish/Bird/Turtle	6	3	49	3	61	12.7323	20.33603	23.3533	4.57844	61	3.5597	14.7786	28.1654	0.5442	47.0479			-1.89	**-3.84**	**5.31**	-0.74
	1574	2514	2887	566	7541	1574	2514	2887	566	7541	3.7019	31.2235	33.4679	16.4646	**84.8579**	6	**0.000**				
Domestic	442	527	798	210	1977	443.843	597.1584	766.579	169.42	1977	0.0076	8.2427	1.2879	9.7197	19.2579			-0.09	**-2.87**	1.13	**3.12**
Wild Fauna	247	400	392	53	1092	245.157	329.8416	423.421	93.5797	1092	0.0138	14.9229	2.3317	17.5969	34.8653			0.12	**3.86**	-1.53	**-4.19**
	689	927	1190	263	3069	689	927	1190	263	3069	0.0215	23.1656	3.6196	27.3165	**54.1233**	3	**0.000**				
Domestic	442	527	798	210	1977	449.938	524.0754	802.73	200.256	1977	0.1400	0.0163	0.0279	0.4741	0.6583			-0.37	0.13	-0.17	0.69
Wild Vertebrates	86	88	144	25	343	78.0621	90.92457	139.27	34.7435	343	0.8072	0.0941	0.1607	2.7325	3.7944			0.90	-0.31	0.40	-1.65
	528	615	942	235	2320	528	615	942	235	2320	0.9472	0.1104	0.1885	3.2066	4.4527	3	0.217				
Domestic	442	527	798	210	1977	449.938	524.0754	802.73	200.256	1977	0.1400	0.0163	0.0279	0.4741	0.6583			-0.37	0.13	-0.17	0.69
Wild Mammal	82	85	106	22	295	67.1379	78.20043	119.78	29.8815	295	3.2900	0.5912	1.5853	2.0788	7.5453			1.81	0.77	-1.26	-1.44
Fish/Bird/Turtle	4	3	38	3	48	10.9241	12.72414	19.4897	4.86207	48	4.3888	7.4315	17.5802	0.7131	30.1136			**-2.09**	**-2.73**	**4.19**	-0.84
	528	615	942	235	2320	528	615	942	235	2320	7.8188	8.0390	19.1935	3.2660	**38.3173**	6	**0.000**				
Ovicaprid	158	187	231	86	662	148.848	176.7146	266.091	70.346	662	0.5627	0.5986	4.6278	3.4835	9.2726			0.75	0.77	**-2.15**	1.87
Pig	138	140	186	51	515	115.796	137.4743	207.005	54.7254	515	4.2578	0.0464	2.1313	0.2536	6.6891			**2.06**	0.22	-1.46	-0.50
Cattle	74	122	143	39	378	84.9918	100.9035	151.937	40.1674	378	1.4215	4.4108	0.5257	0.0339	6.3920			-1.19	**2.10**	-0.73	-0.18
Horse	68	71	223	31	393	88.3645	104.9076	157.967	41.7613	393	4.6932	10.9594	26.7736	2.7730	45.1993			**-2.17**	**-3.31**	**5.17**	-1.67
	438	520	783	207	1948	438	520	783	207	1948	10.9352	16.0152	34.0584	6.5440	**67.5529**	9	**0.000**				
Red Deer	69	72	90	18	249	69.2136	71.74576	89.4712	18.5695	249	0.0007	0.0009	0.0031	0.0175	0.0222			-0.03	0.03	0.06	-0.13
Other Game	13	13	16	4	46	12.7864	13.25424	16.5288	3.43051	46	0.0036	0.0049	0.0169	0.0945	0.1199			0.06	-0.07	-0.13	0.31
	82	85	106	22	295	82	85	106	22	295	0.0042	0.0058	0.0200	0.1120	0.1421	3	0.986				
Large Mammal	701	1125	1479	274	3579	758.396	1121.818	1401.85	296.935	3579	4.3438	0.0090	4.2459	1.7715	10.3703			**-2.08**	0.09	**2.06**	-1.33
Medium Mammal	640	855	984	251	2730	578.492	855.7037	1069.31	226.497	2730	6.5399	0.0006	6.8057	2.6508	15.9969			**2.56**	-0.02	**-2.61**	1.63
Small Mammal	5	11	25	2	43	9.11178	13.47812	16.8426	3.56754	43	1.8555	0.4556	3.9509	0.6888	6.9508			-1.36	-0.68	1.99	-0.83
	1346	1991	2488	527	6352	1346	1991	2488	527	6352	12.7392	0.4652	15.0025	5.1110	**33.3179**	6	**0.000**				
High Value	221	268	462	91	1042	235.892	314.2923	402.709	89.1071	1042	0.9401	6.8184	8.7295	0.0402	16.5283			-0.97	**-2.61**	**2.95**	0.20
Medium Value	297	329	425	138	1189	269.17	358.6311	459.521	101.678	1189	2.8773	2.4482	2.5933	12.9753	20.8941			1.70	-1.56	-1.61	**3.60**
Low Value	165	313	279	29	786	177.938	237.0766	303.771	67.2151	786	0.9407	24.3144	2.0199	21.7272	49.0021			-0.97	**4.93**	-1.42	**-4.66**
	683	910	1166	258	3017	683	910	1166	258	3017	4.7581	33.5810	13.3428	34.7427	**86.4246**	6	**0.000**				

note: statistically significant values in **bold**

APPENDIX 9.4: Chi-square tests, taxon representation, Late Period

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Ph 1	Ph 2		Ph 1	Ph 2		Ph 1	Ph 2				Ph 1	Ph 2
Mammal	1820	4324	6144	1787.3	4356.7	6144	0.5983	0.2454	0.8437			0.77	-0.50
Mollusk	249	724	973	283.047	689.953	973	4.0955	1.6801	5.7756			**-2.02**	1.30
Fish	37	78	115	33.4537	81.5463	115	0.3759	0.1542	0.5302			0.61	-0.39
Bird/Turtle	1	10	11	3.19992	7.80008	11	1.5124	0.6205	2.1329			-1.23	0.79
	2107	5136	7243	2107	5136	7243	6.5821	2.7003	9.2824	3	0.026		
Domestic	421	1197	1618	419.481	1198.52	1618	0.0055	0.0019	0.0074			0.07	-0.04
Wild Fauna	377	1083	1460	378.519	1081.48	1460	0.0061	0.0021	0.0082			-0.08	0.05
	798	2280	3078	798	2280	3078	0.0116	0.0041	0.0156	1	0.900		
Domestic	421	1197	1618	421.987	1196.01	1618	0.0023	0.0008	0.0031			-0.05	0.03
Wild Vertebrates	128	359	487	127.013	359.987	487	0.0077	0.0027	0.0104			0.09	-0.05
	549	1556	2105	549	1556	2105	0.0100	0.0035	0.0135	1	0.908		
Domestic	421	1197	1618	421.987	1196.01	1618	0.0023	0.0008	0.0031			-0.05	0.03
Wild Mammal	101	296	397	103.541	293.459	397	0.0623	0.0220	0.0843			-0.25	0.15
Fish	26	53	79	20.6038	58.3962	79	1.4133	0.4986	1.9119			1.19	-0.71
Bird/Turtle	1	10	11	2.86888	8.13112	11	1.2175	0.4296	1.6470			-1.10	0.66
	549	1556	2105	549	1556	2105	2.6954	0.9510	3.6464	3	0.302		
Ovicaprid	153	528	681	173.18	507.82	681	2.3514	0.8019	3.1533			-1.53	0.90
Pig	148	346	494	125.625	368.375	494	3.9851	1.3590	5.3441			**2.00**	-1.17
Cattle	79	231	310	78.8337	231.166	310	0.0004	0.0001	0.0005			0.02	-0.01
Horse	19	65	84	21.3614	62.6386	84	0.2610	0.0890	0.3501			-0.51	0.30
	399	1170	1569	399	1170	1569	6.5979	2.2501	**8.8480**	3	**0.031**		
Red Deer	81	210	291	74.0327	216.967	291	0.6557	0.2237	0.8794			0.81	-0.47
Other Game	20	86	106	26.9673	79.0327	106	1.8001	0.6142	2.4143			-1.34	0.78
	101	296	397	101	296	397	2.4557	0.8379	3.2937	1	0.070		
Large Mammal	812	1734	2546	763.324	1782.68	2546	3.1040	1.3291	4.4330			1.76	-1.15
Medium Mammal	942	2344	3286	985.186	2300.81	3286	1.8931	0.8106	2.7037			-1.38	0.90
Small Mammal	11	44	55	16.4897	38.5103	55	1.8276	0.7826	2.6102			-1.35	0.88
	1765	4122	5887	1765	4122	5887	6.8247	2.9223	**9.7469**	2	**0.008**		
High Value	183	523	706	182.484	523.516	706	0.0015	0.0005	0.0020			0.04	-0.02
Medium Value	316	915	1231	318.184	912.816	1231	0.0150	0.0052	0.0202			-0.12	0.07
Low Value	271	771	1042	269.332	772.668	1042	0.0103	0.0036	0.0139			0.10	-0.06
	770	2209	2979	770	2209	2979	0.0268	0.0093	0.0361	2	0.982		

note: statistically significant values in **bold**

APPENDIX 9.5: Chi-square tests, taxon representation, period comparisons

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
	Early	Flor.	Late		Early	Flor.	Late		Early	Flor.	Late				Early	Flor.	Late
Mammal		7235	6144	13379		7052.0153	6326.98	13379		4.7481	5.2922	10.0402				**2.18**	**-2.30**
Mollusk		772	973	1745		919.78225	825.218	1745		23.7443	26.4653	50.2096				**-4.87**	**5.14**
Fish		57	115	172		90.660486	81.3395	172		12.4975	13.9296	26.4271				**-3.54**	**3.73**
Bird/Turtle		9	11	20		10.541917	9.45808	20		0.2255	0.2514	0.4769				-0.47	0.50
		8073	7243	15316		8073	7243	15316		41.2154	45.9384	**87.1538**	3	**0.000**			
Domestic		2123	1618	3741		1917.6358	1823.36	3741		21.9929	23.1300	45.1230				**4.69**	**-4.81**
Wild Fauna		1152	1496	2648		1357.3642	1290.64	2648		31.0709	32.6773	63.7481				**-5.57**	**5.72**
		3275	3114	6389		3275	3114	6389		53.0638	55.8073	**108.8711**	1	**0.000**			
Domestic		2123	1618	3741		2016.3056	1724.69	3741		5.6458	6.6004	12.2462				**2.38**	**-2.57**
Wild Vertebrates		380	523	903		486.69444	416.306	903		23.3898	27.3446	50.7344				**-4.84**	**5.23**
		2503	2141	4644		2503	2141	4644		29.0357	33.9450	**62.9807**	1	**0.000**			
Domestic		2123	1618	3741		2027.2231	1713.78	3741		4.5250	5.3526	9.8777				**2.13**	**-2.31**
Wild Mammal		314	397	711		385.28618	325.714	711		13.1895	15.6018	28.7913				**-3.63**	**3.95**
Fish		44	79	123		66.652884	56.3471	123		7.6989	9.1070	16.8059				**-2.77**	**3.02**
Bird/Turtle		9	11	20		10.837867	9.16213	20		0.3117	0.3687	0.6803				-0.56	0.61
		2490	2105	4595		2490	2105	4595		25.7250	30.4301	**56.1551**	3	**0.000**			
Ovicaprid	369	727	681	1777	263.305	865.14562	648.549	1777	42.4275	22.0590	1.6237	66.1102			**6.51**	**-4.70**	1.27
Pig	149	558	494	1201	177.957	584.71575	438.327	1201	4.7118	1.2206	7.0711	13.0036			**-2.17**	-1.10	**2.66**
Cattle	104	395	310	809	119.873	393.86764	295.26	809	2.1018	0.0033	0.7359	2.8409			-1.45	0.06	0.86
Horse	15	413	84	512	75.8651	249.27099	186.864	512	48.8309	107.5423	56.6240	212.9972			**-6.99**	**10.37**	**-7.52**
	637	2093	1569	4299	637	2093	1569	4299	98.0720	130.8252	66.0547	**294.9520**	6	**0.000**			
Red Deer	39	266	291	596	43.515	243.99478	308.49	596	0.4685	1.9846	0.9916	3.4447			-0.68	1.41	-1.00
Other Game	17	48	106	171	12.485	70.005215	88.5098	171	1.6328	6.9170	3.4562	12.0060			1.28	**-2.63**	1.86
	56	314	397	767	56	314	397	767	2.1012	8.9016	4.4478	**15.4507**	2	**0.000**			
Large Mammal		3755	2546	6301		3598.3391	2702.66	6301		6.8205	9.0809	15.9015				**2.61**	**-3.01**
Medium Mammal		1300	1226	2526		1442.5336	1083.47	2526		14.0834	18.7508	32.8342				**-3.75**	**4.33**
Small Mammal		11	33	44		25.127269	18.8727	44		7.9428	10.5750	18.5178				**-2.82**	**3.25**
		5066	3805	8871		5066	3805	8871		28.8467	38.4067	**67.2535**	2	**0.000**			
High Value		1075	706	1781		912.65319	868.347	1781		28.8790	30.3525	59.2315				**5.37**	**-5.51**
Medium Value		1269	1231	2500		1281.0966	1218.9	2500		0.1142	0.1200	0.2343				-0.34	0.35
Low Value		787	1042	1829		937.25025	891.75	1829		24.0866	25.3156	49.4021				**-4.91**	**5.03**
		3131	2979	6110		3131	2979	6110		53.0798	55.7881	**108.8678**	4	**0.000**			

note: statistically significant values in **bold**

APPENDIX 9.6: Chi-square tests, taxon representation, off-tell phases

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Ph B	Ph A		Ph B	Ph A		Ph B	Ph A				Ph B	Ph A
Mammal	103	143	246	115.482	130.518	246	1.3491	1.1936	2.5427			-1.16	1.09
Mollusk	77	62	139	65.2518	73.7482	139	2.1152	1.8715	3.9867			1.45	-1.37
Fish/Bird/Turtle	12	12	24	11.2665	12.7335	24	0.0478	0.0423	0.0900			0.22	-0.21
	192	217	409	192	217	409	3.5120	3.1074	6.6194	3	0.085		
Domestic	23	44	67	33.232	33.768	67	3.1504	3.1004	6.2508			-1.77	1.76
Wild Fauna	101	82	183	90.768	92.232	183	1.1534	1.1351	2.2885			1.07	-1.07
	124	126	250	124	126	250	4.3038	4.2355	**8.5393**	1	**0.003**		
Domestic	23	44	67	28.3694	38.6306	67	1.0162	0.7463	1.7625			-1.01	0.86
Wild Vertebrates	24	20	44	18.6306	25.3694	44	1.5475	1.1364	2.6839			1.24	-1.07
	47	64	111	47	64	111	2.5637	1.8827	**4.4464**	1	**0.035**		
Domestic	23	44	67	28.3694	38.6306	67	1.0162	0.7463	1.7625			-1.01	0.86
Wild Mammal	13	14	27	11.4324	15.5676	27	0.2149	0.1578	0.3728			0.46	-0.40
Fish/Bird/Turtle	11	6	17	7.1982	9.8018	17	2.0080	1.4746	3.4826			1.42	-1.21
	47	64	111	47	64	111	3.2391	2.3787	5.6179	3	0.132		
Ovicaprid	11	22	33	10.8197	22.1803	33	0.0030	0.0015	0.0045			0.05	-0.04
Pig	6	13	19	6.22951	12.7705	19	0.0085	0.0041	0.0126			-0.09	0.06
Cattle	3	6	9	2.95082	6.04918	9	0.0008	0.0004	0.0012			0.03	-0.02
Horse	20	41	61	20	41	61	0.0123	0.0060	0.0183	3	0.999		
Red Deer	3	9	12	5.77778	6.22222	12	1.3355	1.2401	2.5755			-1.16	1.11
Other Game	10	5	15	7.22222	7.77778	15	1.0684	0.9921	2.0604			1.03	-1.00
	13	14	27	13	14	27	2.4038	2.2321	**4.6360**	1	**0.031**		
Large Mammal	29	36	65	28.5435	36.4565	65	0.0073	0.0057	0.0130			0.09	-0.08
Medium Mammal	68	90	158	69.3826	88.6174	158	0.0276	0.0216	0.0491			-0.17	0.15
Small Mammal	4	3	7	3.07391	3.92609	7	0.2790	0.2184	0.4975			0.53	-0.47
	101	129	230	101	129	230	0.3139	0.2457	0.5596	2	0.756		
High Value	8	17	25	12.2967	12.7033	25	1.5014	1.4533	2.9547			-1.23	1.21
Medium Value	25	40	65	31.9715	33.0285	65	1.5202	1.4715	2.9917			-1.23	1.21
Low Value	88	68	156	76.7317	79.2683	156	1.6548	1.6018	3.2566			1.29	-1.27
	121	125	246	121	125	246	4.6763	4.5267	**9.2030**	2	**0.010**		

note: statistically significant values in **bold**

APPENDIX 9.7: Chi-square tests, taxon representation, on- versus off-tell occupation (Florescent Period)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	On Tell	Off Tell		On Tell	Off Tell		On Tell	Off Tell				On Tell	Off Tell
Mammal	4255	246	4501	4143.89	357.111	4501	2.9793	34.5711	37.5504			1.73	**-5.88**
Mollusk	431	139	570	524.776	45.2241	570	16.7575	194.4524	211.2099			**-4.09**	**13.94**
Fish	55	22	77	70.8908	6.10921	77	3.5621	41.3338	44.8959			-1.89	**6.43**
Bird/Turtle	5	2	7	6.44462	0.55538	7	0.3238	3.7576	4.0814			-0.57	1.94
	4746	409	5155	4746	409	5155	23.6226	274.1150	**297.7376**	3	**0.000**		
Domestic	1283	67	1350	1197.08	152.923	1350	6.1673	48.2773	54.4445			**2.48**	**-6.95**
Wild Fauna	674	183	857	759.923	97.0775	857	9.7150	76.0494	85.7644			**-3.12**	**8.72**
	1957	250	2207	1957	250	2207	15.8823	124.3266	**140.2089**	1	**0.000**		
Domestic	1283	67	1350	1258.46	91.5394	1350	0.4785	6.5784	7.0569			0.69	**-2.56**
Wild Vertebrates	243	44	287	267.539	19.4606	287	2.2508	30.9437	33.1945			-1.50	**5.56**
	1526	111	1637	1526	111	1637	2.7293	37.5221	**40.2514**	1	**0.000**		
Domestic	1283	67	1350	1258.46	91.5394	1350	0.4785	6.5784	7.0569			0.69	**-2.56**
Wild Mammal	196	27	223	207.879	15.121	223	0.6788	9.3322	10.0110			-0.82	**3.05**
Fish	42	15	57	53.135	3.865	57	2.3335	32.0798	34.4132			-1.53	**5.66**
Bird/Turtle	5	2	7	6.52535	0.47465	7	0.3566	4.9019	5.2585			-0.60	**2.21**
	1526	111	1637	1526	111	1637	3.8473	52.8923	**56.7397**	3	**0.000**		
Ovicaprid	408	33	441	419.431	21.5688	441	0.3115	6.0583	6.3699			-0.56	**2.46**
Pig	333	19	352	334.784	17.216	352	0.0095	0.1849	0.1944			-0.10	0.43
Cattle	224	9	233	221.604	11.3958	233	0.0259	0.5037	0.5296			0.16	-0.71
Horse	299	4	303	288.181	14.8194	303	0.4062	7.8991	8.3053			0.64	**-2.81**
	1264	65	1329	1264	65	1329	0.7532	14.6460	**15.3991**	3	**0.002**		
Red Deer	165	12	177	155.57	21.4305	177	0.5717	4.1499	4.7216			0.76	**-2.04**
Other Game	31	15	46	40.4305	5.56951	46	2.1997	15.9681	18.1677			-1.48	**4.00**
	196	27	223	196	27	223	2.7713	20.1179	22.8893	1	**0.000**		
Large Mammal	2253	65	2318	2192.32	125.681	2318	1.6796	29.2981	30.9777			1.30	**-5.41**
Medium Mammal	1708	158	1866	1764.83	101.174	1866	1.8298	31.9173	33.7470			-1.35	**5.65**
Small Mammal	51	7	58	54.8553	3.14474	58	0.2709	4.7263	4.9973			-0.52	**2.17**
	4012	230	4242	4012	230	4242	3.7803	65.9416	**69.7219**	2	**0.000**		
High Value	704	25	729	646.887	82.1126	729	5.0424	39.7241	44.7665			**2.25**	**-6.30**
Medium Value	762	65	827	733.849	93.1511	827	1.0799	8.5075	9.5874			1.04	**-2.92**
Low Value	472	156	628	557.264	70.7363	628	13.0457	102.7748	115.8205			**-3.61**	**10.14**
	1938	246	2184	1938	246	2184	19.1680	151.0064	**170.1744**	2	**0.000**		

note: statistically significant values in **bold**

APPENDIX 9.8: Chi-square tests, livestock age class, period and context comparisons

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Ovicaprid	**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**				**juvenile**	**subadult**	**adult**
Early	4	8	11	23	6.688776	10.20918	6.102041	23	1.0808	0.4780	3.9315	5.4904			-1.04	-0.69	**1.98**
Florescent	5.5	12.5	5	23	6.688776	10.20918	6.102041	23	0.2113	0.5140	0.1990	0.9243			-0.46	0.72	-0.45
Late	19	23	10	52	15.12245	23.08163	13.79592	52	0.9942	0.0003	1.0444	2.0390			1.00	-0.02	-1.02
	28.5	43.5	26	98	28.5	43.5	26	98	2.2864	0.9924	5.1749	**8.4537**	4	**0.076**			
Cattle	**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**				**juvenile**	**subadult**	**adult**
Florescent	6.5	12.5	7	26	6.333333	11.66667	8	26	0.0044	0.0595	0.1250	0.1889			0.07	0.24	-0.35
Late	3	5	5	13	3.166667	5.833333	4	13	0.0088	0.1190	0.2500	0.3778			-0.09	-0.35	0.50
	9.5	17.5	12	39	9.5	17.5	12	39	0.0132	0.1786	0.3750	0.5667	2	0.753			
Pig	**juvenile**	**SA/adult**			**juvenile**	**SA/adult**			**juvenile**	**SA/adult**					**juvenile**	**SA/adult**	
Early	2	13	15		6.923077	8.076923	15		3.5009	3.0007	6.5016				-1.87	1.73	
Florescent	20	20	40		18.46154	21.53846	40		0.1282	0.1099	0.2381				0.36	-0.33	
Late	20	16	36		16.61538	19.38462	36		0.6895	0.5910	1.2804				0.83	-0.77	
	42	49	91		42	49	91		4.3185	3.7016	**8.0201**		2	**0.018**			
Horse	**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**				**<5 yrs**	**5-10 yrs**	**>10 yrs**
Late*	3	1	4	8	2.666667	1.824561	3.508772	8	0.0417	0.3726	0.0688	0.4831			0.204	-0.61	0.26
Florescent	16	12	21	49	16.33333	11.17544	21.49123	49	0.0068	0.0608	0.0112	0.0789			-0.082	0.25	-0.11
	19	13	25	57	19	13	25	57	0.0485	0.4335	0.0800	0.5619	2	0.755			
Horse	**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**				**<5 yrs**	**5-10 yrs**	**>10 yrs**
Bone Piles*	0	3	1	4	1.306122	0.979592	1.714286	4	1.3061	4.1671	0.2976	5.7708			-1.14	**2.04**	-0.55
Florescent Other	16	9	20	45	14.69388	11.02041	19.28571	45	0.1161	0.3704	0.0265	0.5130			0.34	-0.61	0.16
	16	12	21	49	16	12	21	49	1.4222	4.5375	0.3241	**6.2838**	2	**0.043**			

note: statistically significant values in **bold**

*small sample

APPENDIX 9.9: Chi-square tests, body part representation by utility, taxon comparisons by phase and context

	Observed Values					Expected Values					Chi Square Values					df	p	Standardized Residuals			
Early Period	**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**				**OC**	**Pig**	**Cattle**	**Horse**
Higher Utility	223	99	48	13	383	218.2	91.892	62.43	10.522	383	0.108	0.5498	3.335	0.5836	4.57649			0.33	0.74	**-1.83**	0.76
Lower Utility	88	32	41	2	163	92.84	39.108	26.57	4.478	163	0.253	1.2919	7.837	1.3713	10.7534			-0.50	-1.14	**2.80**	-1.17
	311	131	89	15	546	311	131	89	15	546	0.36	1.8417	11.17	1.9549	**15.3298**	3	**0.002**				
Florescent	**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**				**OC**	**Pig**	**Cattle**	**Horse**
Higher Utility	416	333	160	261	1170	412.7	314.95	220.5	221.85	1170	0.027	1.0346	16.61	6.9084	24.5841			0.16	1.02	**-4.08**	**2.63**
Lower Utility	209	144	174	75	602	212.3	162.05	113.5	114.15	602	0.052	2.0107	32.29	13.427	47.7797			-0.23	-1.42	**5.68**	**-3.66**
	625	477	334	336	1772	625	477	334	336	1772	0.079	3.0452	48.9	20.335	**72.3637**	3	**0.000**				
Late Period	**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**				**OC**	**Pig**	**Cattle**	**Horse**
Higher Utility	345	293	119	36	793	331.9	267.32	151.9	41.863	793	0.516	2.4662	7.127	0.8211	10.93			0.72	1.57	**-2.67**	-0.91
Lower Utility	210	154	135	34	533	223.1	179.68	102.1	28.137	533	0.768	3.6693	10.6	1.2216	16.2616			-0.88	-1.92	**3.26**	1.11
	555	447	254	70	1326	555	447	254	70	1326	1.284	6.1355	17.73	2.0426	**27.1916**	3	**0.000**				
Off Tell	**OC**	**Pig**	**Cattle**			**OC**	**Pig**	**Cattle**			**OC**	**Pig**	**Cattle**					**OC**	**Pig**	**Cattle**	
Higher	20	12	0	32		17.66	9.931	4.414	32		0.311	0.431	4.414	5.1563				0.56	0.66	**-2.10**	
Lower	12	6	8	26		14.34	8.069	3.586	26		0.383	0.5305	5.432	6.3462				-0.62	-0.73	**2.33**	
	32	18	8	58		32	18	8	58		0.695	0.9615	9.846	**11.502**		2	**0.003**				
Early Period	**OC**	**Pig**				**OC**	**Pig**				**OC**	**Pig**						**OC**	**Pig**		
Higher Utility	223	99	322			226.6	95.434	322			0.056	0.1332	0.189					-0.24	0.36		
Lower Utility	88	32	120			84.43	35.566	120			0.151	0.3575	0.508					0.39	-0.60		
	311	131	442			311	131	442			0.207	0.4907	0.697			1	0.404				
Florescent	**OC**	**Pig**				**OC**	**Pig**				**OC**	**Pig**						**OC**	**Pig**		
Higher Utility	416	333	749			424.8	324.2	749			0.182	0.2386	0.421					-0.43	0.49		
Lower Utility	209	144	353			200.2	152.8	353			0.386	0.5063	0.893					0.62	-0.71		
	625	477	1102			625	477	1102			0.569	0.745	1.314			1	0.252				
Late Period	**OC**	**Pig**				**OC**	**Pig**				**OC**	**Pig**						**OC**	**Pig**		
Higher Utility	345	293	638			353.4	284.62	638			0.199	0.2469	0.446					-0.45	0.50		
Lower Utility	210	154	364			201.6	162.38	364			0.349	0.4328	0.781					0.59	-0.66		
	555	447	1002			555	447	1002			0.547	0.6797	1.227			1	0.268				

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Off Tell	**OC**	**Pig**		**OC**	**Pig**		**OC**	**Pig**				**OC**	**Pig**
Higher Utility	20	12	32	20.48	11.52	32	0.011	0.02	0.031			-0.11	0.14
Lower Utility	12	6	18	11.52	6.48	18	0.02	0.0356	0.056			0.14	-0.19
	32	18	50	32	18	50	0.031	0.0556	0.087	1	0.768		
Early Period	**Cattle**	**Horse**		**Cattle**	**Horse**		**Cattle**	**Horse**				**Cattle**	**Horse**
Higher Utility	48	13	61	52.2	8.7981	61	0.338	2.0068	2.345			-0.58	1.42
Lower Utility	41	2	43	36.8	6.2019	43	0.48	2.8469	3.327			0.69	**-1.69**
	89	15	104	89	15	104	0.818	4.8537	**5.672**	1	**0.017**		
Florescent	**Cattle**	**Horse**		**Cattle**	**Horse**		**Cattle**	**Horse**				**Cattle**	**Horse**
Higher Utility	160	261	421	209.9	211.13	421	11.85	11.78	23.63			**-3.44**	**3.43**
Lower Utility	174	75	249	124.1	124.87	249	20.04	19.918	39.96			**4.48**	**-4.46**
	334	336	670	334	336	670	31.89	31.698	**63.59**	1	**0.000**		
Late Period	**Cattle**	**Horse**		**Cattle**	**Horse**		**Cattle**	**Horse**				**Cattle**	**Horse**
Higher Utility	119	36	155	121.5	33.488	155	0.052	0.1885	0.24			-0.23	0.43
Lower Utility	135	34	169	132.5	36.512	169	0.048	0.1729	0.221			0.22	-0.42
	254	70	324	254	70	324	0.1	0.3614	0.461	1	0.497		

note: statistically significant values in **bold**

APPENDIX 9.10: Chi-square tests, body part representation, Florescent Period

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Mammals (all)	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	286	519	150	955	308.3	522.53	124.2	955	1.607	0.0239	5.354	6.9844			-1.27	-0.15	**2.31**
Axial	251	383	75	709	228.8	387.93	92.22	709	2.144	0.0628	3.214	5.4207			1.46	-0.25	-1.79
Lower Limb	92	181	33	306	98.77	167.43	39.8	306	0.464	1.0998	1.162	2.7256			-0.68	1.05	-1.08
Upper Limb	273	469	118	860	277.6	470.55	111.9	860	0.076	0.0051	0.338	0.4185			-0.28	-0.07	0.58
Foot	46	55	6	107	34.54	58.546	13.92	107	3.804	0.2147	4.504	8.5229			1.95	-0.46	**-2.12**
	948	1607	382	2937	948	1607	382	2937	8.095	1.4064	14.57	**24.072**	8	**0.002**			
Very High	239	403	86	728	231.9	400.58	95.56	728	0.219	0.0147	0.955	1.1894			0.47	0.12	-0.98
High	287	461	125	873	278.1	480.36	114.6	873	0.288	0.7803	0.946	2.0144			0.54	-0.88	0.97
Medium	79	134	34	247	78.67	135.91	32.42	247	0.001	0.0268	0.077	0.1052			0.04	-0.16	0.28
Low	197	407	93	697	222	383.52	91.49	697	2.814	1.4378	0.025	4.2773			-1.68	1.20	0.16
Very Low	57	79	16	152	48.41	83.637	19.95	152	1.523	0.257	0.782	2.5628			1.23	-0.51	-0.88
	859	1484	354	2697	859	1484	354	2697	4.846	2.5166	2.786	10.149	8	0.255			
Higher	605	998	245	1848	588.6	1016.8	242.6	1848	0.457	0.3493	0.024	0.8312			0.68	-0.59	0.16
Lower	254	486	109	849	270.4	467.15	111.4	849	0.996	0.7602	0.053	1.8092			-1.00	0.87	-0.23
	859	1484	354	2697	859	1484	354	2697	1.453	1.1095	0.078	2.6403	2	0.267			

Ovicaprid	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	38	55	26	119	39.58	57.872	21.55	119	0.063	0.1425	0.921	1.1269			-0.25	-0.38	0.96
Axial	0	3	0	3	0.998	1.4589	0.543	3	0.998	1.6278	0.543	3.1688			-1.00	1.28	-0.74
Lower Limb	85	107	44	236	78.5	114.77	42.73	236	0.538	0.5261	0.038	1.102			0.73	-0.73	0.19
Upper Limb	34	63	15	112	37.25	54.467	20.28	112	0.284	1.3367	1.374	2.9948			-0.53	1.16	-1.17
Foot	1	3	1	5	1.663	2.4316	0.905	5	0.264	0.1329	0.01	0.4072			-0.51	0.36	0.10
	158	231	86	475	158	231	86	475	2.148	3.7659	2.886	8.7997	8	0.359			
Very High	17	24	9	50	16.67	23.995	9.338	50	0.007	9E-07	0.012	0.0189			0.08	0.00	-0.11
High	52	86	38	176	58.67	84.463	32.87	176	0.758	0.028	0.801	1.5862			-0.87	0.17	0.89
Medium	31	17	10	58	19.33	27.835	10.83	58	7.04	4.2173	0.064	11.321			**2.65**	**-2.05**	-0.25
Low	40	71	20	131	43.67	62.868	24.47	131	0.308	1.052	0.815	2.175			-0.55	1.03	-0.90
Very Low	1	5	2	8	2.667	3.8392	1.494	8	1.042	0.3509	0.171	1.5639			-1.02	0.59	0.41
	141	203	79	423	141	203	79	423	9.154	5.6482	1.863	**16.665**	8	**0.034**			
Higher	100	127	57	284	94.67	136.29	53.04	284	0.3	0.6337	0.296	1.2297			0.55	-0.80	0.54
Lower	41	76	22	139	46.33	66.707	25.96	139	0.614	1.2947	0.604	2.5126			-0.78	1.14	-0.78
	141	203	79	423	141	203	79	423	0.914	1.9283	0.9	3.7423	2	0.154			

	Observed Values				**Expected Values**				**Chi Square Values**				**df**	**p**	**Standardized Residuals**		
Pig	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	61	85	22	168	62.21	83.546	22.25	168	0.023	0.0253	0.003	0.0514			-0.15	0.16	-0.05
Axial	7	11	1	19	7.035	9.4486	2.516	19	2E-04	0.2547	0.914	1.1685			-0.01	0.50	-0.96
Lower Limb	49	66	22	137	50.73	68.13	18.14	137	0.059	0.0666	0.82	0.9452			-0.24	-0.26	0.91
Upper Limb	10	17	3	30	11.11	14.919	3.973	30	0.111	0.2903	0.238	0.6391			-0.33	0.54	-0.49
Foot	10	5	1	16	5.924	7.9568	2.119	16	2.804	1.0987	0.591	4.4935			1.67	-1.05	-0.77
	137	184	49	370	137	184	49	370	2.997	1.7356	2.565	7.2978	8	0.505			
Very High	19	27	6	52	19.09	26.329	6.582	52	4E-04	0.0171	0.052	0.069			-0.02	0.13	-0.23
High	45	58	17	120	44.05	60.759	15.19	120	0.02	0.1253	0.216	0.3615			0.14	-0.35	0.46
Medium	15	16	5	36	13.22	18.228	4.557	36	0.241	0.2723	0.043	0.5564			0.49	-0.52	0.21
Low	27	54	11	92	33.77	46.582	11.65	92	1.358	1.1812	0.036	2.575			-1.17	1.09	-0.19
Very Low	10	5	1	16	5.873	8.1013	2.025	16	2.899	1.1872	0.519	4.6055			1.70	-1.09	-0.72
	116	160	40	316	116	160	40	316	4.519	2.7831	0.865	8.1674	8	0.417			
Higher	79	101	28	208	76.35	105.32	26.33	208	0.092	0.1769	0.106	0.3746			0.30	-0.42	0.33
Lower	37	59	12	108	39.65	54.684	13.67	108	0.177	0.3407	0.204	0.7215			-0.42	0.58	-0.45
	116	160	40	316	116	160	40	316	0.268	0.5176	0.31	1.0961	2	0.578			

Cattle	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	26	51	18	95	27.46	53.066	14.47	95	0.078	0.0805	0.86	1.0179			-0.28	-0.28	0.93
Axial	4	3	1	8	2.313	4.4688	1.219	8	1.231	0.4827	0.039	1.7534			1.11	-0.69	-0.20
Lower Limb	19	44	11	74	21.39	41.336	11.27	74	0.267	0.1717	0.007	0.4455			-0.52	0.41	-0.08
Upper Limb	15	31	7	53	15.32	29.605	8.074	53	0.007	0.0657	0.143	0.2153			-0.08	0.26	-0.38
Foot	10	14	2	26	7.516	14.523	3.961	26	0.821	0.0189	0.971	1.8109			0.91	-0.14	-0.99
	74	143	39	256	74	143	39	256	2.404	0.8195	2.019	5.243	8	0.731			
Very High	6	14	5	25	6.726	14.35	3.924	25	0.078	0.0085	0.295	0.3822			-0.28	-0.09	0.54
High	18	26	7	51	13.72	29.274	8.004	51	1.334	0.3661	0.126	1.8259			1.15	-0.61	-0.36
Medium	6	22	4	32	8.61	18.368	5.022	32	0.791	0.7183	0.208	1.7176			-0.89	0.85	-0.46
Low	18	37	15	70	18.83	40.179	10.99	70	0.037	0.2516	1.466	1.7547			-0.19	-0.50	1.21
Very Low	12	29	4	45	12.11	25.83	7.063	45	1E-03	0.3891	1.328	1.7183			-0.03	0.62	-1.15
	60	128	35	223	60	128	35	223	2.241	1.7336	3.424	7.3985	8	0.494			
Higher	30	62	16	108	29.06	61.991	16.95	108	0.031	1E-06	0.053	0.0838			0.17	0.00	-0.23
Lower	30	66	19	115	30.94	66.009	18.05	115	0.029	1E-06	0.05	0.0787			-0.17	0.00	0.22
	60	128	35	223	60	128	35	223	0.059	3E-06	0.103	0.1626	2	0.922			

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Horse	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Very High	7	39	6	52	10.72	36.718	4.565	52	1.289	0.1419	0.451	1.8825			-1.14	0.38	0.67
High	13	49	6	68	14.02	48.015	5.969	68	0.074	0.0202	2E-04	0.0939			-0.27	0.14	0.01
Medium	15	69	10	94	19.37	66.374	8.252	94	0.988	0.1039	0.37	1.4617			-0.99	0.32	0.61
Low	9	15	0	24	4.947	16.947	2.107	24	3.322	0.2236	2.107	5.652			1.82	-0.47	-1.45
Very Low	10	13	1	24	4.947	16.947	2.107	24	5.163	0.9191	0.582	6.6632			**2.27**	-0.96	-0.76
	54	185	23	262	54	185	23	262	10.83	1.4086	3.51	**15.753**	8	**0.046**			
Higher	35	157	22	214	44.11	151.11	18.79	214	1.88	0.2298	0.55	2.6599			-1.37	0.48	0.74
Lower	19	28	1	48	9.893	33.893	4.214	48	8.383	1.0247	2.451	11.859			**2.90**	-1.01	-1.57
	54	185	23	262	54	185	23	262	10.26	1.2545	3.001	**14.519**	2	**0.001**			

note: statistically significant values in **bold**

APPENDIX 9.11: Chi-square tests, body part representation, Late Period

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammals (all)	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	339	714	1053	291.3061	761.6939	1053	7.8086	2.9864	10.7950			**2.79**	-1.73
Axial	279	678	957	264.7483	692.2517	957	0.7672	0.2934	1.0606			0.88	-0.54
Lower Limb	127	338	465	128.6395	336.3605	465	0.0209	0.0080	0.0289			-0.14	0.09
Upper Limb	305	1022	1327	367.1066	959.8934	1327	10.5071	4.0184	14.5255			**-3.24**	**2.00**
Foot	48	119	167	46.19955	120.8005	167	0.0702	0.0268	0.0970			0.26	-0.16
	1098	2871	3969	1098	2871	3969	19.1740	7.3330	**26.5070**	4	**0.000**		
Very High	244	696	940	256.7109	683.2891	940	0.6294	0.2365	0.8658			-0.79	0.49
High	328	927	1255	342.7364	912.2636	1255	0.6336	0.2380	0.8717			-0.80	0.49
Medium	102	314	416	113.6082	302.3918	416	1.1861	0.4456	1.6317			-1.09	0.67
Low	268	581	849	231.8591	617.1409	849	5.6334	2.1165	7.7499			**2.37**	-1.45
Very Low	66	165	231	63.08534	167.9147	231	0.1347	0.0506	0.1853			0.37	-0.22
	1008	2683	3691	1008	2683	3691	8.2172	3.0872	**11.3044**	4	**0.023**		
Higher	674	1937	2611	713.0555	1897.944	2611	2.1392	0.8037	2.9428			-1.46	0.90
Lower	334	746	1080	294.9445	785.0555	1080	5.1716	1.9430	7.1146			**2.27**	-1.39
	1008	2683	3691	1008	2683	3691	7.3108	2.7466	**10.0574**	1	**0.002**		
Ovicaprid	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	56	184	240	53.9207	186.0793	240	0.0802	0.0232	0.1034			0.28	-0.15
Axial	4	2	6	1.348018	4.651982	6	5.2173	1.5118	6.7291			**2.28**	-1.23
Lower Limb	41	209	250	56.1674	193.8326	250	4.0958	1.1868	5.2826			**-2.02**	1.09
Upper Limb	46	125	171	38.4185	132.5815	171	1.4961	0.4335	1.9297			1.22	-0.66
Foot	6	8	14	3.145374	10.85463	14	2.5908	0.7507	3.3415			1.61	-0.87
	153	528	681	153	528	681	13.4802	3.9062	**17.3863**	4	**0.002**		
Very High	7	32	39	8.081081	30.91892	39	0.1446	0.0378	0.1824			-0.38	0.19
High	30	160	190	39.36937	150.6306	190	2.2298	0.5828	2.8126			-1.49	0.76
Medium	24	92	116	24.03604	91.96396	116	0.0001	0.0000	0.0001			-0.01	0.00
Low	46	144	190	39.36937	150.6306	190	1.1167	0.2919	1.4086			1.06	-0.54
Very Low	8	12	20	4.144144	15.85586	20	3.5876	0.9377	4.5253			1.89	-0.97
	115	440	555	115	440	555	7.0788	1.8501	8.9290	4	0.063		
Higher	61	284	345	71.48649	273.5135	345	1.5383	0.4021	1.9403			-1.24	0.63
Lower	54	156	210	43.51351	166.4865	210	2.5272	0.6605	3.1877			1.59	-0.81
	115	440	555	115	440	555	4.0655	1.0626	**5.1280**	1	**0.024**		

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Pig	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	72	116	188	55.78862	132.2114	188	4.7108	1.9878	6.6986			**2.17**	-1.41
Axial	0	5	5	1.48374	3.51626	5	1.4837	0.6261	2.1098			-1.22	0.79
Lower Limb	45	168	213	63.20732	149.7927	213	5.2447	2.2131	7.4578			**-2.29**	1.49
Upper Limb	16	41	57	16.91463	40.08537	57	0.0495	0.0209	0.0703			-0.22	0.14
Foot	13	16	29	8.605691	20.39431	29	2.2439	0.9468	3.1907			1.50	-0.97
	146	346	492	146	346	492	13.7326	5.7947	**19.5273**	4	**0.001**		
Very High	4	43	47	13.6689	33.3311	47	6.8394	2.8048	9.6443			**-2.62**	1.67
High	57	135	192	55.83893	136.1611	192	0.0241	0.0099	0.0340			0.16	-0.10
Medium	11	43	54	15.7047	38.2953	54	1.4094	0.5780	1.9874			-1.19	0.76
Low	45	80	125	36.35347	88.64653	125	2.0565	0.8434	2.8999			1.43	-0.92
Very Low	13	16	29	8.434004	20.566	29	2.4719	1.0137	3.4857			1.57	-1.01
	130	317	447	130	317	447	12.8015	5.2498	**18.0513**	4	**0.001**		
Higher	72	221	293	85.21253	207.7875	293	2.0487	0.8401	2.8888			-1.43	0.92
Lower	58	96	154	44.78747	109.2125	154	3.8978	1.5985	5.4962			**1.97**	-1.26
	130	317	447	130	317	447	5.9464	2.4386	**8.3850**	1	**0.004**		
Cattle	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	33	73	106	27.0129	78.9871	106	1.3270	0.4538	1.7808			1.15	-0.67
Axial	4	6	10	2.548387	7.451613	10	0.8269	0.2828	1.1096			0.91	-0.53
Lower Limb	14	57	71	18.09355	52.90645	71	0.9261	0.3167	1.2429			-0.96	0.56
Upper Limb	19	56	75	19.1129	55.8871	75	0.0007	0.0002	0.0009			-0.03	0.02
Foot	9	39	48	12.23226	35.76774	48	0.8541	0.2921	1.1462			-0.92	0.54
	79	231	310	79	231	310	3.9347	1.3456	5.2804	4	0.260		
Very High	3	11	14	3.141732	10.85827	14	0.0064	0.0019	0.0082			-0.08	0.04
High	8	46	54	12.11811	41.88189	54	1.3995	0.4049	1.8044			-1.18	0.64
Medium	15	36	51	11.44488	39.55512	51	1.1043	0.3195	1.4239			1.05	-0.57
Low	20	62	82	18.40157	63.59843	82	0.1388	0.0402	0.1790			0.37	-0.20
Very Low	11	42	53	11.8937	41.1063	53	0.0672	0.0194	0.0866			-0.26	0.14
	57	197	254	57	197	254	2.7162	0.7859	3.5021	4	0.478		
Higher	26	93	119	26.70472	92.29528	119	0.0186	0.0054	0.0240			-0.14	0.07
Lower	31	104	135	30.29528	104.7047	135	0.0164	0.0047	0.0211			0.13	-0.07
	57	197	254	57	197	254	0.0350	0.0101	0.0451	1	0.832		
Horse	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Higher	5	31	36	7.2	28.8	36	0.6722	0.1681	0.8403			-0.82	0.41
Lower	9	25	34	6.8	27.2	34	0.7118	0.1779	0.8897			0.84	-0.42
	14	56	70	14	56	70	1.3840	0.3460	1.7300	1	0.188		

note: statistically significant values in **bold**

APPENDIX 9.12: Chi-square tests, body part representation, period comparisons (on-tell)

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Mammals (all)	**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Head	1053	1393	293	2739	1163.06	1299.03	276.918	2739	10.4143	6.7984	0.9339	18.1467			**-3.23**	**2.61**	0.97
Axial	957	1173	131	2261	960.084	1072.32	228.592	2261	0.0099	9.4520	41.6643	51.1262			-0.10	**3.07**	**-6.45**
Lower Limb	465	473	142	1080	458.598	512.211	109.19	1080	0.0894	3.0018	9.8588	12.9500			0.30	-1.73	**3.14**
Upper Limb	1327	1232	344	2903	1232.7	1376.81	293.499	2903	7.2145	15.2299	8.6895	31.1339			**2.69**	**-3.90**	**2.95**
Foot	167	162	35	364	154.565	172.634	36.8011	364	1.0005	0.6551	0.0881	1.7437			1.00	-0.81	-0.30
	3969	4433	945	9347	3969	4433	945	9347	18.7286	35.1371	61.2347	**115.1004**	8	**0.000**			
Very High	940	1150	186	2276	976.487	1072.26	227.256	2276	1.3633	5.6367	7.4896	14.4896			-1.17	**2.37**	**-2.74**
High	1255	1311	314	2880	1235.62	1356.81	287.565	2880	0.3038	1.5467	2.4301	4.2807			0.55	-1.24	1.56
Medium	416	369	82	867	371.975	408.456	86.569	867	5.2107	3.8115	0.2411	9.2633			**2.28**	-1.95	-0.49
Low	849	1000	231	2080	892.396	979.919	207.686	2080	2.1103	0.4115	2.6172	5.1390			-1.45	0.64	1.62
Very Low	231	223	46	500	214.518	235.557	49.9244	500	1.2663	0.6694	0.3085	2.2442			1.13	-0.82	-0.56
	3691	4053	859	8603	3691	4053	859	8603	10.2544	12.0758	13.0866	**35.4168**	8	**0.000**			
Higher	2611	2830	582	6023	2584.09	2837.52	601.39	6023	0.2803	0.0200	0.6252	0.9254			0.53	-0.14	-0.79
Lower	1080	1223	277	2580	1106.91	1215.48	257.61	2580	0.6544	0.0466	1.4594	2.1604			-0.81	0.22	1.21
	3691	4053	859	8603	3691	4053	859	8603	0.9347	0.0665	2.0846	3.0858	2	0.214			
Ovicaprid	**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Head	240	214	105	559	214.226	228.696	116.078	559	3.1010	0.9444	1.0573	5.1027			1.76	-0.97	-1.03
Axial	6	4	1	11	4.21553	4.50028	2.28419	11	0.7554	0.0556	0.7220	1.5330			0.87	-0.24	-0.85
Lower Limb	250	329	180	759	290.872	310.519	157.609	759	5.7431	1.0999	3.1810	10.0240			**-2.40**	1.05	1.78
Upper Limb	171	173	80	424	162.49	173.465	88.045	424	0.4457	0.0012	0.7351	1.1821			0.67	-0.04	-0.86
Foot	14	7	3	24	9.19752	9.8188	4.98368	24	2.5076	0.8092	0.7896	4.1064			1.58	-0.90	-0.89
	681	727	369	1777	681	727	369	1777	12.5528	2.9103	6.4850	**21.9481**	8	**0.005**			
Very High	39	73	44	156	58.0684	65.3924	32.5392	156	6.2617	0.8851	4.0366	11.1834			**-2.50**	0.94	**2.01**
High	190	258	141	589	219.245	246.898	122.856	589	3.9011	0.4992	2.6794	7.0798			**-1.98**	0.71	1.64
Medium	116	85	38	239	88.9638	100.184	49.8518	239	8.2163	2.3014	2.8176	13.3354			**2.87**	-1.52	-1.68
Low	190	198	85	473	176.066	198.273	98.6606	473	1.1027	0.0004	1.8915	2.9945			1.05	-0.02	-1.38
Very Low	20	11	3	34	12.6559	14.2522	7.09188	34	4.2617	0.7421	2.3609	7.3647			**2.06**	-0.86	-1.54
	555	625	311	1491	555	625	311	1491	23.7434	4.4282	13.7861	**41.9578**	8	**0.000**			
Higher	345	416	223	984	366.278	412.475	205.247	984	1.2361	0.0301	1.5355	2.8017			-1.11	0.17	1.24
Lower	210	209	88	507	188.722	212.525	105.753	507	2.3990	0.0585	2.9801	5.4375			1.55	-0.24	-1.73
	555	625	311	1491	555	625	311	1491	3.6350	0.0886	4.5156	**8.2392**	2	**0.016**			

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Pig	**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Head	188	245	40	473	196.717	219.907	56.3762	473	0.3863	2.8633	4.7570	8.0065			-0.62	1.69	**-2.18**
Axial	5	20	3	28	11.645	13.0178	3.33728	28	3.7918	3.7450	0.0341	7.5709			-1.95	1.94	-0.18
Lower Limb	213	223	77	513	213.352	238.504	61.1437	513	0.0006	1.0078	4.1120	5.1204			-0.02	-1.00	**2.03**
Upper Limb	57	41	17	115	47.8276	53.4658	13.7067	115	1.7591	2.9064	0.7913	5.4568			1.33	-1.70	0.89
Foot	29	21	4	54	22.4582	25.1057	6.43618	54	1.9056	0.6714	0.9221	3.4991			1.38	-0.82	-0.96
	492	550	141	1183	492	550	141	1183	7.8433	11.1940	10.6164	**29.6538**	8	**0.000**			
Very High	47	70	18	135	57.1991	61.0379	16.763	135	1.8186	1.3159	0.0913	3.2257			-1.35	1.15	0.30
High	192	211	63	466	197.443	210.694	57.8635	466	0.1500	0.0004	0.4560	0.6064			-0.39	0.02	0.68
Medium	54	52	18	124	52.5384	56.0645	15.3972	124	0.0407	0.2947	0.4400	0.7753			0.20	-0.54	0.66
Low	125	123	28	276	116.94	124.789	34.2711	276	0.5555	0.0256	1.1475	1.7286			0.75	-0.16	-1.07
Very Low	29	21	4	54	22.8796	24.4152	6.70521	54	1.6372	0.4777	1.0914	3.2063			1.28	-0.69	-1.04
	447	477	131	1055	447	477	131	1055	4.2020	2.1143	3.2262	9.5425	8	0.299			
Higher	293	333	99	725	307.18	327.796	90.0237	725	0.6546	0.0826	0.8950	1.6322			-0.81	0.29	0.95
Lower	154	144	32	330	139.82	149.204	40.9763	330	1.4381	0.1815	1.9664	3.5860			1.20	-0.43	-1.40
	447	477	131	1055	447	477	131	1055	2.0927	0.2641	2.8614	5.2182	2	0.074			

Cattle	**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**df**	**p**	**Late**	**Flor.**	**Early**
Head	106	143	46	295	112.901	143.858	38.2407	295	0.4218	0.0051	1.5744	2.0014			-0.65	-0.07	1.25
Axial	10	11	4	25	9.5679	12.1914	3.24074	25	0.0195	0.1164	0.1779	0.3138			0.14	-0.34	0.42
Lower Limb	71	111	19	201	76.9259	98.0185	26.0556	201	0.4565	1.7193	1.9106	4.0863			-0.68	1.31	-1.38
Upper Limb	75	82	20	177	67.7407	86.3148	22.9444	177	0.7779	0.2157	0.3779	1.3715			0.88	-0.46	-0.61
Foot	48	48	16	112	42.8642	54.6173	14.5185	112	0.6153	0.8017	0.1512	1.5683			0.78	-0.90	0.39
	310	395	105	810	310	395	105	810	2.2911	2.8582	4.1919	9.3412	8	0.314			
Very High	14	28	7	49	18.384	24.1743	6.44165	49	1.0455	0.6054	0.0484	1.6993			-1.02	0.78	0.22
High	54	72	30	156	58.5288	76.9631	20.5081	156	0.3504	0.3201	4.3932	5.0636			-0.59	-0.57	2.10
Medium	51	60	11	122	45.7725	60.1891	16.0384	122	0.5970	0.0006	1.5828	2.1804			0.77	-0.02	-1.26
Low	82	104	18	204	76.5377	100.644	26.8183	204	0.3898	0.1119	2.8996	3.4014			0.62	0.33	-1.70
Very Low	53	70	23	146	54.777	72.0295	19.1935	146	0.0576	0.0572	0.7549	0.8697			-0.24	-0.24	0.87
	254	334	89	677	254	334	89	677	2.4404	1.0952	9.6789	13.2144	8	0.105			
Higher	119	160	48	327	122.685	161.326	42.9882	327	0.1107	0.0109	0.5843	0.7059			-0.33	-0.10	0.76
Lower	135	174	41	350	131.315	172.674	46.0118	350	0.1034	0.0102	0.5459	0.6595			0.32	0.10	-0.74
	254	334	89	677	254	334	89	677	0.2141	0.0211	1.1302	1.3654	2	0.505			

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Horse	**Late**	**Flor.**			**Late**	**Flor.**			**Late**	**Flor.**					**Late**	**Flor.**	
Head	20	126	146		24.6761	121.324	146		0.8861	0.1802	1.0663				-0.94	0.42	
Axial	4	17	21		3.5493	17.4507	21		0.0572	0.0116	0.0689				0.24	-0.11	
Lower Limb	23	170	193		32.6197	160.38	193		2.8369	0.5770	3.4139				-1.68	0.76	
Upper Limb	22	68	90		15.2113	74.7887	90		3.0298	0.6162	3.6460				1.74	-0.79	
Foot	15	32	47		7.94366	39.0563	47		6.2681	1.2749	7.5430				**2.50**	-1.13	
	84	413	497		84	413	497		13.0782	2.6600	**15.7381**		4	**0.003**			
Very High	8	61	69		11.8966	57.1034	69		1.2763	0.2659	1.5421				-1.13	0.52	
High	13	84	97		16.7241	80.2759	97		0.8293	0.1728	1.0021				-0.91	0.42	
Medium	15	116	131		22.5862	108.414	131		2.5480	0.5308	3.0789				-1.60	0.73	
Low	19	43	62		10.6897	51.3103	62		6.4606	1.3460	7.8066				**2.54**	-1.16	
Very Low	15	32	47		8.10345	38.8966	47		5.8694	1.2228	7.0922				**2.42**	-1.11	
	70	336	406		70	336	406		16.9836	3.5383	**20.5219**		4	**0.000**			
Horse	**Late (**	**Flor.**	**arly**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Higher	36	261	13	310	51.5439	247.411	11.0451	310	4.6875	0.7464	0.3460	5.7799			**-2.17**	0.86	0.59
Lower	34	75	2	111	18.4561	88.5891	3.95487	111	13.0913	2.0845	0.9663	16.1421			**3.62**	-1.44	-0.98
	70	336	15	421	70	336	15	421	17.7789	2.8309	1.3123	**21.9220**	2	**0.000**			

note: statistically significant values in **bold**

APPENDIX 9.13: Chi-square tests, body part representation, on- versus off-tell

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammals (all)	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Head	840	36	876	828.303	47.6968	876	0.1652	2.8684	3.0336			0.41	-1.69
Axial	670	48	718	678.906	39.094	718	0.1168	2.0289	2.1457			-0.34	1.42
Lower Limb	287	25	312	295.012	16.9879	312	0.2176	3.7788	3.9964			-0.47	1.94
Upper Limb	755	35	790	746.986	43.0142	790	0.0860	1.4932	1.5792			0.29	-1.22
Foot	105	9	114	107.793	6.20712	114	0.0724	1.2567	1.3290			-0.27	1.12
	2657	153	2810	2657	153	2810	0.6579	11.4260	**12.0839**	4	**0.017**		
Very High	669	29	698	662.254	35.7459	698	0.0687	1.2731	1.3418			0.26	-1.13
High	772	41	813	771.365	41.6353	813	0.0005	0.0097	0.0102			0.02	-0.10
Medium	221	8	229	217.272	11.7275	229	0.0639	1.1848	1.2487			0.25	-1.09
Low	623	39	662	628.098	33.9023	662	0.0414	0.7665	0.8079			-0.20	0.88
Very Low	142	14	156	148.011	7.98905	156	0.2441	4.5226	4.7667			-0.49	2.13
	2427	131	2558	2427	131	2558	0.4187	7.7567	8.1754	4	0.085		
Higher	1662	78	1740	1650.89	89.1087	1740	0.0747	1.3849	1.4596			0.27	-1.18
Lower	765	53	818	776.109	41.8913	818	0.1590	2.9458	3.1048			-0.40	1.72
	2427	131	2558	2427	131	2558	0.2338	4.3306	**4.5644**	1	**0.033**		
Ovicaprid	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Very High	41	2	43	39.4352	3.56477	43	0.0621	0.6869	0.7489			0.25	-0.83
High	139	13	152	139.399	12.601	152	0.0011	0.0126	0.0138			-0.03	0.11
Medium	52	5	57	52.2746	4.72539	57	0.0014	0.0160	0.0174			-0.04	0.13
Low	115	11	126	115.554	10.4456	126	0.0027	0.0294	0.0321			-0.05	0.17
Very Low	7	1	8	7.33679	0.66321	8	0.0155	0.1710	0.1865			-0.12	0.41
	354	32	386	354	32	386	0.0828	0.9159	0.9987	4	0.910		
Higher	232	20	252	231.109	20.8912	252	0.0034	0.0380	0.0415			0.06	-0.19
Lower	122	12	134	122.891	11.1088	134	0.0065	0.0715	0.0780			-0.08	0.27
	354	32	386	354	32	386	0.0099	0.1095	0.1194	1	0.730		

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Pig	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Higher	185	12	197	185.18	11.82	197	0.0002	0.0027	0.0029			-0.01	0.05
Lower	97	6	103	96.82	6.18	103	0.0003	0.0052	0.0056			0.02	-0.07
	282	18	300	282	18	300	0.0005	0.0080	0.0085	1	0.927		
Cattle	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Higher	93	0	93	89.3168	3.68317	93	0.1519	3.6832	3.8351			0.39	-1.92
Lower	101	8	109	104.683	4.31683	109	0.1296	3.1425	3.2721			-0.36	1.77
	194	8	202	194	8	202	0.2815	6.8257	**7.1072**	1	**0.008**		

note: statistically significant values in **bold**

APPENDIX 10.1: Wild plant communities represented at Pecica (classification follows Ellenberg 1988)

Type I	Type II	Community Name	Type III	Taxon	Common name	Late	Flor.
freshwater and mire	reed/tall sedge swamp	Magnocaricion	tall sedge swamp	*Galium cf. palustre*	common marsh-bedstraw		1
herbaceous/frequently disturbed	bur marigold mud bank	Bidention tripatitae	bur marigold (narrow)	*Polygonum cf. hydropiper*	swamp smartweed		1
		Chenopodium rubri	Orache community	*Chenopodium glaucum*	oak-leaved goosefoot		2
	arable/waste land and garden weeds	Chenopodietea		*cf. Solanum nigrum*	black nightshade		1
				Portulaca oleracea	common purslane	1	1
				Chenopodium album	white goosefoot	56	71
		Sisymbrietalia	short-lived ruderals	*Chenopodium cf. hybridum*	maple-leaved goosefoot		6
				Malva cf. neglecta	common mallow	3	2
				Bromus cf. tectorum	downy brome		4
				Hordeum murinum	wall barley	1	
				Brassica sp.	mustard (non ID)	1	2
		Polygono-Chenopodietalia	rich arable soils and garden weeds	*Chenopodium cf. polyspermum*	many-seeded goosefoot		6
		Fumario-Euphorbion	demanding arable and garden, base rich soils	*Atriplex cf. patula*	common orache		1
	persistent nitrophilous ruderals	Calystegion	veil and riverbank	*Rubus caesius*	European dewberry	1	
				Saponaria officinalis cf.	common soapwort		1
				Cucubalus cf.	bladder campion	1	
		Aegopodion	semi-shade fringe adj. to woody plants	*Sambucus cf. ebulus*	European dwarf elder	3	9
	couch grass pioneer dry habitats	Convolvulo-Agropyrion		*Poa cf. compressa*	flattened meadowgrass		1
	swards pathways and flooded	Agrostietalia stoloniferae	pioneer swards flooded and damp	*Rumex crispus*	curley dock		1
heaths/grassslands human/animal activity	matgrass pastures/dwarf shrub heath	Violo-Nardion	matgrass swards lower levels	*Festuca cf. tenuifolia/ pseudovina*	sheep's fescue	1	
	more or less arid poor Ca soils	Festucetalia valesiaceae	continental more or less arid	*Stipa sp.*	needlegrass	3	1
	cultivated meadow and pasture	Molinio-Arrhenatheretea		*Plantago cf. lanceolata*	ribwort platain	2	
				Festuca pratensis	meadow fescue		1
				Rumex acetosella	sheep's sorrel		4
		Molinietalia	moist meadow and stream bank	*Lychnis flos-cuculi*	ragged robin		1
		Arrhenatherion	oatgrass meadows	Arrhenatherum cf.	oat grass	3	
		Cynosurion	ryegrass-crested dogstail meadows	*Hordeum cf. secalinum*	knotted barley grass		1
				Trifolium cf. repens	white clover		1
woodland herbaceous perennial/shrub	woodland clearing	Epilobietea augustifolii, Atropetalia		*Fragaria vesca/potentilla*	wild strawberry	1	
		Sambuco-Salicion capreae	woodland clearing shrub	*Sambucus cf. racemosa*	European red elder		5
broadleaf woodland	broadleaved woods and scrub fertile soils	Querco-Fagetea		*Moehringia trinervia cf.*	three-nerved sandwort	12	27
(multiple but narrow ecological range)		(woodland)		*Teucrium cf. scorodonia*	woodland germander	3	6
				Carex cf. flacca	blue sedge	1	1
				Silene dioica	red campion	1	
		(woodland/fens/ clearances)		*Deschampsia caespitosa cf.*	tussock grass		1
				Rubus cf. idaeus	European red raspberry		1
		(fens/floodplain)		*Solanum cf. dulcamara*	bitter nightshade		2
		(semi-arid grassland)		*cf. Brachypodium pinnatum*	tor-grass	4	

APPENDIX 10.2: Chi-square statistics, period comparisons, general botanical assemblage (all Florescent Period contexts)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
einkorn wheat	69	369	438	75.6754	362.325	438	0.5888	0.1230	0.7118			-0.77	0.35
other ID wheat	8	16	24	4.1466	19.8534	24	3.5809	0.7479	4.3289			1.89	-0.86
barley	22	89	111	19.178	91.822	111	0.4152	0.0867	0.5020			0.64	-0.29
	99	474	573	99	474	573	4.5850	0.9576	5.5427	2	0.063		
wheats (all)	132	470	602	134.165	467.835	602	0.0349	0.0100	0.0450			-0.19	0.10
barley	22	67	89	19.835	69.165	89	0.2363	0.0678	0.3041			0.49	-0.26
	154	537	691	154	537	691	0.2712	0.0778	0.3490	1	0.555		
grain	245	701	946	225.098	720.902	946	1.7596	0.5494	2.3091			1.33	-0.74
chaff	61	279	340	80.902	259.098	340	4.8959	1.5287	6.4247			**-2.21**	1.24
	306	980	1286	306	980	1286	6.6556	2.0782	**8.7337**	1	**0.003**		
crop seeds	309	1005	1314	369.146	944.854	1314	9.7998	3.8287	13.6285			**-3.13**	**1.96**
wild seeds	245	413	658	184.854	473.146	658	19.5698	7.6457	27.2155			**4.42**	**-2.77**
	554	1418	1972	554	1418	1972	29.3695	11.4744	**40.8439**	1	**0.000**		
chenopod	98	155	253	91.5619	161.438	253	0.4527	0.2567	0.7094			0.67	-0.51
grass	68	131	199	72.019	126.981	199	0.2243	0.1272	0.3515			-0.47	0.36
carnation	15	30	45	16.2857	28.7143	45	0.1015	0.0576	0.1591			-0.32	0.24
buckwheat	26	10	36	13.0286	22.9714	36	12.9145	7.3247	20.2392			**3.59**	**-2.71**
other	21	76	97	35.1048	61.8952	97	5.6672	3.2142	8.8814			**-2.38**	1.79
	228	402	630	228	402	630	19.3602	10.9804	**30.3406**	4	**0.000**		
rose/elderberry	6	22	28	6.06186	21.9381	28	0.0006	0.0002	0.0008			-0.03	0.01
sedges	5	6	11	2.38144	8.61856	11	2.8793	0.7956	3.6749			1.70	-0.89
clover/wild legumes	3	18	21	4.54639	16.4536	21	0.5260	0.1453	0.6713			-0.73	0.38
nightshade/mint	7	30	37	8.01031	28.9897	37	0.1274	0.0352	0.1626			-0.36	0.19
	21	76	97	21	76	97	3.5333	0.9763	4.5096	3	0.211		
annual	63	99	162	61.8423	100.158	162	0.0217	0.0134	0.0351			0.15	-0.12
perennial	29	50	79	30.1577	48.8423	79	0.0444	0.0274	0.0719			-0.21	0.17
	92	149	241	92	149	241	0.0661	0.0408	0.1069	1	0.744		
winter weeds	0	6	6	2.34437	3.65563	6	2.3444	1.5035	3.8478			-1.53	1.23
spring weeds	59	86	145	56.6556	88.3444	145	0.0970	0.0622	0.1592			0.31	-0.25
	59	92	151	59	92	151	2.4414	1.5657	**4.0070**	1	**0.045**		

note: statistically significant values in **bold**

APPENDIX 10.3: Chi-square statistics, period comparisons, general botanical assemblage (on-tell Florescent Period contexts only, no platform)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
einkorn wheat	69	229	298	78.672	219.328	298	1.1891	0.4265	1.6156			-1.09	0.65
other ID wheat	8	6	14	3.696	10.304	14	5.0120	1.7978	6.8098			**2.24**	-1.34
barley	22	41	63	16.632	46.368	63	1.7325	0.6215	2.3540			1.32	-0.79
	99	276	375	99	276	375	7.9336	2.8458	**10.7794**	2	**0.005**		
wheats (all)	132	356	488	136.392	351.608	488	0.1414	0.0549	0.1963			-0.38	0.23
barley	22	41	63	17.608	45.392	63	1.0955	0.4250	1.5205			1.05	-0.65
	154	397	551	154	397	551	1.2369	0.4798	1.7168	1	0.190		
grain	245	542	787	229.136	557.864	787	1.0983	0.4511	1.5494			1.05	-0.67
chaff	61	203	264	76.8639	187.136	264	3.2742	1.3448	4.6190			-1.81	1.16
	306	745	1051	306	745	1051	4.3725	1.7959	**6.1684**	1	**0.013**		
crop seeds	309	755	1064	389.08	674.92	1064	16.4819	9.5015	25.9835			**-4.06**	**3.08**
wild seeds	245	206	451	164.92	286.08	451	38.8842	22.4161	61.3003			**6.24**	**-4.73**
	554	961	1515	554	961	1515	55.3661	31.9176	**87.2837**	1	**0.000**		
chenopod	98	72	170	90.1395	79.8605	170	0.6855	0.7737	1.4591			0.83	-0.88
grass	68	67	135	71.5814	63.4186	135	0.1792	0.2022	0.3814			-0.42	0.45
carnation	15	21	36	19.0884	16.9116	36	0.8757	0.9884	1.8640			-0.94	0.99
buckwheat	26	4	30	15.907	14.093	30	6.4041	7.2283	13.6324			**2.53**	**-2.69**
other	21	38	59	31.2837	27.7163	59	3.3805	3.8156	7.1961			-1.84	1.95
	228	202	430	228	202	430	11.5249	13.0083	**24.5331**	4	**0.000**		
rose/elderberry	6	7	13	4.62712	8.37288	13	0.4073	0.2251	0.6324			0.64	-0.47
sedges	5	6	11	3.91525	7.08475	11	0.3005	0.1661	0.4666			0.55	-0.41
clover/wild legumes	3	11	14	4.98305	9.01695	14	0.7892	0.4361	1.2253			-0.89	0.66
nightshade/mint	7	14	21	7.47458	13.5254	21	0.0301	0.0167	0.0468			-0.17	0.13
	21	38	59	21	38	59	1.5272	0.8440	2.3711	3	0.499		

note: statistically significant values in **bold**

APPENDIX 10.4: Chi-square statistics, on- versus off-tell comparisons, general botanical assemblage (Florescent Period)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	On Tell	Off Tell		On Tell	Off Tell		On Tell	Off Tell				On Tell	Off Tell
einkorn wheat	94	56	150	93.75	56.25	150	0.0007	0.0011	0.0018			0.03	-0.03
other ID wheat	4	2	6	3.75	2.25	6	0.0167	0.0278	0.0444			0.13	-0.17
barley	12	8	20	12.5	7.5	20	0.0200	0.0333	0.0533			-0.14	0.18
	110	66	176	110	66	176	0.0373	0.0622	0.0996	2	0.951		
wheats (all)	157	83	240	156	84	240	0.0064	0.0119	0.0183			0.08	-0.11
barley	12	8	20	13	7	20	0.0769	0.1429	0.2198			-0.28	0.38
	169	91	260	169	91	260	0.0833	0.1548	0.2381	1	0.626		
crop seeds	157	113	270	164.531	105.469	270	0.3447	0.5378	0.8825			-0.59	0.73
chaff	116	62	178	108.469	69.5313	178	0.5229	0.8157	1.3387			0.72	-0.90
	273	175	448	273	175	448	0.8676	1.3535	2.2212	1	0.136		
crop seeds	274	176	450	262.832	187.168	450	0.4746	0.6664	1.1409			0.69	-0.82
wild seeds	56	59	115	67.1681	47.8319	115	1.8569	2.6076	4.4646			-1.36	1.61
	330	235	565	330	235	565	2.3315	3.2740	**5.6055**	1	**0.018**		
chenopod	23	26	49	23.8496	25.1504	49	0.0303	0.0287	0.0590			-0.17	0.17
grass	14	14	28	13.6283	14.3717	28	0.0101	0.0096	0.0197			0.10	-0.10
other	18	18	36	17.5221	18.4779	36	0.0130	0.0124	0.0254			0.11	-0.11
	55	58	113	55	58	113	0.0534	0.0507	0.1041	2	0.949		

note: statistically significant values in **bold**

APPENDIX 10.5: Chi-square statistics, period comparisons, wild plant taxa characteristics

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
shade/half shade	12	27	39	13.26	25.74	39	0.1197	0.0617	0.1814			-0.35	0.25
half to partial shade	10	20	30	10.2	19.8	30	0.0039	0.0020	0.0059			-0.06	0.04
partial shade	10	22	32	10.88	21.12	32	0.0712	0.0367	0.1078			-0.27	0.19
partial shade to light loving	4	3	7	2.38	4.62	7	1.1027	0.5681	1.6707			1.05	-0.75
light loving	15	27	42	14.28	27.72	42	0.0363	0.0187	0.0550			0.19	-0.14
LIGHT	51	99	150	51	99	150	1.3338	0.6871	2.0209	4	0.732		
cool to warm	0	5	5	1.71756	3.28244	5	1.7176	0.8987	2.6163			-1.31	0.95
fairly warm	24	53	77	26.4504	50.5496	77	0.2270	0.1188	0.3458			-0.48	0.34
fairly warm to warm	16	26	42	14.4275	27.5725	42	0.1714	0.0897	0.2611			0.41	-0.30
warm	5	2	7	2.40458	4.59542	7	2.8014	1.4659	4.2673			1.67	-1.21
TEMPERATURE	45	86	131	45	86	131	4.9174	2.5730	7.4904	3	0.058		
oceanic	4	7	11	3.84553	7.15447	11	0.0062	0.0033	0.0095			0.08	-0.06
oceanic to suboceanic	26	44	70	24.4715	45.5285	70	0.0955	0.0513	0.1468			0.31	-0.23
suboceanic to intermediate	7	12	19	6.64228	12.3577	19	0.0193	0.0104	0.0296			0.14	-0.10
subcontinental to continental	6	17	23	8.04065	14.9593	23	0.5179	0.2784	0.7963			-0.72	0.53
CONTINENTALITY	43	80	123	43	80	123	0.6388	0.3434	0.9822	3	0.806		
dry	3	6	9	3.36614	5.63386	9	0.0398	0.0238	0.0636			-0.20	0.15
dry to moist	66	79	145	54.2323	90.7677	145	2.5534	1.5256	4.0791			1.60	-1.24
moist	22	53	75	28.0512	46.9488	75	1.3054	0.7799	2.0853			-1.14	0.88
moist to damp	2	13	15	5.61024	9.38976	15	2.3232	1.3881	3.7113			-1.52	1.18
damp to wet	2	8	10	3.74016	6.25984	10	0.8096	0.4837	1.2934			-0.90	0.70
WATER	95	159	254	95	159	254	7.0315	4.2012	**11.2327**	4	**0.024**		
acid to fairly acid	4	12	16	5.1134	10.8866	16	0.2424	0.1139	0.3563			-0.49	0.34
neutral	22	33	55	17.5773	37.4227	55	1.1128	0.5227	1.6355			1.05	-0.72
neutral to basic	5	21	26	8.30928	17.6907	26	1.3180	0.6190	1.9370			-1.15	0.79
REACTION	31	66	97	126	225	351	2.6732	1.2556	3.9288	2	0.140		

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
nitrogen poor	4	2	6	2.29344	3.70656	6	1.2699	0.7857	2.0556			1.13	-0.89
poor to average nitrogen	7	12	19	7.26255	11.7375	19	0.0095	0.0059	0.0154			-0.10	0.08
average nitrogen	6	7	13	4.96911	8.03089	13	0.2139	0.1323	0.3462			0.46	-0.36
average to rich nitrogen	77	113	190	72.6255	117.375	190	0.2635	0.1630	0.4265			0.51	-0.40
nitrogen rich	5	26	31	11.8494	19.1506	31	3.9592	2.4498	6.4090			**-1.99**	1.57
NITROGEN	99	160	259	99	160	259	5.71595	3.53674	9.25269	4	0.055		
forest/riparian	23	58	81	30.5308	50.4692	81	1.85755	1.1237	2.98126			-1.36	1.06
grassland/pasture	13	10	23	8.66923	14.3308	23	2.16346	1.30876	3.47222			1.47	-1.14
crop weed/disturbed	62	94	156	58.8	97.2	156	0.17415	0.10535	0.2795			0.42	-0.32
GENERAL ECOLOGY	98	162	260	98	162	260	4.1952	2.5378	**6.7330**	2	**0.035**		
large seed	5	11	16	6.16867	9.83133	16	0.22141	0.13892	0.36033			-0.47	0.37
medium seed	59	86	145	55.9036	89.0964	145	0.1715	0.10761	0.27911			0.41	-0.33
small seed		5	5	1.92771	3.07229	5	1.92771	1.20954	3.13725			-1.39	1.10
SEED SIZE	64	102	166	64	102	166	2.32062	1.45608	3.7767	2	0.151		

note: statistically significant values in **bold**

APPENDIX 11.1: Worked Osseous Materials

The worked bone typology used in this dissertation is presented in Table 11.1A. This system takes into account several variables, including raw material, degree of modification, standardization, and final form to infer the item's function. This classification system is adapted from Choyke (Choyke 1982, 1983, 1984a, 1997, 1999, 2000, 2001; Choyke and Schibler 2007; Sofaer, et al. 2013), who has worked extensively on Bronze Age assemblages in the study region, to maintain inter-site comparability (see also Chapter 7). Additional considerations of use wear follow Christidou (2008).

Table 11.1A: Pecica worked bone typology (major classes)

Type	Modification	Material	Taxon	Element	Function
hammer (flat end)	formal	antler	red deer	beam/burr	various heavy-duty tasks, wood working, metalworking
adze/mattock (angled end)	formal	antler	red deer	beam/burr	various heavy-duty tasks, wood working, agriculture
antler pick	formal	antler	red deer	tine	agriculture, digging
planer	semi-formal	bone	horse	pelvis	wood working
scraper (flat end)	semi-formal	bone	large mammal	rib	hide working, ceramics?
scraper (flat end)	expedient	bone	large mammal	flat bone	hide working
scraper (gouge)	expedient	bone	various	long bone	hide working, wood working? marrow extraction?
smoother (rounded)	semi-formal	antler	red deer	tine	burnishing, ceramic decoration
smoother (flat)	semi-formal	bone	various	astragalus	burnishing, hide working?
awl/punch	expedient	bone/tooth	medium mammal	long bone	hide working, ceramic decoration
needle/pin	formal	bone	medium mammal	long bone	hide working, textile production, ornament?
"skate"/beamer	semi-formal	bone	red deer	radius	transportation? hide working?
harpoon/toggle	formal	antler	red deer	beam/tine	fishing
cheek piece	formal	antler	red deer	beam	horse harness, transportation, ornament
worked shell	formal	shell	various	shell	ornament

Heavy-duty hafted antler tools (Figure 11.1A) are fairly common items from Pecica. These include hammers, mattocks/adzes, and picks. Mattocks and hammers are very similar in form and often cannot be distinguished if fragmented. Hammers have flattened ends on both sides while mattocks have one end that is angled. It is possible that some of the flat ended pieces with one end hollowed out may have been used as sockets for heavy metal or stone tools, such as axes. Both flat- and angled-end forms are made from large beam and burr sections of red deer antler. Picks are made from tines. Unfinished examples show that the antler beam was cut around its circumference with a sharp implement (stone or metal) in a sawing manner then snapped through the cortical interior (Figure 11.2A). The working ends are then further cut and ground to create the desired shape. These tools were likely used in a variety of activities, including carpentry and metallurgy, and for the mattocks/adzes, perhaps agricultural activities as well. Use wear studies have shown abrasions consistent with wood splitting (Christidou 2008). In ore and salt producing regions, picks are associated with mining (Boroffka 2006). Note that none of these antler tools are billets for chipped stone tool manufacture.

Figure 11.1A: Heavy-duty antler tools. Left, unfinished antler hammer/socket; right: antler mattock.

Figure 11.2A: Antler working debitage. Left, beam and burr with tines in various stages of removal; right, cut and snapped antler tine fragment.

Scrapers are bevel-ended tools (Figure 11.3A, upper left). They are the most common worked bone form at Pecica and generally are dominant at other settlements as well (Sofaer, et al. 2013). They are found in several forms. The most frequent type is made from ribs of large mammals, generally cattle. They are standardized in shape, but require little to no bone modification their manufacture. The proximal half of the rib is either broken or cut off and the wider, flatter distal end is used as a scraper. Often, the medial (inside) surface of the working end is cut at an angle to create a shaper edge. Flat-ended scrapers are also sometimes made on larger flat bones, especially mandibles, pelves, and scapulae. These show little modification other than using the broken edge as a scraping surface. The examples from Pecica do no show the level of polish as seen on the rib scrapers and appear to be more expedient-type tools. Both of these flat-ended scraper types were probably utilized in hide working, but their use in other activities that require scraping cannot be excluded, including ceramics manufacture (for at least the smaller rib type). Gouge-like scrapers are more ambiguous in their function. They are expediently made from transversely or diagonally fractured mammal long bones of various types and sizes. Some have been shaped to some degree creating a more uniform u-shaped working edge while others are left rough and angular and show only light use wear. They may have been used in a wide variety of tasks. The last scraper type is unique. It may be a planer used to smooth the surface of posts. It is made on a horse pelvis that has been shaped to form a concave working edge, the same diameter at most posts on site. It is also possible that this is a thong smoother.

Figure 11.3A: Smaller bone tools. Upper left, cattle rib scraper; lower left, awl/punch fragment; right, astragalus smoother/burnisher.

Smoothers are another frequent tool type, falling into two general classes. The first and more abundant type are made from red deer tines. These are manufactured in the same way as the heavy-duty antler tools, with the cut-and-snap method. The tine tips are polished to varying degrees from use and often show light burning to harden the working surface. Note that antler tines may become polished by the deer itself through rubbing, so only specimens with a moderate to high degree of polish over significant areas, including handling wear, are considered to be worked, rather than debitage. I would argue that are likely used in ceramic manufacture, to smooth or burnish surfaces as well as to create the deep channeling characteristic of Maros pottery, which is the same thickness as tine tips.[18] It is also important to note that none of these show tip damage associated with their use as pressure flakers. This type tool type is not common at other sites and it is possible that these may be lumped in with debitage in some collections. Other "smoothers" are made on astragali (Figure 11.3A, right),[19] with the anterior side cut and ground down to create a flat surface. These probably used as smoothers, although it has been suggested that these are "gaming pieces," especially those made on ovicaprid astragali. It has also been argued that these are used for burnishing ceramics, but given that their broad working surface is flat rather than concave, it seems more likely that these were used in hide working or for smoothing daub walls.

Awls (or punches) are thin, pointed tools (Figure 11.3A, lower left). They span a range of sizes and end forms, with varying degrees of sharpness. They generally are made on long bones of small to medium sized mammals and either use naturally pointed elements or use a fractured long bone that is further cut and ground to a point. Awls and made on ulnae and horse peripheral metapodia are a fairly standardized classes as their natural shape requires little additional modification. Awls made on other long bones are highly variable and generally made expediently. There is a single specimen manufactured from a deciduous pig incisor with its root cut to an extremely sharp, needle-like point. These items are used for piercing and were likely used in hide working and perhaps textile manufacture. Use-wear studies from other sites show evidence for contact with both animal hide and plant-based materials (Christidou 2008). They can also be used for making fine incisions on materials such as ceramics or wood.

[18]It is possible that some of the more fragmented specimens may be portions of picks. Further examination of use wear should be able to distinguish these as the size and orientation of the striae would differ (thin and horizontal in burnishing, larger and vertical in digging, also battering)

[19] At other sites, these are also made on phalanges, usually phalanx 1, from a variety of species.

The remaining classes of worked bone occur singly or in low numbers. There are three bone “needles.” This is in quotations as they superficially resemble needles but their location in graves (on the shoulder) suggests that they may have been used as clothing pins (O'Shea 1996:189). There is a fragment of what is termed a “skate” (Choyke 1982, 1983), in this case made from a red deer radius. The posterior surface, primarily of the articular ends, are cut and smoothed to make a flat, level surface. Based on ethnohistoric analogs, it has been argued that these are either used as sled runners or strapped to the bottom of shoes like ice skates. While this is possible, I am not excluding alternative uses, for example as large smoothers or beamers used in hide working. There are several composite antler tools. There are two small cut and drilled antler tine artifacts that superficially resemble harpoons but lack a sharpened tip. These have been described as “toggles” that may have been used to manufacture fishing nets (O'Shea 1996:228). While not included in this study, a finely crafted toggle-head harpoon and a tool handle, presumably for a metal item such as an awl or chisel, were recovered in 2013 (Figure 11.4A).[20]

Figure 11.4A: Composite antler tools. Left, toggle-head harpoon; right, handle (for metal tool?)

Other than the incisor awl described above, there are few worked animal teeth from Pecica. There is a modified boar tusk from deep deposits in Trench 1 (Early Period), but it has not been analyzed. Little can be said about its form and function. They are sometimes used as scrapers (Sofaer, et al. 2013). But they are also commonly used in ornamentation, often being

[20] Note that both of these were recovered from E layer fill (Phase 4) immediately under the burned platform (D0), underscoring the qualitative difference in the worked bone industries between Florescent and Late period occupations.

split and drilled at both ends for suspension or mounting. A number of these from the contemporary Ottomány/ Gyulavarsánd tell site Sarkad Peckes (Körös region) were described by the author (Nicodemus 2009). They do not appear to have been used extensively by the Maros people and are absent from Lower Maros cemeteries. Instead, carnivore teeth are typically used for ornamentation, one of which was found at Pecica in 2013.[21] While not included in this study, the highly polished dog canine pendent deserves mention (Figure 11.5A). Similar items have also been found at Százhalombatta with some frequency (Choyke 2000; Sofaer 2010).

Figure 11.5A: Dog canine pendant

Of particular interest is a horse harness cheek piece recovered from the platform (Figure 11.6A). It is bar-type piece made from a red deer antler tine. It has one large central oval shaped hole and a second, smaller round hole below, off-set by 90 degrees. There would have been one (or more) small holes at the proximal end in line with the central aperture, but this portion is broken. It is a Füzesabony Type A piece, which was used both in the Early and Middle Bronze Ages and is common throughout the Carpathian Basin (Hüttel 1981). Although it has been calcined, it is still possible to discern traces of decoration. There are several bands of chevrons around its circumference. It should also be noted that two other harness pieces were recovered from Pecica by Dömötör during his excavations at the turn of the last century. It is not clear what their exact contexts were, but images are provided by Crişan (1978), which are reprinted in Figure 11.6A. The piece to the left is similar to the one from the platform, although it is not decorated (Füzesabony Type A). The right piece is of the Spiš type, which has a wider distribution, with specimens being found as far as Moldavia, Ukraine, and Switzerland (Hüttel 1981).

[21] In lower E layer fill, Phase 5, Florescent Period.

It is interesting to note that these bar-type cheek pieces appear to be local inventions in the Carpathian Basin. Disk-shaped pieces are only found in the final Early Bronze Age and first part of the Middle Bronze Age, when they are eventually replaced by bar types (Hüttel 1981). The disk pieces have analogs throughout Eurasia and may have been imported (at least stylistically; local varieties lack the interior pegs) from the steppes along with chariotry technology at the end of the Early Bronze Age. Bar pieces in the Early and Middle Bronze Age are strongly concentrated in the Carpathian Basin region, eventually spreading to the rest of Europe (and back into Eurasia to some degree) in the Late Bronze Age. This westward spread of cheek pieces may track the spread of chariots into these areas. The cheek piece from the platform at Pecica is among the earliest examples in Europe, dating to sometime before 1750 cal. BC.[22] This, along with the relatively large number of check pieces compared to most sites, the presence of a model chariot wheel,[23] and very large number of horses, underscores Pecica's importance in horse husbandry and early chariotry.

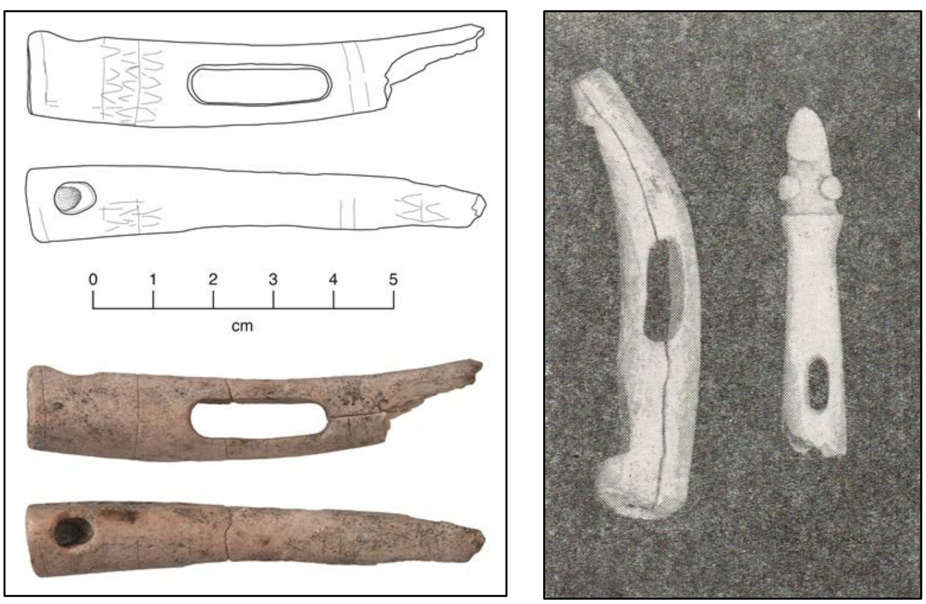


Figure 11.6A: *left* Horse harness cheek piece from the platform in 2008, *right* cheek pieces recovered by Dömötör (Crişan 1978)

[22] It cannot be directly dated since it is within redeposited sediments. C14 dates from overlying deposits place it sometime before 1750 cal BC and associated ceramics show it to post-date c. 2000 BC. It is hoped that more detailed analysis of the ceramics will be able to more precisely place this deposit's origin.
[23] A possible second clay chariot wheel fragment was recovered in 2013 in the upper E layer fill (Phase 4, Florescent Period).

Lastly, there are four classes of worked shells present at Pecica, two of which are more likely to been made locally given their respective species distribution. Unfortunately, there is no direct evidence of local manufacture via debitage. The first is an *Unio sp*. (freshwater mussel) valve that has hole punched through its umbo, presumably for suspension (Figure 11.7A, left). One was found in Phase 5 (Florescent Period) between Structures 4 and 5 and the other from Structure 0 in Phase 2 (Late Period). The holes on the two specimens identified are still fairly rough and the do not show use wear. It is possible these were unfinished. This genus is very abundant in the Maros River and was a common food source prehistorically. There are not many examples of these *Unio* shell “medals,” but they have been found at other prehistoric sites in the Carpathian Basin (Gulyás and Sümegi 2004).

There is a highly unusual worked snail shell, from outside of the structures in Phase 4 (Florescent Period). It is large, purple, and shows marks over its entire surface where the outer layer appears to have cut off and polished. It appears to be *Planorbarius corneus* (great ramshorn snail), a member of the planorbid snail family. These are freshwater gastropods that are abundant in the plains region in calm, richly vegetated waters (Grossu 1993), which would have been present in the floodplains below the site. The purple color may be due to burning/heat treating. The purpose of this item is not known as it has no drill marks for suspension, but it is assumed to be some sort of display item or trinket. I have not been able to find any analogs for this item in the archaeological literature. Lastly, there are also several marine shell ornaments present (*Columbella* beads, Figure 11.7A right, *Cardium* pendant). These are import goods, either as a raw material or as finished items, and are discussed in the trade section of Chapter 11.

Figure 11.7A: Left: freshwater mussel valve medallion; right: *Columbella* bead.

APPENDIX 11.2: Representative images of stone, weaving, and metalworking artifacts

Figure 11.8A: Groundstone items. Upper left: polished axe fragment; upper right: quern fragment; lower left: small pestle; lower center: square bead; lower right: pendant/weight.

Figure 11.9A: left: denticulated sickle blade, burned (platform/D0); center: obsidian prismatic blade fragment (F 171, Ph 4); right: point (lower E fill, Ph 5).

Figure 11.10A: Weaving tools. Upper left: flat disk whorl fragment; upper right, ovoid whorl fragment; lower left: loom weight; lower right, needle fragment (pig fibula).

Figure 11.11A: Metal and metallurgical items from Pecica. Left, bronze spear head; right, fish plate crucible with scorching.

APPENDIX 11.3: Inventory of metal and molds from previous Pecica excavations (from Gogâltan 1999:100-101)

Molds	Type	Count
	axe- flat	6
	axe- Hajdúsámson type	11
	axe- unspecified	4
	dagger	1
	spear head	1
	chisel	7
	awl	2
	buckles	2
		34

Metal	Type	Count
	axe	1
	chisel	4
	bracelet- simple	1
	pin- pod shaped head	2
	pendant- spectacle	5
	button- bronze	1
	button- gold	1
	spiral tube	5
	sheet	2
	casting debris/scrap	6
		28

APPENDIX 11.4: Imported artifacts

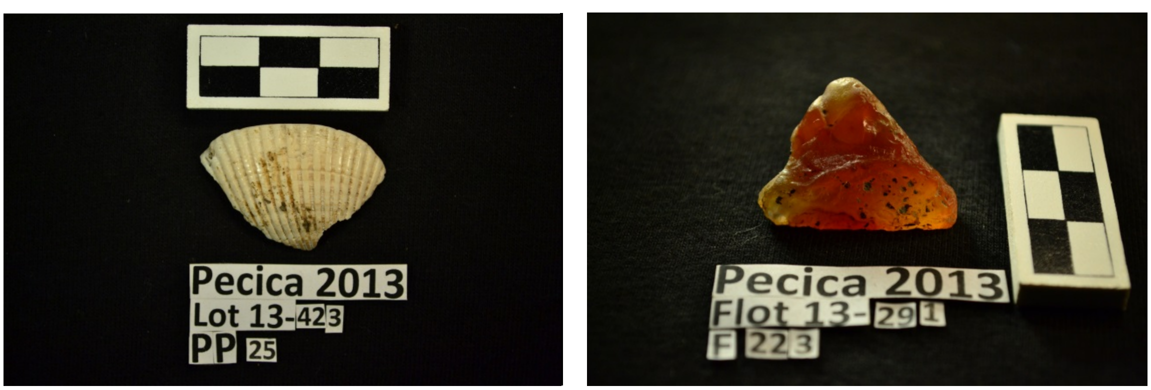


Figure 11.12A: Left: *Cardium* shell pendant fragment; right: raw amber nodule.

Appendix 13.1: Chi-Square Tests, Body Part Representation

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Klara.**		**Pecica**	**Klara.**		**Pecica**	**Klara.**				**Pecica**	**Klara.**
Very High/High	5156	2953	8109	5077.3	3031.7	8109	1.2207	2.0444	3.2651			1.10	-1.43
Med/Low	2947	1779	4726	2959.1	1766.9	4726	0.0493	0.0826	0.1319			-0.22	0.29
Very Low	500	405	905	566.65	338.35	905	7.8385	13.1273	20.9659			**-2.80**	**3.62**
	8603	5137	13740	8603	5137	13740	9.1086	15.2543	**24.3629**	2	**0.000**		
Ovicaprid													
Very High/High	745	346	1091	751.7	339.3	1091	0.0597	0.1323	0.1921			-0.24	0.36
Med/Low	712	293	1005	692.45	312.55	1005	0.5521	1.2232	1.7754			0.74	-1.11
Very Low	34	34	68	46.852	21.148	68	3.5255	7.8106	11.3361			-1.88	**2.79**
	1491	673	2164	1491	673	2164	4.1374	9.1662	**13.3035**	2	**0.001**		
Pig													
Very High/High	601	317	918	557.56	360.44	918	3.3837	5.2343	8.6180			1.84	**-2.29**
Med/Low	400	239	639	388.11	250.89	639	0.3643	0.5636	0.9279			0.60	-0.75
Very Low	54	126	180	109.33	70.674	180	27.9988	43.3120	71.3108			**-5.29**	**6.58**
	1055	682	1737	1055	682	1737	31.7469	49.1099	**80.8567**	2	**0.000**		
Cattle													
Very High/High	205	89	294	219.93	74.069	294	1.0137	3.0100	4.0238			-1.01	1.73
Med/Low	326	68	394	294.74	99.262	394	3.3158	9.8457	13.1616			1.82	**-3.14**
Very Low	146	71	217	162.33	54.67	217	1.6428	4.8781	6.5209			-1.28	**2.21**
	677	228	905	677	228	905	5.9724	17.7338	**23.7062**	2	**0.000**		

note: statistically significant values in **bold**

	Observed Values			**Expected Values**			**Chi Square Values**			**df**	**p**	**Standardized Residuals**	
Mammal	**Pecica**	**Kisz.**		**Pecica**	**Kisz.**		**Pecica**	**Kisz.**				**Pecica**	**Kisz.**
Very High/High	5156	569	5725	5076.5	648.5	5725	1.2451	9.7466	10.9917			1.12	**-3.12**
Med/Low	2947	429	3376	2993.6	382.42	3376	0.7248	5.6740	6.3988			-0.85	**2.38**
Very Low	500	101	601	532.92	68.079	601	2.0337	15.9201	17.9538			-1.43	**3.99**
	8603	1099	9702	8603	1099	9702	4.0036	31.3407	**35.3443**	2	**0.000**		
Ovicaprid													
Very High/High	745	163	908	741.42	166.58	908	0.0173	0.0771	0.0944			0.13	-0.28
Med/Low	712	154	866	707.12	158.88	866	0.0336	0.1497	0.1834			0.18	-0.39
Very Low	34	18	52	42.46	9.54	52	1.6856	7.5023	9.1880			-1.30	**2.74**
	1491	335	1826	1491	335	1826	1.7366	7.7291	**9.4657**	2	**0.009**		
Pig													
Very High/High	601	68	669	595.11	73.895	669	0.0584	0.4702	0.5286			0.24	-0.69
Med/Low	400	47	447	397.63	49.374	447	0.0142	0.1141	0.1283			0.12	-0.34
Very Low	54	16	70	62.268	7.7319	70	1.0979	8.8416	9.9394			-1.05	**2.97**
	1055	131	1186	1055	131	1186	1.1704	9.4259	**10.5963**	2	**0.005**		
Cattle													
Very High/High	205	35	240	204.63	35.365	240	0.0007	0.0038	0.0044			0.03	-0.06
Med/Low	326	40	366	312.07	53.932	366	0.6220	3.5990	4.2210			0.79	-1.90
Very Low	146	42	188	160.3	27.703	188	1.2752	7.3787	8.6539			-1.13	**2.72**
	677	117	794	677	117	794	1.8978	10.9815	**12.8793**	2	**0.002**		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Tarhos**		**Pecica**	**Tarhos**		**Pecica**	**Tarhos**				**Pecica**	**Tarhos**
Very High/High	5156	372	5528	5150.8	377.19	5528	0.0052	0.0715	0.0768			0.07	-0.27
Med/Low	2947	205	3152	2936.9	215.07	3152	0.0345	0.4717	0.5062			0.19	-0.69
Very Low	500	53	553	515.27	37.733	553	0.4523	6.1770	6.6293			-0.67	**2.49**
	8603	630	9233	8603	630	9233	0.4921	6.7202	**7.2123**	2	**0.027**		
Ovicaprid													
Very High/High	745	63	808	735.49	72.513	808	0.1230	1.2480	1.3710			0.35	-1.12
Med/Low	712	74	786	715.46	70.538	786	0.0167	0.1699	0.1866			-0.13	0.41
Very Low	34	10	44	40.051	3.9487	44	0.9143	9.2734	10.1877			-0.96	**3.05**
	1491	147	1638	1491	147	1638	1.0541	10.6912	**11.7453**	2	**0.003**		
Pig													
Very High/High	601	33	634	589.83	44.168	634	0.2114	2.8237	3.0351			0.46	-1.68
Med/Low	400	31	431	400.97	30.026	431	0.0024	0.0316	0.0340			-0.05	0.18
Very Low	54	15	69	64.193	4.8069	69	1.6185	21.6148	23.2334			-1.27	**4.65**
	1055	79	1134	1055	79	1134	1.8324	24.4701	**26.3024**	2	**0.000**		
Cattle													
Very High/High	205	25	230	213.01	16.99	230	0.3012	3.7759	4.0770			-0.55	1.94
Med/Low	326	9	335	310.25	24.747	335	0.7992	10.0201	10.8193			0.89	**-3.17**
Very Low	146	20	166	153.74	12.263	166	0.3894	4.8820	5.2714			-0.62	**2.21**
	677	54	731	677	54	731	1.4898	18.6779	**20.1677**	2	**0.000**		

note: statistically significant values in **bold**

Mammal	Observed Values Pecica	Sarkad		Expected Values Pecica	Sarkad		Chi Square Values Pecica	Sarkad		df	p	Standardized Residuals Pecica	Sarkad
Very High/High	5156	1779	6935	5261.6	1673.4	6935	2.1212	6.6699	8.7911			-1.46	**2.58**
Med/Low	2947	827	3774	2863.4	910.63	3774	2.4427	7.6808	10.1236			1.56	**-2.77**
Very Low	500	130	630	477.99	152.01	630	1.0138	3.1878	4.2016			1.01	-1.79
	8603	2736	11339	8603	2736	11339	5.5778	17.5385	**23.1163**	2	**0.000**		
Ovicaprid													
Very High/High	745	288	1033	789.04	243.96	1033	2.4579	7.9495	10.4074			-1.57	**2.82**
Med/Low	712	162	874	667.59	206.41	874	2.9544	9.5553	12.5097			1.72	**-3.09**
Very Low	34	11	45	34.372	10.628	45	0.0040	0.0131	0.0171			-0.06	0.11
	1491	461	1952	1491	461	1952	5.4163	17.5179	**22.9343**	2	**0.000**		
Pig													
Very High/High	601	303	904	599.45	304.55	904	0.0040	0.0079	0.0119			0.06	-0.09
Med/Low	400	200	600	397.86	202.14	600	0.0115	0.0226	0.0341			0.11	-0.15
Very Low	54	33	87	57.69	29.31	87	0.2360	0.4646	0.7006			-0.49	0.68
	1055	536	1591	1055	536	1591	0.2515	0.4951	0.7466	2	0.688		
Cattle													
Very High/High	205	52	257	205.9	51.096	257	0.0040	0.0160	0.0200			-0.06	0.13
Med/Low	326	73	399	319.67	79.328	399	0.1253	0.5048	0.6300			0.35	-0.71
Very Low	146	43	189	151.42	37.576	189	0.1943	0.7828	0.9771			-0.44	0.88
	677	168	845	677	168	845	0.3235	1.3036	1.6271	2	0.443		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Szaz.**		**Pecica**	**Szaz.**		**Pecica**	**Szaz.**				**Pecica**	**Szaz.**
Very High/High	5156	1690	6846	5239.9	1606.1	6846	1.3424	4.3796	5.7220			-1.16	**2.09**
Med/Low	2947	815	3762	2879.4	882.6	3762	1.5869	5.1772	6.7641			1.26	**-2.28**
Very Low	500	132	632	483.73	148.27	632	0.5474	1.7859	2.3333			0.74	-1.34
	8603	2637	11240	8603	2637	11240	3.4768	11.3427	**14.8194**	2	**0.001**		
Ovicaprid													
Very High/High	745	413	1158	770.11	387.89	1158	0.8185	1.6250	2.4435			-0.90	1.27
Med/Low	712	315	1027	682.99	344.01	1027	1.2325	2.4469	3.6793			1.11	-1.56
Very Low	34	23	57	37.907	19.093	57	0.4026	0.7994	1.2020			-0.63	0.89
	1491	751	2242	1491	751	2242	2.4536	4.8712	**7.3248**	2	**0.026**		
Pig													
Very High/High	601	182	783	599.9	183.1	783	0.0020	0.0066	0.0086			0.04	-0.08
Med/Low	400	131	531	406.83	124.17	531	0.1147	0.3757	0.4904			-0.34	0.61
Very Low	54	9	63	48.268	14.732	63	0.6807	2.2303	2.9110			0.83	-1.49
	1055	322	1377	1055	322	1377	0.7974	2.6125	3.4099	2	0.182		
Cattle													
Very High/High	205	385	590	271.72	318.28	590	16.3834	13.9868	30.3702			**-4.05**	**3.74**
Med/Low	326	320	646	297.51	348.49	646	2.7279	2.3289	5.0568			1.65	-1.53
Very Low	146	88	234	107.77	126.23	234	13.5638	11.5797	25.1435			**3.68**	**-3.40**
	677	793	1470	677	793	1470	32.6751	27.8954	**60.5705**	2	**0.000**		

note: statistically significant values in **bold**

	Observed Values			**Expected Values**			**Chi Square Values**			**df**	**p**	**Standardized Residuals**	
Mammal	**Klara.**	**Kisz.**		**Klara.**	**Kisz.**		**Klara.**	**Kisz.**				**Klara.**	**Kisz.**
Very High/High	2953	569	3522	2901.3	620.7	3522	0.9212	4.3061	5.2273			0.96	**-2.08**
Med/Low	1779	429	2208	1818.9	389.13	2208	0.8741	4.0858	4.9600			-0.93	**2.02**
Very Low	405	101	506	416.83	89.175	506	0.3355	1.5681	1.9036			-0.58	1.25
	5137	1099	6236	5137	1099	6236	2.1308	9.9600	**12.0908**	2	**0.002**		
Ovicaprid													
Very High/High	346	163	509	339.84	169.16	509	0.1117	0.2244	0.3362			0.33	-0.47
Med/Low	293	154	447	298.44	148.56	447	0.0993	0.1995	0.2987			-0.32	0.45
Very Low	34	18	52	34.718	17.282	52	0.0149	0.0299	0.0447			-0.12	0.17
	673	335	1008	673	335	1008	0.2259	0.4538	0.6796	2	0.712		
Pig													
Very High/High	317	68	385	322.96	62.036	385	0.1101	0.5734	0.6836			-0.33	0.76
Med/Low	239	47	286	239.92	46.084	286	0.0035	0.0182	0.0217			-0.06	0.13
Very Low	126	16	142	119.12	22.881	142	0.3974	2.0692	2.4666			0.63	-1.44
	682	131	813	682	131	813	0.5111	2.6608	3.1719	2	0.205		
Cattle													
Very High/High	89	35	124	81.948	42.052	124	0.6069	1.1827	1.7895			0.78	-1.09
Med/Low	68	40	108	71.374	36.626	108	0.1595	0.3108	0.4703			-0.40	0.56
Very Low	71	42	113	74.678	38.322	113	0.1812	0.3531	0.5342			-0.43	0.59
	228	117	345	228	117	345	0.9475	1.8465	2.7941	2	0.247		

note: statistically significant values in **bold**

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APPENDIX 4.1: Carpathian Stone Resources

This appendix presents a more detailed review of economically useful stone from the Carpathian Region as well as major imports from neighboring areas. It should be noted that this discussion is strongly biased towards Hungary and the Apuseni Mountains of Romania, where most of the stone sourcing work has been done, and should not be considered comprehensive. Given the very large number of materials available in the greater Carpathian Region,[1] only the major stone categories and geographic regions are presented in the text.

Unfortunately, there is much ambiguity in the literature concerning the nomenclature and taxonomy of useful stone. This discussion will largely follow the system devised by Biró (1998, 2002, 2009, 2011), who has created the most systematic typology and sourcing database for the region, supplemented by (Crandell 2008, 2009) for sources in the Apuseni Mountains and Rapp (2009) for general geologic considerations.

Cherts and related materials

This category contains the microcrystalline quartzes, which are siliceous stones forming as precipitates within sedimentary (primarily limestone) rocks, those typically classified as cherts and closely related materials.[2] These include chert *sensu stricto*, flint, radiolarite, lydite, hornstone, porcellanite, chalcedony, agate, japser, and plasma. Chert and flints will be considered together here as many of the "flints" should be considered chert geologically. Cherts have a widespread distribution in the greater Carpathian region, including numerous sources in the Western Romanian Carpathians and the Bakony Mountains of Transdanubia (Table 4.1A). There are also very important chert sources found just outside the Carpathian Region to the north

[1] Biró (1993) has identified 80 classes of material in Hungary an adjacent regions to the north and west alone!

[2] Microcrystalline quartzes suffer from the most problems concerning standardized nomenclature, particularly in the use of silex, chert, and flint. Chert is a micro- or cryptocrystalline quartz with nearly equidimensional crystals. Flint is often used synonymously with chert, but this term should be used only for very dense cherts with high organic content, which gives them their dark color. Chalcedony differs from chert in that it has a fibrous crystalline structure that gives it a greasy luster. Silex is also used generically for any rock with high quartz content, especially in the French literature (Rapp 2009).

and south that were imported prehistorically. The so-called “northern flints” largely refer to the extensive chert outcrops of the Outer Carpathian Depression (Biró 1998; Crandell 2008; Domański and Webb 2000).[3] Southern sources primarily refer to the high quality Balkan flints of the Moesian Platform along the southern bank of the Danube in Bulgaria (Biagi and Starnini 2011).

Radiolarite[4] is a common stone in the western Carpathian Region and was one of the most important lithic raw materials in Hungary prehistorically. It also has a fairly widespread distribution, found in Transdanubia, the Outer Western Carpathians, and the Northern Limestone Alps near Vienna (Elburg and van der Kroft 2008). Lydite[5] is found in Cserhát Mountains (IWC) and the Gerecse Mountains of Transdanubia (Biró 2002, 2009, 2011). Hornstone[6] is another frequent microcrystalline stone in the region. The most extensive outcrops are found in Transdanubian Mountains. Other sources are found in the Cserhát and Bükk Mountains (IWC) and the Outer Western Carpathian Depression (Biró 2002, 2009, 2011). The Central Beskids (OEC) produce menelite hornstone (Elburg and van der Kroft 2008).

There are also a number of related materials that are located in comparatively isolated areas and in smaller quantities. Chalcedony is found in the Slanské Mountains and the Matras (IWC) as well as in the Gerecse and Mecsek Mountains of Transdanubia. There are also small quantities of chalcedony and agate[7] in the Trascău Mountains (WRC). There are a number of jasper[8] outcrops in the Northern Hungarian Mountains (IWC) and in the Apusenis (WRC) as well as in the Maramureş region of northern Romania. Plasma[9] is found in southern Moravia, southwest of Brno (Biró 2002, 2009, 2011; Crandell 2008, 2009; Elburg and van der Kroft 2008).

[3] Note that some of these Polish varieties may be considered true flints given their very dark color and density, particularly the chocolate flint.
[4] Radiolarite is a siliceous rock formed in deep water oceanic conditions from bodies of radiolarians, which are amoeboid protozoa.
[5] Lydite is typically a green banded stone that forms from a compressed radiolarite, but can become dark if thermally altered.
[6] Hornstone, also called hornfels, is formed in sedimentary rock in contact zones with hot intrusive igneous masses.
[7] Agate is a chalcedony variety formed in volcanic rocks.
[8] Jasper is a high quality, typically reddish chalcedony with high iron oxide content.
[9] Plasma is a green variety of chalcedony with yellow spots.

Table 4.1A: Locations of major chert (and related stone) sources in the Carpathian Region. Sources in *italics* are outside of the study area but frequently imported.

Resource	Range	Region	Important Locales
Sümeg chert	Transdanubian Mountains	Bakony Mountains	
Tevel chert	Transdanubian Mountains	Bakony Mountains	
Lower Jurassic chert	Transdanubian Mountains	Bakony Mountains	
Nummulitic chert	Transdanubian Mountains	Gerecse Mountains	
Cserhát chert	Inner Western Carpathians	Cserhát Mountains	
Other cherts	Western Romanian Carpathians	Metalliferous Mountains	
	Western Romanian Carpathians	Trascău Mountains	
	Western Romanian Carpathians	Strei River	
	Southern Carpathians		
	Dinaridies		
Jurassic-Cracow flint	*Outer Carpathian Depression*		
Chocolate flint	*Outer Carpathian Depression*		
Banded flint	*Outer Carpathian Depression*		
Gray-white spotted flint	*Outer Carpathian Depression*		
Volhynian/Prut/Miorcani flint	*Outer Carpathian Depression*		
Balkan flint	*Moesian Platform*		
Szentgál radiolarite	Transdanubian Mountains	Bakony Mountains	
Urkút-Eplény radiolarite	Transdanubian Mountains	Bakony Mountains	
Tata radiolarite	Transdanubian Mountains	Gerecse Mountains	
Other radiolarites	Transdanubian Hills	Mecsek Mountains	
	Outer Western Carpathians	Slovak-Moravian Carpathians	Vlára Pass
		Western Beskids	Podhale Basin
			Peieniny Mountains
			Čergov Mountains
	Northern Limestone Alps		Wien-Antonshöhe
Lydite	Transdanubian Mountains	Gerecse Mountains	
	Inner Western Carpathians	Cserhát Mountains	
Hornstone	Transdanubian Mountains	Balaton Highlands	
		Keszthely Mountains	
		Buda Hills	
	Inner Western Carpathians	Cserhát Mountains	
		Bükk Mountains	
	Outer Eastern Carpathians	Central Beskids	Ondava Highlands
	Outer W. Carpathian Depression		*Krumlovský Les*
			Stránská Skála
Porcellanite	Transdanubian Mountains	Bakony Mountains	
Chalcedony	Transdanubian Mountains	Gerecse Mountains	
	Transdanubian Hills	Mecsek Mountains	
	Inner Western Carpathians	Matras	
		Slanské Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Agate	Western Romanian Carpathians	Trascău Mountains	
Jasper	Inner Western Carpathians	Matras	
		Rudabánya Mountains	
		Tokaj-Zemplín Mountains	
	Western Romanian Carpathians	Metalliferous Mountains	
		Trascău Mountains	
Plasma	*Moravia*		*Boskovštejn*

Quartzites, opalites, and related materials

This group entails a variety of rocks formed under disparate geological conditions, typically through metamorphic or post-volcanic processes, and are largely comprised of opaline silica (Rapp 2009).[10] In the study region, these are generally related to hydrothermal activities during Tertiary volcanism in the Inner Carpathians (Biró 2002).

Quartzites are common in the Carpathian region and fall into two categories based on formation conditions (Table 4.2A). Metaquartzite is metamorphosed sandstone while orthoquartzites are sandstones that have been cemented by nearly pure silica from groundwater. Metaquartzite (generally referred to as just quartzite) is found in the Hungarian Foothills of the Eastern Alps, Outer Western Carpathian Depression, Szendrő Mountains (IWC), and Velence Mountains of Transdanubia. Orthoquartzites include hydro- and limnic quartzites and are found throughout the Northern Hungarian Mountains (IWC). Limnoquartzites are the most commonly utilized raw materials in the Pannonian Plain behind obsidian (Biró 1993, 2002, 2009, 2011; Elburg and van der Kroft 2008; Šarić 2002). Related quartzite sandstones are located in the Trascău Mountains (WRC) and the Cerna Valley across the Maros to the southwest (Figure 4.7) (Crandell 2008, 2009).

Opal and opalites are formed in the same general geologic conditions as the orthoquartzites[11] (Rapp 2009) and follow their distribution. They are located widely throughout the southern arc of the Northern Hungarian Mountains and in the Trascău Mountains. Geyserite (or sinter) sources are found in Matras and in the Metalliferous Mountains and there are siliceous shale outcrops in the Trascău and Poiana Ruscă Mountains.[12] Other miscellaneous silicified materials include “volcanics” (Börzsöny Mountains, IWC) and tuffs, magnesites, and marls from unspecified sources in Serbia[13] (Biró 2002, 2009, 2011; Crandell 2008; Elburg and van der Kroft 2008; Šarić 2002).

[10] These are often grouped together as “porcellanite rocks,” which are less dense than micro-crystalline cherts (Rapp 2009).
[11] Opals and opalites are amorphous sub-microcrystalline cristobalites. During late stages of volcanism, hot groundwater precipitates low density colloidal silica into the cavities of volcanic or sedimentary rocks, especially sandstone. Its internal structure of silica spheres in cubic or hexagonal lattices causes light to diffract, particularly in its precious gemstone form. The largest opal deposits in Europe are found in Hungary (Rapp 2009).
[12] Note that the Poieni siliceous shale from the Poiana Ruscă Mountains is often incorrectly called “Banat chert” in the literature.
[13] These are commonly referred to as “white stone of different origins” in the Serbian literature (Šarić 2002).

Table 4.2A: Locations of other major stone sources in the Carpathian Region

Resource	Range	Region	Important Locales
Metaquartzite (Quartzite)	Hungarian Alpine Foothills		
	Transdanubian Mountains	Velence Mountains	
	Inner Western Carpathians	Szendrő Mountains	
	Outer W. Carpathian Depression		
Hydroquartzite	Inner Western Carpathians	Börzsöny Mountains	
		Matras	
		Tokaj-Zemplín Mountains	
Limnoquartzite	Inner Western Carpathians	Matras	
		Bükk Mountains	
		Tokaj-Zemplín Mountains	
		Slanské Mountains	
Quartzitic sandstone	Western Romanian Carpathians	Trascău Mountains	
		Cerna Valley	
Opal	Inner Western Carpathians	Cserhát Mountains	
		Matras	
		Bükk Mountains	
		Tokaj-Zemplín Mountains	
		Slanské Mountains	
Limnic opalite	Inner Western Carpathians	Matras	
Wooden opalite	Inner Western Carpathians	Bükk Mountains	
		Tokaj-Zemplín Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Geyserite/Sinter	Inner Western Carpathians	Matras	
	Western Romanian Carpathians	Metalliferous Mountains	
Siliceous shale	Western Romanian Carpathians	Poiana Ruscă Mountains	
Silicified volcanics	Inner Western Carpathians	Börzsöny Mountains	
Silicified tuff	Serbia (unspecified)		
Silicified magnesite	Serbia (unspecified)		
Silicified marl	Serbia (unspecified)		
Quartz crystal	Central Eastern Alps		Vienna
	Inner Western Carpathians	Matras	
	Dinaridies	Vardar Zone	Rudnik Mountain Region
Obsidian	Inner Western Carpathians	Slovakian Highlands	(type C4)
		Tokaj-Zemplín Mountains	(types C2a,b and C5)
		Slanské Mountains	(types C1a,b)
	Inner Eastern Carpathians	Vihorlat-Gutin Area	(type C3)
	Dinaridies	Vardar Zone	Rudnik Mountain Region
Felsitic porphyry	Inner Western Carpathians	Bükk Mountains	
Rhyolite	Inner Western Carpathians	Tokaj-Zemplín Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Andesite	Inner Western Carpathians	Bükk Mountains	
		Matras	
		Cserhát Mountains	
	Western Romanian Carpathians	Trascău Mountains	
Microgranite	Western Romanian Carpathians	Trascău Mountains	
Basalt	Western Romanian Carpathians	Trascău Mountains	

Volcanics

Perhaps the best known lithic resource of the Carpathians is obsidian, a volcanic glass,[14] which supplied large regions of Europe in prehistory. It was the most frequent raw material used

[14] Obsidian is a volcanic glass that is generally a high silica rhyolite containing less than 1% water (Rapp 2009).

from a single source area in Hungary, particularly on the Pannonian Plain (Biró 1993). There are a number of chemically distinct varieties in the Carpathians (Table 4.4), all formed during Miocene volcanism (Rosania and Barker 2009; Thorpe, et al. 1984). The Inner Western Carpathians house obsidian in the Slovakian Highlands and to the east in the Slanské and adjacent Tokaj-Zemplén Mountains (Figure 4.9). There are also sources in the Vihorlat-Gutin Area, Ukraine.[15] The Slanské and Tokaj areas are the two most important obsidian sources. The Slovakian Slanské sub-types are older, higher quality, more glassy and transparent, and found in larger nodules than the Tokaj varieties (Biró 2002). Note that obsidian from the Slovakian Highlands is of too low of a quality to be used for chipped stone manufacture (Nandris 1975; Williams and Nandris 1977). The Ukrainian materials are primarily volcanic bombs rather than flow deposits (Rosania and Barker 2009) and are of unknown suitability for working. A Serbian obsidian source has also been suggested as pebbles were found in the Onjega Valley near Rudnik Mountain in the Dinaridies (Šarić 2002).

In addition to obsidian, there are several other important volcanics used in chipped and ground stone technologies. Andesite,[16] rhyolite,[17] and related materials were also widely utilized prehistorically, primarily for groundstone items in post-Paleolithic periods, as their crystalline formation generally does not facture as well as finer grained materials. These rocks are found in large areas of the region hosting volcanic activity, especially in the inner ring of the Carpathians and the Apuseni Mountains (Brezsnyánszky and Haas 1989). In the Northern Hungarian Mountains, rhyolite is found in the Tokaj region and andesite in the central ranges (Biró 1998, 2002, 2009). Rhyolite, andesite, microgranite, and basalt are all found in the Trascău Mountains (Crandell 2008).

[15] The Ukrainian obsidians grade into the Romanian perlite zone of the zone of the Oaş-Tibliş Range. Perlite, a hydrated obsidian, is low quality and friable, unsuitable for working. The Romanian "obsidian" sources often mentioned in the literature are actually perlite (Nandris 1975).
[16] Andesite is an intermediate volcanic rock with 52-63% silica.
[17] Rhyolite has a larger silica component, over 69%, containing primarily quartz and feldspar, and similar in composition to granite.

APPENDIX 8.1: Faunal coding form and sample entries

Lot	Context	Taxon	Element	Portion	Count	Side	Age	Modification	Measurements	Other Comments
6-181	F2	Sus scrofa	pelvis	ilium	1		fetal			photo taken
8-108	C5	Unio spp.	valve	umbo	1	l		burned		
8-147	C5	Sus scrofa	MC III	prox epi and shaft	1	r		gnawed		
8-386	D0	Large Mammal	thoracic vertebra	centrum fragment	1		f	calcined		
8-498	E	Ovicapridae	ulna	olecranon/shaft	1	r	su	gnawed, worked	gl 103.8 gb 17.6	awl, tip at radial articulation polished, olecranon gnawed
9-244	Ea1	Sus scrofa	mandible	M2	1	r	1yr		M2l 22.6 wa 13.0 wp 13.2	M2:a, M3: V/E
9-304	Ea1	Ovis aries	1 phalanx	complete	1	r	jf		glpe 42.1 bp 13.3 bd 12.2 sd 10.5	
9-369	F171	Equus caballus	mandible	ascending ramus	1	r				pathology: arthritic lipping condyle, 4 pc, likely assoc. with l mand
9-369	F171	Medium Mammal	long bone	shaft fragment	12			5 gnawed		
9-382	E ash	Cyprinus carpio	opercular	fragment	1					large cyprinid

APPENDIX 8.2: Ceramic coding attribute list

Variable	Codes
Internal Color	1 = Brown (brown)
	2 =Yellow
	3 =Orange
	4 = Black
	5 = Gray
	6 = Tan
Interior Surface Treatment	1 = Plain
	2 = Coarse Burnished
	3 = Burnished
	4 = Polished
	5 = Brushed/Combed
	6 = Rusticated
	7 = Smooth
	8 = Reburned
External Color	1 = Brown (brown)
	2 =Yellow
	3 =Orange
	4 = Black
	5 = Gray
	6 = Tan
External Surface Treatment	1 = Plain
	2 = Coarse Burnished
	3 = Burnished
	4 = Polished
	5 = Brushed/Combed
	6 = Rusticated
	7 = Smooth
	8 = Reburned
Sooting	1 = Interior
	2 = Exterior
	3 = No Soot
Ware	1 = Fine
	2 = Coarse
	3 = Wheel Turned
Things to Note:	
Type of exotic	
Suspension Holes	

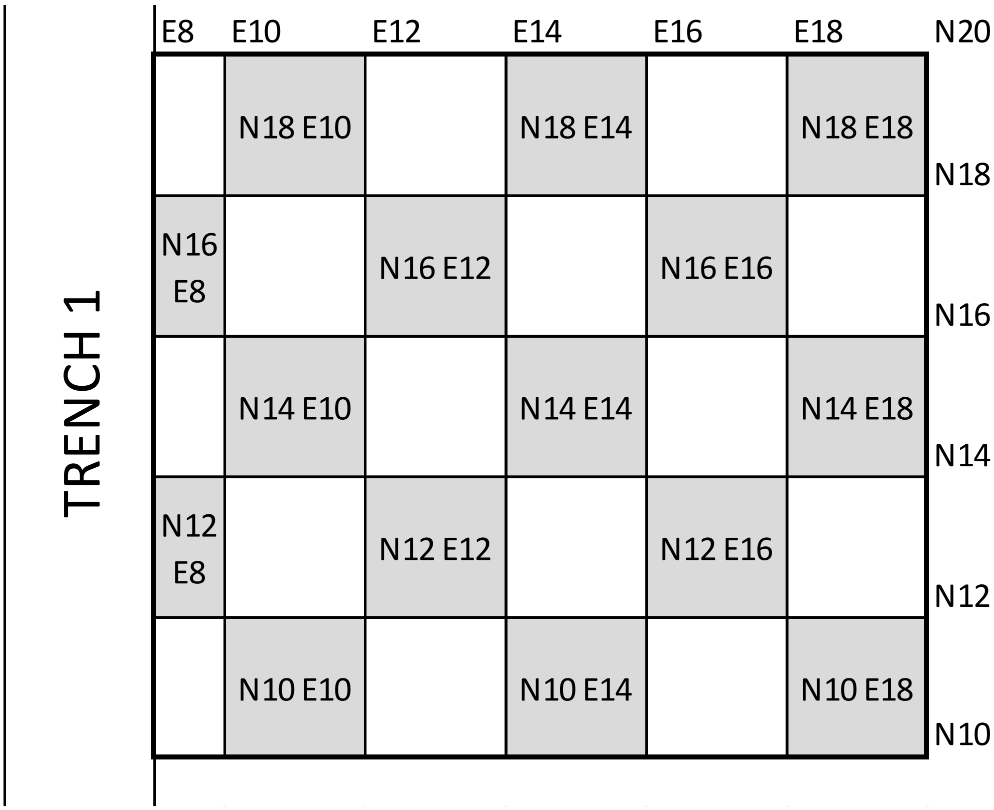
Variable	Codes
Presumed Vessel Type	1 = Cup
	2 = Jar
	3 = Pitcher/Jug
	4 = Bowl
	5 = Plain Cooking Pot
	6 = Lid
	7 = Strainer
	8 = Brazier
	9 =Miniature
	10 = Fish Plate
	11 = Wheel
	12 = Spindle Whorl
	13 = Other
Part	1 = Rim
	2 = Base
	3 = Handle
	4 = Shoulder
	5 = Body Sherd
	6 = Other
Exotic	1 = Yes
	2 = No (Maros)
Thickness 1 (rim)	in mm
Thickness 2 (lip)	in mm
Diameter	in cm
% Present	
Lip Shape	1 = Rounded
	2 = Tapered
	3 = Beveled
	4 = Square
	5 = T-shaped
Rim Orientation	1 = Everted
	2 = Straight
	3 = Inverted
	4 = 90 degrees
Odd Tempering	
Non-Round Orifice Shape	
Handle Attachment Below Rim	

Variable	Codes
Handle XS	1 = D-shaped
	2 = C-shaped
	3 = Oval
	4 = Flat
	5 = Rounded
	6 = Triangular
Handle Surface	1 = Plain
	2 = Coarse Burnished
	3 = Burnished
	4 = Polished
	5 = Brushed/Combed
	6 = Rusticated
	7 = Smooth
	8 = Reburned
Handle Decoration	1 = Yes
	2 = No
High Arch Handle	1 = Yes
	2 = No
Kantharos	1 = Yes
	2 = No
Handle Form	1 = Loop
	2 = Tab
	3 = Double Tab
	4 = Lug
	5 = Double Lug
Handle Width	in mm
Base XC	1 = Flat
	2 = Hollow (Concave)
	3 = Footed
	4 = Rounded
	5 = Dimpled
	6= Pedestal
Base Profile	1 = Simple
	2 = Inflected
Base Diameter	in cm
Exterior Decoration	1 = Yes
	2 = No

APPENDIX 8.3: Sample ceramic coding form

Lot #										
Object #/Piece Plot #										
Reference #										
INT Color										
INT Surf										
EXT Color										
EXT Surf										
Sooting										
Ware										
Pres. Vessel Type										
Part										
Exotic										
Thickness 1 (rim)										
Thickness 2 (lip)										
Diameter										
%										
Lip Shape										
Rim Orientation										
Handle XS										
Handle Surface										
Handle Decorated?										
High Arch Handle										
Kantharos										
Handle Form										
Handle Width										
Base XC										
Base Profile										
Base Diameter										
Decoration										
Channeled										
Trailed										
Incised										
Engraved										
Punctated										
Bossed										
Tick										
Node										
Arch										
Hatch										
Triangular										
Encrusted										
Chevron										
Pinched Fillet										
Pinched lip										
Pin. fillet even w/ lip										
Prow										
Applique										
Finger nail impressed										
Other										
Notes										

APPENDIX 9.1: Pecica Excavation Block Sampling Grid



Note: Fauna from general fill layers was analyzed in shaded cells only (50% sample)

APPENDIX 9.2: Chi-square tests, bone modification by phase, period, and context

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
	Ph 5	**Ph 4**	**Ph 3**		**Ph 5**	**Ph 4**	**Ph 3**		**Ph 5**	**Ph 4**	**Ph 3**				**Ph 5**	**Ph 4**	**Ph 3**
Weathered	11	10	1	22	2.44205	12.6546	6.90331	22	29.9906	0.5569	5.0482	35.5957			**5.48**	-0.75	**-2.25**
Animal Modified	70	491	210	771	85.5827	443.488	241.93	771	2.8372	5.0902	4.2141	12.1415			-1.68	**2.26**	**-2.05**
Burned/Calcined	31	220	86	337	37.4077	193.846	105.746	337	1.0976	3.5287	3.6873	8.3136			-1.05	1.88	-1.92
Butchery Marks	6	17	15	38	4.21808	21.858	11.9239	38	0.7528	1.0797	0.7936	2.6260			0.87	-1.04	0.89
Worked	1	12	10	23	2.55305	13.2298	7.2171	23	0.9447	0.1143	1.0731	2.1321			-0.97	-0.34	1.04
Unmodified	447	2183	1278	3908	433.796	2247.92	1226.28	3908	0.4019	1.8751	2.1814	4.4584			0.63	-1.37	1.48
	566	2933	1600	5099	566	2933	1600	5099	36.0249	12.2449	16.9975	**65.2674**	10	**0.000**			
	Ph 2	**Ph 1**			**Ph 2**	**Ph 1**			**Ph 2**	**Ph 1**					**Ph 2**	**Ph 1**	
Weathered	0	6	6		4.24792	1.75208	6		4.2479	10.2991	14.5471				**-2.06**	**3.21**	
Animal Modified	321	40	361		255.583	105.417	361		16.7433	40.5944	57.3377				**4.09**	**-6.37**	
Burned/Calcined	126	17	143		101.242	41.7578	143		6.0543	14.6787	20.7329				**2.46**	**-3.83**	
Butchery Marks	14	11	25		17.6997	7.30031	25		0.7733	1.8749	2.6483				-0.88	1.37	
Worked	23	0	23		16.2837	6.71629	23		2.7702	6.7163	9.4865				1.66	**-2.59**	
Unmodified	4719	2072	6791		4807.94	1983.06	6791		1.6454	3.9892	5.6346				-1.28	**2.00**	
	5203	2146	7349		5203	2146	7349		30.5890	74.1634	**104.7525**		5	**0.000**			
	Early	**Flor.***	**Late**		**Early**	**Flor.***	**Late**		**Early**	**Flor.***	**Late**				**Early**	**Flor.***	**Late**
Weathered	12	22	6	40	3.50601	15.8319	20.6621	40	20.5783	2.4031	10.4044	33.3859			**4.54**	1.55	**-3.23**
Animal Modified	60	814	361	1235	108.248	488.809	637.943	1235	21.5050	216.3406	120.2261	358.0717			**-4.64**	**14.71**	**-10.96**
Burned/Calcined	12	413	143	568	49.7853	224.813	293.402	568	28.6778	157.5291	77.0983	263.3051			**-5.36**	**12.55**	**-8.78**
Butchery Marks	26	42	25	93	8.15147	36.8091	48.0394	93	39.0813	0.7320	11.0496	50.8629			**6.25**	0.86	**-3.32**
Worked	0	24	23	47	4.11956	18.6024	24.278	47	4.1196	1.5661	0.0673	5.7530			**-2.03**	1.25	-0.26
Unmodified	1137	4316	6791	12244	1073.19	4846.14	6324.68	12244	3.7941	57.9933	34.3826	96.1699			1.95	**-7.62**	**5.86**
	1247	5631	7349	14227	1247	5631	7349	14227	117.7560	436.5642	253.2283	**807.5485**	10	**0.000**			
	On Tell	**Off Tell**			**On Tell**	**Off Tell**			**On Tell**	**Off Tell**					**On Tell**	**Off Tell**	
Weathered	11	0	11		10.1045	0.89552	11		0.0794	0.8955	0.9749				0.28	-0.95	
Animal Modified	730	22	752		690.779	61.221	752		2.2269	25.1268	27.3536				1.49	**-5.01**	
Burned/Calcined	370	38	408		374.784	33.2156	408		0.0611	0.6891	0.7502				-0.25	0.83	
Butchery Marks	33	0	33		30.3134	2.68656	33		0.2381	2.6866	2.9247				0.49	-1.64	
Worked	23	2	25		22.9647	2.03527	25		0.0001	0.0006	0.0007				0.01	-0.02	
Unmodified	3651	365	4016		3689.05	326.946	4016		0.3925	4.4292	4.8217				-0.63	2.10	
	4818	427	5245		4818	427	5245		2.6055	29.3986	**32.0041**		5	**0.000**			

note: statistically significant values in **bold**

*Classic Maros excludes the platform

APPENDIX 9.3: Chi-square tests, taxon representation, Florescent Period

	Observed Values					Expected Values					Chi Square Values					df	p	Standardized Residuals			
	Ph 3	Platform	Ph 4	Ph 5		Ph 3	Platform	Ph 4	Ph 5		Ph 3	Platform	Ph 4	Ph 5				Ph 3	Platform	Ph 4	Ph 5
Mammal	1407	2199	2590	535	6731	1404.93	2243.964	2576.9	505.204	6731	0.0030	0.9010	0.0666	1.7573	2.7279			0.06	-0.95	0.26	1.33
Mollusk	161	312	248	28	749	156.335	249.6998	286.748	56.2172	749	0.1392	15.5439	5.2359	14.1631	35.0821			0.37	**3.94**	**-2.29**	**-3.76**
Fish/Bird/Turtle	6	3	49	3	61	12.7323	20.33603	23.3533	4.57844	61	3.5597	14.7786	28.1654	0.5442	47.0479			-1.89	**-3.84**	**5.31**	-0.74
	1574	2514	2887	566	7541	1574	2514	2887	566	7541	3.7019	31.2235	33.4679	16.4646	**84.8579**	6	**0.000**				
Domestic	442	527	798	210	1977	443.843	597.1584	766.579	169.42	1977	0.0076	8.2427	1.2879	9.7197	19.2579			-0.09	**-2.87**	1.13	**3.12**
Wild Fauna	247	400	392	53	1092	245.157	329.8416	423.421	93.5797	1092	0.0138	14.9229	2.3317	17.5969	34.8653			0.12	**3.86**	-1.53	**-4.19**
	689	927	1190	263	3069	689	927	1190	263	3069	0.0215	23.1656	3.6196	27.3165	**54.1233**	3	**0.000**				
Domestic	442	527	798	210	1977	449.938	524.0754	802.73	200.256	1977	0.1400	0.0163	0.0279	0.4741	0.6583			-0.37	0.13	-0.17	0.69
Wild Vertebrates	86	88	144	25	343	78.0621	90.92457	139.27	34.7435	343	0.8072	0.0941	0.1607	2.7325	3.7944			0.90	-0.31	0.40	-1.65
	528	615	942	235	2320	528	615	942	235	2320	0.9472	0.1104	0.1885	3.2066	4.4527	3	0.217				
Domestic	442	527	798	210	1977	449.938	524.0754	802.73	200.256	1977	0.1400	0.0163	0.0279	0.4741	0.6583			-0.37	0.13	-0.17	0.69
Wild Mammal	82	85	106	22	295	67.1379	78.20043	119.78	29.8815	295	3.2900	0.5912	1.5853	2.0788	7.5453			1.81	0.77	-1.26	-1.44
Fish/Bird/Turtle	4	3	38	3	48	10.9241	12.72414	19.4897	4.86207	48	4.3888	7.4315	17.5802	0.7131	30.1136			**-2.09**	**-2.73**	**4.19**	-0.84
	528	615	942	235	2320	528	615	942	235	2320	7.8188	8.0390	19.1935	3.2660	**38.3173**	6	**0.000**				
Ovicaprid	158	187	231	86	662	148.848	176.7146	266.091	70.346	662	0.5627	0.5986	4.6278	3.4835	9.2726			0.75	0.77	**-2.15**	1.87
Pig	138	140	186	51	515	115.796	137.4743	207.005	54.7254	515	4.2578	0.0464	2.1313	0.2536	6.6891			**2.06**	0.22	-1.46	-0.50
Cattle	74	122	143	39	378	84.9918	100.9035	151.937	40.1674	378	1.4215	4.4108	0.5257	0.0339	6.3920			-1.19	**2.10**	-0.73	-0.18
Horse	68	71	223	31	393	88.3645	104.9076	157.967	41.7613	393	4.6932	10.9594	26.7736	2.7730	45.1993			**-2.17**	**-3.31**	**5.17**	-1.67
	438	520	783	207	1948	438	520	783	207	1948	10.9352	16.0152	34.0584	6.5440	**67.5529**	9	**0.000**				
Red Deer	69	72	90	18	249	69.2136	71.74576	89.4712	18.5695	249	0.0007	0.0009	0.0031	0.0175	0.0222			-0.03	0.03	0.06	-0.13
Other Game	13	13	16	4	46	12.7864	13.25424	16.5288	3.43051	46	0.0036	0.0049	0.0169	0.0945	0.1199			0.06	-0.07	-0.13	0.31
	82	85	106	22	295	82	85	106	22	295	0.0042	0.0058	0.0200	0.1120	0.1421	3	0.986				
Large Mammal	701	1125	1479	274	3579	758.396	1121.818	1401.85	296.935	3579	4.3438	0.0090	4.2459	1.7715	10.3703			**-2.08**	0.09	**2.06**	-1.33
Medium Mammal	640	855	984	251	2730	578.492	855.7037	1069.31	226.497	2730	6.5399	0.0006	6.8057	2.6508	15.9969			**2.56**	-0.02	**-2.61**	1.63
Small Mammal	5	11	25	2	43	9.11178	13.47812	16.8426	3.56754	43	1.8555	0.4556	3.9509	0.6888	6.9508			-1.36	-0.68	1.99	-0.83
	1346	1991	2488	527	6352	1346	1991	2488	527	6352	12.7392	0.4652	15.0025	5.1110	**33.3179**	6	**0.000**				
High Value	221	268	462	91	1042	235.892	314.2923	402.709	89.1071	1042	0.9401	6.8184	8.7295	0.0402	16.5283			-0.97	**-2.61**	**2.95**	0.20
Medium Value	297	329	425	138	1189	269.17	358.6311	459.521	101.678	1189	2.8773	2.4482	2.5933	12.9753	20.8941			1.70	-1.56	-1.61	**3.60**
Low Value	165	313	279	29	786	177.938	237.0766	303.771	67.2151	786	0.9407	24.3144	2.0199	21.7272	49.0021			-0.97	**4.93**	-1.42	**-4.66**
	683	910	1166	258	3017	683	910	1166	258	3017	4.7581	33.5810	13.3428	34.7427	**86.4246**	6	**0.000**				

note: statistically significant values in **bold**

APPENDIX 9.4: Chi-square tests, taxon representation, Late Period

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Ph 1	Ph 2		Ph 1	Ph 2		Ph 1	Ph 2				Ph 1	Ph 2
Mammal	1820	4324	6144	1787.3	4356.7	6144	0.5983	0.2454	0.8437			0.77	-0.50
Mollusk	249	724	973	283.047	689.953	973	4.0955	1.6801	5.7756			**-2.02**	1.30
Fish	37	78	115	33.4537	81.5463	115	0.3759	0.1542	0.5302			0.61	-0.39
Bird/Turtle	1	10	11	3.19992	7.80008	11	1.5124	0.6205	2.1329			-1.23	0.79
	2107	5136	7243	2107	5136	7243	6.5821	2.7003	9.2824	3	0.026		
Domestic	421	1197	1618	419.481	1198.52	1618	0.0055	0.0019	0.0074			0.07	-0.04
Wild Fauna	377	1083	1460	378.519	1081.48	1460	0.0061	0.0021	0.0082			-0.08	0.05
	798	2280	3078	798	2280	3078	0.0116	0.0041	0.0156	1	0.900		
Domestic	421	1197	1618	421.987	1196.01	1618	0.0023	0.0008	0.0031			-0.05	0.03
Wild Vertebrates	128	359	487	127.013	359.987	487	0.0077	0.0027	0.0104			0.09	-0.05
	549	1556	2105	549	1556	2105	0.0100	0.0035	0.0135	1	0.908		
Domestic	421	1197	1618	421.987	1196.01	1618	0.0023	0.0008	0.0031			-0.05	0.03
Wild Mammal	101	296	397	103.541	293.459	397	0.0623	0.0220	0.0843			-0.25	0.15
Fish	26	53	79	20.6038	58.3962	79	1.4133	0.4986	1.9119			1.19	-0.71
Bird/Turtle	1	10	11	2.86888	8.13112	11	1.2175	0.4296	1.6470			-1.10	0.66
	549	1556	2105	549	1556	2105	2.6954	0.9510	3.6464	3	0.302		
Ovicaprid	153	528	681	173.18	507.82	681	2.3514	0.8019	3.1533			-1.53	0.90
Pig	148	346	494	125.625	368.375	494	3.9851	1.3590	5.3441			**2.00**	-1.17
Cattle	79	231	310	78.8337	231.166	310	0.0004	0.0001	0.0005			0.02	-0.01
Horse	19	65	84	21.3614	62.6386	84	0.2610	0.0890	0.3501			-0.51	0.30
	399	1170	1569	399	1170	1569	6.5979	2.2501	**8.8480**	3	**0.031**		
Red Deer	81	210	291	74.0327	216.967	291	0.6557	0.2237	0.8794			0.81	-0.47
Other Game	20	86	106	26.9673	79.0327	106	1.8001	0.6142	2.4143			-1.34	0.78
	101	296	397	101	296	397	2.4557	0.8379	3.2937	1	0.070		
Large Mammal	812	1734	2546	763.324	1782.68	2546	3.1040	1.3291	4.4330			1.76	-1.15
Medium Mammal	942	2344	3286	985.186	2300.81	3286	1.8931	0.8106	2.7037			-1.38	0.90
Small Mammal	11	44	55	16.4897	38.5103	55	1.8276	0.7826	2.6102			-1.35	0.88
	1765	4122	5887	1765	4122	5887	6.8247	2.9223	**9.7469**	2	**0.008**		
High Value	183	523	706	182.484	523.516	706	0.0015	0.0005	0.0020			0.04	-0.02
Medium Value	316	915	1231	318.184	912.816	1231	0.0150	0.0052	0.0202			-0.12	0.07
Low Value	271	771	1042	269.332	772.668	1042	0.0103	0.0036	0.0139			0.10	-0.06
	770	2209	2979	770	2209	2979	0.0268	0.0093	0.0361	2	0.982		

note: statistically significant values in **bold**

APPENDIX 9.5: Chi-square tests, taxon representation, period comparisons

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
	Early	Flor.	Late		Early	Flor.	Late		Early	Flor.	Late				Early	Flor.	Late
Mammal		7235	6144	13379		7052.0153	6326.98	13379		4.7481	5.2922	10.0402				**2.18**	**-2.30**
Mollusk		772	973	1745		919.78225	825.218	1745		23.7443	26.4653	50.2096				**-4.87**	**5.14**
Fish		57	115	172		90.660486	81.3395	172		12.4975	13.9296	26.4271				**-3.54**	**3.73**
Bird/Turtle		9	11	20		10.541917	9.45808	20		0.2255	0.2514	0.4769				-0.47	0.50
		8073	7243	15316		8073	7243	15316		41.2154	45.9384	**87.1538**	3	**0.000**			
Domestic		2123	1618	3741		1917.6358	1823.36	3741		21.9929	23.1300	45.1230				**4.69**	**-4.81**
Wild Fauna		1152	1496	2648		1357.3642	1290.64	2648		31.0709	32.6773	63.7481				**-5.57**	**5.72**
		3275	3114	6389		3275	3114	6389		53.0638	55.8073	**108.8711**	1	**0.000**			
Domestic		2123	1618	3741		2016.3056	1724.69	3741		5.6458	6.6004	12.2462				**2.38**	**-2.57**
Wild Vertebrates		380	523	903		486.69444	416.306	903		23.3898	27.3446	50.7344				**-4.84**	**5.23**
		2503	2141	4644		2503	2141	4644		29.0357	33.9450	**62.9807**	1	**0.000**			
Domestic		2123	1618	3741		2027.2231	1713.78	3741		4.5250	5.3526	9.8777				**2.13**	**-2.31**
Wild Mammal		314	397	711		385.28618	325.714	711		13.1895	15.6018	28.7913				**-3.63**	**3.95**
Fish		44	79	123		66.652884	56.3471	123		7.6989	9.1070	16.8059				**-2.77**	**3.02**
Bird/Turtle		9	11	20		10.837867	9.16213	20		0.3117	0.3687	0.6803				-0.56	0.61
		2490	2105	4595		2490	2105	4595		25.7250	30.4301	**56.1551**	3	**0.000**			
Ovicaprid	369	727	681	1777	263.305	865.14562	648.549	1777	42.4275	22.0590	1.6237	66.1102			**6.51**	**-4.70**	1.27
Pig	149	558	494	1201	177.957	584.71575	438.327	1201	4.7118	1.2206	7.0711	13.0036			**-2.17**	-1.10	**2.66**
Cattle	104	395	310	809	119.873	393.86764	295.26	809	2.1018	0.0033	0.7359	2.8409			-1.45	0.06	0.86
Horse	15	413	84	512	75.8651	249.27099	186.864	512	48.8309	107.5423	56.6240	212.9972			**-6.99**	**10.37**	**-7.52**
	637	2093	1569	4299	637	2093	1569	4299	98.0720	130.8252	66.0547	**294.9520**	6	**0.000**			
Red Deer	39	266	291	596	43.515	243.99478	308.49	596	0.4685	1.9846	0.9916	3.4447			-0.68	1.41	-1.00
Other Game	17	48	106	171	12.485	70.005215	88.5098	171	1.6328	6.9170	3.4562	12.0060			1.28	**-2.63**	1.86
	56	314	397	767	56	314	397	767	2.1012	8.9016	4.4478	**15.4507**	2	**0.000**			
Large Mammal		3755	2546	6301		3598.3391	2702.66	6301		6.8205	9.0809	15.9015				**2.61**	**-3.01**
Medium Mammal		1300	1226	2526		1442.5336	1083.47	2526		14.0834	18.7508	32.8342				**-3.75**	**4.33**
Small Mammal		11	33	44		25.127269	18.8727	44		7.9428	10.5750	18.5178				**-2.82**	**3.25**
		5066	3805	8871		5066	3805	8871		28.8467	38.4067	**67.2535**	2	**0.000**			
High Value		1075	706	1781		912.65319	868.347	1781		28.8790	30.3525	59.2315				**5.37**	**-5.51**
Medium Value		1269	1231	2500		1281.0966	1218.9	2500		0.1142	0.1200	0.2343				-0.34	0.35
Low Value		787	1042	1829		937.25025	891.75	1829		24.0866	25.3156	49.4021				**-4.91**	**5.03**
		3131	2979	6110		3131	2979	6110		53.0798	55.7881	**108.8678**	4	**0.000**			

note: statistically significant values in **bold**

APPENDIX 9.6: Chi-square tests, taxon representation, off-tell phases

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Ph B	Ph A		Ph B	Ph A		Ph B	Ph A				Ph B	Ph A
Mammal	103	143	246	115.482	130.518	246	1.3491	1.1936	2.5427			-1.16	1.09
Mollusk	77	62	139	65.2518	73.7482	139	2.1152	1.8715	3.9867			1.45	-1.37
Fish/Bird/Turtle	12	12	24	11.2665	12.7335	24	0.0478	0.0423	0.0900			0.22	-0.21
	192	217	409	192	217	409	3.5120	3.1074	6.6194	3	0.085		
Domestic	23	44	67	33.232	33.768	67	3.1504	3.1004	6.2508			-1.77	1.76
Wild Fauna	101	82	183	90.768	92.232	183	1.1534	1.1351	2.2885			1.07	-1.07
	124	126	250	124	126	250	4.3038	4.2355	**8.5393**	1	**0.003**		
Domestic	23	44	67	28.3694	38.6306	67	1.0162	0.7463	1.7625			-1.01	0.86
Wild Vertebrates	24	20	44	18.6306	25.3694	44	1.5475	1.1364	2.6839			1.24	-1.07
	47	64	111	47	64	111	2.5637	1.8827	**4.4464**	1	**0.035**		
Domestic	23	44	67	28.3694	38.6306	67	1.0162	0.7463	1.7625			-1.01	0.86
Wild Mammal	13	14	27	11.4324	15.5676	27	0.2149	0.1578	0.3728			0.46	-0.40
Fish/Bird/Turtle	11	6	17	7.1982	9.8018	17	2.0080	1.4746	3.4826			1.42	-1.21
	47	64	111	47	64	111	3.2391	2.3787	5.6179	3	0.132		
Ovicaprid	11	22	33	10.8197	22.1803	33	0.0030	0.0015	0.0045			0.05	-0.04
Pig	6	13	19	6.22951	12.7705	19	0.0085	0.0041	0.0126			-0.09	0.06
Cattle	3	6	9	2.95082	6.04918	9	0.0008	0.0004	0.0012			0.03	-0.02
Horse	20	41	61	20	41	61	0.0123	0.0060	0.0183	3	0.999		
Red Deer	3	9	12	5.77778	6.22222	12	1.3355	1.2401	2.5755			-1.16	1.11
Other Game	10	5	15	7.22222	7.77778	15	1.0684	0.9921	2.0604			1.03	-1.00
	13	14	27	13	14	27	2.4038	2.2321	**4.6360**	1	**0.031**		
Large Mammal	29	36	65	28.5435	36.4565	65	0.0073	0.0057	0.0130			0.09	-0.08
Medium Mammal	68	90	158	69.3826	88.6174	158	0.0276	0.0216	0.0491			-0.17	0.15
Small Mammal	4	3	7	3.07391	3.92609	7	0.2790	0.2184	0.4975			0.53	-0.47
	101	129	230	101	129	230	0.3139	0.2457	0.5596	2	0.756		
High Value	8	17	25	12.2967	12.7033	25	1.5014	1.4533	2.9547			-1.23	1.21
Medium Value	25	40	65	31.9715	33.0285	65	1.5202	1.4715	2.9917			-1.23	1.21
Low Value	88	68	156	76.7317	79.2683	156	1.6548	1.6018	3.2566			1.29	-1.27
	121	125	246	121	125	246	4.6763	4.5267	**9.2030**	2	**0.010**		

note: statistically significant values in **bold**

APPENDIX 9.7: Chi-square tests, taxon representation, on- versus off-tell occupation (Florescent Period)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	On Tell	Off Tell		On Tell	Off Tell		On Tell	Off Tell				On Tell	Off Tell
Mammal	4255	246	4501	4143.89	357.111	4501	2.9793	34.5711	37.5504			1.73	**-5.88**
Mollusk	431	139	570	524.776	45.2241	570	16.7575	194.4524	211.2099			**-4.09**	**13.94**
Fish	55	22	77	70.8908	6.10921	77	3.5621	41.3338	44.8959			-1.89	**6.43**
Bird/Turtle	5	2	7	6.44462	0.55538	7	0.3238	3.7576	4.0814			-0.57	1.94
	4746	409	5155	4746	409	5155	23.6226	274.1150	**297.7376**	3	**0.000**		
Domestic	1283	67	1350	1197.08	152.923	1350	6.1673	48.2773	54.4445			**2.48**	**-6.95**
Wild Fauna	674	183	857	759.923	97.0775	857	9.7150	76.0494	85.7644			**-3.12**	**8.72**
	1957	250	2207	1957	250	2207	15.8823	124.3266	**140.2089**	1	**0.000**		
Domestic	1283	67	1350	1258.46	91.5394	1350	0.4785	6.5784	7.0569			0.69	**-2.56**
Wild Vertebrates	243	44	287	267.539	19.4606	287	2.2508	30.9437	33.1945			-1.50	**5.56**
	1526	111	1637	1526	111	1637	2.7293	37.5221	**40.2514**	1	**0.000**		
Domestic	1283	67	1350	1258.46	91.5394	1350	0.4785	6.5784	7.0569			0.69	**-2.56**
Wild Mammal	196	27	223	207.879	15.121	223	0.6788	9.3322	10.0110			-0.82	**3.05**
Fish	42	15	57	53.135	3.865	57	2.3335	32.0798	34.4132			-1.53	**5.66**
Bird/Turtle	5	2	7	6.52535	0.47465	7	0.3566	4.9019	5.2585			-0.60	**2.21**
	1526	111	1637	1526	111	1637	3.8473	52.8923	**56.7397**	3	**0.000**		
Ovicaprid	408	33	441	419.431	21.5688	441	0.3115	6.0583	6.3699			-0.56	**2.46**
Pig	333	19	352	334.784	17.216	352	0.0095	0.1849	0.1944			-0.10	0.43
Cattle	224	9	233	221.604	11.3958	233	0.0259	0.5037	0.5296			0.16	-0.71
Horse	299	4	303	288.181	14.8194	303	0.4062	7.8991	8.3053			0.64	**-2.81**
	1264	65	1329	1264	65	1329	0.7532	14.6460	**15.3991**	3	**0.002**		
Red Deer	165	12	177	155.57	21.4305	177	0.5717	4.1499	4.7216			0.76	**-2.04**
Other Game	31	15	46	40.4305	5.56951	46	2.1997	15.9681	18.1677			-1.48	**4.00**
	196	27	223	196	27	223	2.7713	20.1179	22.8893	1	**0.000**		
Large Mammal	2253	65	2318	2192.32	125.681	2318	1.6796	29.2981	30.9777			1.30	**-5.41**
Medium Mammal	1708	158	1866	1764.83	101.174	1866	1.8298	31.9173	33.7470			-1.35	**5.65**
Small Mammal	51	7	58	54.8553	3.14474	58	0.2709	4.7263	4.9973			-0.52	**2.17**
	4012	230	4242	4012	230	4242	3.7803	65.9416	**69.7219**	2	**0.000**		
High Value	704	25	729	646.887	82.1126	729	5.0424	39.7241	44.7665			**2.25**	**-6.30**
Medium Value	762	65	827	733.849	93.1511	827	1.0799	8.5075	9.5874			1.04	**-2.92**
Low Value	472	156	628	557.264	70.7363	628	13.0457	102.7748	115.8205			**-3.61**	**10.14**
	1938	246	2184	1938	246	2184	19.1680	151.0064	**170.1744**	2	**0.000**		

note: statistically significant values in **bold**

APPENDIX 9.8: Chi-square tests, livestock age class, period and context comparisons

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Ovicaprid	**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**				**juvenile**	**subadult**	**adult**
Early	4	8	11	23	6.688776	10.20918	6.102041	23	1.0808	0.4780	3.9315	5.4904			-1.04	-0.69	**1.98**
Florescent	5.5	12.5	5	23	6.688776	10.20918	6.102041	23	0.2113	0.5140	0.1990	0.9243			-0.46	0.72	-0.45
Late	19	23	10	52	15.12245	23.08163	13.79592	52	0.9942	0.0003	1.0444	2.0390			1.00	-0.02	-1.02
	28.5	43.5	26	98	28.5	43.5	26	98	2.2864	0.9924	5.1749	**8.4537**	4	**0.076**			
Cattle	**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**		**juvenile**	**subadult**	**adult**				**juvenile**	**subadult**	**adult**
Florescent	6.5	12.5	7	26	6.333333	11.66667	8	26	0.0044	0.0595	0.1250	0.1889			0.07	0.24	-0.35
Late	3	5	5	13	3.166667	5.833333	4	13	0.0088	0.1190	0.2500	0.3778			-0.09	-0.35	0.50
	9.5	17.5	12	39	9.5	17.5	12	39	0.0132	0.1786	0.3750	0.5667	2	0.753			
Pig	**juvenile**	**SA/adult**			**juvenile**	**SA/adult**			**juvenile**	**SA/adult**					**juvenile**	**SA/adult**	
Early	2	13	15		6.923077	8.076923	15		3.5009	3.0007	6.5016				-1.87	1.73	
Florescent	20	20	40		18.46154	21.53846	40		0.1282	0.1099	0.2381				0.36	-0.33	
Late	20	16	36		16.61538	19.38462	36		0.6895	0.5910	1.2804				0.83	-0.77	
	42	49	91		42	49	91		4.3185	3.7016	**8.0201**		2	**0.018**			
Horse	**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**				**<5 yrs**	**5-10 yrs**	**>10 yrs**
Late*	3	1	4	8	2.666667	1.824561	3.508772	8	0.0417	0.3726	0.0688	0.4831			0.204	-0.61	0.26
Florescent	16	12	21	49	16.33333	11.17544	21.49123	49	0.0068	0.0608	0.0112	0.0789			-0.082	0.25	-0.11
	19	13	25	57	19	13	25	57	0.0485	0.4335	0.0800	0.5619	2	0.755			
Horse	**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**		**<5 yrs**	**5-10 yrs**	**>10 yrs**				**<5 yrs**	**5-10 yrs**	**>10 yrs**
Bone Piles*	0	3	1	4	1.306122	0.979592	1.714286	4	1.3061	4.1671	0.2976	5.7708			-1.14	**2.04**	-0.55
Florescent Other	16	9	20	45	14.69388	11.02041	19.28571	45	0.1161	0.3704	0.0265	0.5130			0.34	-0.61	0.16
	16	12	21	49	16	12	21	49	1.4222	4.5375	0.3241	**6.2838**	2	**0.043**			

note: statistically significant values in **bold**

*small sample

APPENDIX 9.9: Chi-square tests, body part representation by utility, taxon comparisons by phase and context

	Observed Values					Expected Values					Chi Square Values					df	p	Standardized Residuals			
Early Period	**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**				**OC**	**Pig**	**Cattle**	**Horse**
Higher Utility	223	99	48	13	383	218.2	91.892	62.43	10.522	383	0.108	0.5498	3.335	0.5836	4.57649			0.33	0.74	**-1.83**	0.76
Lower Utility	88	32	41	2	163	92.84	39.108	26.57	4.478	163	0.253	1.2919	7.837	1.3713	10.7534			-0.50	-1.14	**2.80**	-1.17
	311	131	89	15	546	311	131	89	15	546	0.36	1.8417	11.17	1.9549	**15.3298**	3	**0.002**				
Florescent	**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**				**OC**	**Pig**	**Cattle**	**Horse**
Higher Utility	416	333	160	261	1170	412.7	314.95	220.5	221.85	1170	0.027	1.0346	16.61	6.9084	24.5841			0.16	1.02	**-4.08**	**2.63**
Lower Utility	209	144	174	75	602	212.3	162.05	113.5	114.15	602	0.052	2.0107	32.29	13.427	47.7797			-0.23	-1.42	**5.68**	**-3.66**
	625	477	334	336	1772	625	477	334	336	1772	0.079	3.0452	48.9	20.335	**72.3637**	3	**0.000**				
Late Period	**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**		**OC**	**Pig**	**Cattle**	**Horse**				**OC**	**Pig**	**Cattle**	**Horse**
Higher Utility	345	293	119	36	793	331.9	267.32	151.9	41.863	793	0.516	2.4662	7.127	0.8211	10.93			0.72	1.57	**-2.67**	-0.91
Lower Utility	210	154	135	34	533	223.1	179.68	102.1	28.137	533	0.768	3.6693	10.6	1.2216	16.2616			-0.88	-1.92	**3.26**	1.11
	555	447	254	70	1326	555	447	254	70	1326	1.284	6.1355	17.73	2.0426	**27.1916**	3	**0.000**				
Off Tell	**OC**	**Pig**	**Cattle**			**OC**	**Pig**	**Cattle**			**OC**	**Pig**	**Cattle**					**OC**	**Pig**	**Cattle**	
Higher	20	12	0	32		17.66	9.931	4.414	32		0.311	0.431	4.414	5.1563				0.56	0.66	**-2.10**	
Lower	12	6	8	26		14.34	8.069	3.586	26		0.383	0.5305	5.432	6.3462				-0.62	-0.73	**2.33**	
	32	18	8	58		32	18	8	58		0.695	0.9615	9.846	**11.502**		2	**0.003**				
Early Period	**OC**	**Pig**				**OC**	**Pig**				**OC**	**Pig**						**OC**	**Pig**		
Higher Utility	223	99	322			226.6	95.434	322			0.056	0.1332	0.189					-0.24	0.36		
Lower Utility	88	32	120			84.43	35.566	120			0.151	0.3575	0.508					0.39	-0.60		
	311	131	442			311	131	442			0.207	0.4907	0.697			1	0.404				
Florescent	**OC**	**Pig**				**OC**	**Pig**				**OC**	**Pig**						**OC**	**Pig**		
Higher Utility	416	333	749			424.8	324.2	749			0.182	0.2386	0.421					-0.43	0.49		
Lower Utility	209	144	353			200.2	152.8	353			0.386	0.5063	0.893					0.62	-0.71		
	625	477	1102			625	477	1102			0.569	0.745	1.314			1	0.252				
Late Period	**OC**	**Pig**				**OC**	**Pig**				**OC**	**Pig**						**OC**	**Pig**		
Higher Utility	345	293	638			353.4	284.62	638			0.199	0.2469	0.446					-0.45	0.50		
Lower Utility	210	154	364			201.6	162.38	364			0.349	0.4328	0.781					0.59	-0.66		
	555	447	1002			555	447	1002			0.547	0.6797	1.227			1	0.268				

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Off Tell	**OC**	**Pig**		**OC**	**Pig**		**OC**	**Pig**				**OC**	**Pig**
Higher Utility	20	12	32	20.48	11.52	32	0.011	0.02	0.031			-0.11	0.14
Lower Utility	12	6	18	11.52	6.48	18	0.02	0.0356	0.056			0.14	-0.19
	32	18	50	32	18	50	0.031	0.0556	0.087	1	0.768		
Early Period	**Cattle**	**Horse**		**Cattle**	**Horse**		**Cattle**	**Horse**				**Cattle**	**Horse**
Higher Utility	48	13	61	52.2	8.7981	61	0.338	2.0068	2.345			-0.58	1.42
Lower Utility	41	2	43	36.8	6.2019	43	0.48	2.8469	3.327			0.69	**-1.69**
	89	15	104	89	15	104	0.818	4.8537	**5.672**	1	**0.017**		
Florescent	**Cattle**	**Horse**		**Cattle**	**Horse**		**Cattle**	**Horse**				**Cattle**	**Horse**
Higher Utility	160	261	421	209.9	211.13	421	11.85	11.78	23.63			**-3.44**	**3.43**
Lower Utility	174	75	249	124.1	124.87	249	20.04	19.918	39.96			**4.48**	**-4.46**
	334	336	670	334	336	670	31.89	31.698	**63.59**	1	**0.000**		
Late Period	**Cattle**	**Horse**		**Cattle**	**Horse**		**Cattle**	**Horse**				**Cattle**	**Horse**
Higher Utility	119	36	155	121.5	33.488	155	0.052	0.1885	0.24			-0.23	0.43
Lower Utility	135	34	169	132.5	36.512	169	0.048	0.1729	0.221			0.22	-0.42
	254	70	324	254	70	324	0.1	0.3614	0.461	1	0.497		

note: statistically significant values in **bold**

APPENDIX 9.10: Chi-square tests, body part representation, Florescent Period

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Mammals (all)	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	286	519	150	955	308.3	522.53	124.2	955	1.607	0.0239	5.354	6.9844			-1.27	-0.15	**2.31**
Axial	251	383	75	709	228.8	387.93	92.22	709	2.144	0.0628	3.214	5.4207			1.46	-0.25	-1.79
Lower Limb	92	181	33	306	98.77	167.43	39.8	306	0.464	1.0998	1.162	2.7256			-0.68	1.05	-1.08
Upper Limb	273	469	118	860	277.6	470.55	111.9	860	0.076	0.0051	0.338	0.4185			-0.28	-0.07	0.58
Foot	46	55	6	107	34.54	58.546	13.92	107	3.804	0.2147	4.504	8.5229			1.95	-0.46	**-2.12**
	948	1607	382	2937	948	1607	382	2937	8.095	1.4064	14.57	**24.072**	8	**0.002**			
Very High	239	403	86	728	231.9	400.58	95.56	728	0.219	0.0147	0.955	1.1894			0.47	0.12	-0.98
High	287	461	125	873	278.1	480.36	114.6	873	0.288	0.7803	0.946	2.0144			0.54	-0.88	0.97
Medium	79	134	34	247	78.67	135.91	32.42	247	0.001	0.0268	0.077	0.1052			0.04	-0.16	0.28
Low	197	407	93	697	222	383.52	91.49	697	2.814	1.4378	0.025	4.2773			-1.68	1.20	0.16
Very Low	57	79	16	152	48.41	83.637	19.95	152	1.523	0.257	0.782	2.5628			1.23	-0.51	-0.88
	859	1484	354	2697	859	1484	354	2697	4.846	2.5166	2.786	10.149	8	0.255			
Higher	605	998	245	1848	588.6	1016.8	242.6	1848	0.457	0.3493	0.024	0.8312			0.68	-0.59	0.16
Lower	254	486	109	849	270.4	467.15	111.4	849	0.996	0.7602	0.053	1.8092			-1.00	0.87	-0.23
	859	1484	354	2697	859	1484	354	2697	1.453	1.1095	0.078	2.6403	2	0.267			

Ovicaprid	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	38	55	26	119	39.58	57.872	21.55	119	0.063	0.1425	0.921	1.1269			-0.25	-0.38	0.96
Axial	0	3	0	3	0.998	1.4589	0.543	3	0.998	1.6278	0.543	3.1688			-1.00	1.28	-0.74
Lower Limb	85	107	44	236	78.5	114.77	42.73	236	0.538	0.5261	0.038	1.102			0.73	-0.73	0.19
Upper Limb	34	63	15	112	37.25	54.467	20.28	112	0.284	1.3367	1.374	2.9948			-0.53	1.16	-1.17
Foot	1	3	1	5	1.663	2.4316	0.905	5	0.264	0.1329	0.01	0.4072			-0.51	0.36	0.10
	158	231	86	475	158	231	86	475	2.148	3.7659	2.886	8.7997	8	0.359			
Very High	17	24	9	50	16.67	23.995	9.338	50	0.007	9E-07	0.012	0.0189			0.08	0.00	-0.11
High	52	86	38	176	58.67	84.463	32.87	176	0.758	0.028	0.801	1.5862			-0.87	0.17	0.89
Medium	31	17	10	58	19.33	27.835	10.83	58	7.04	4.2173	0.064	11.321			**2.65**	**-2.05**	-0.25
Low	40	71	20	131	43.67	62.868	24.47	131	0.308	1.052	0.815	2.175			-0.55	1.03	-0.90
Very Low	1	5	2	8	2.667	3.8392	1.494	8	1.042	0.3509	0.171	1.5639			-1.02	0.59	0.41
	141	203	79	423	141	203	79	423	9.154	5.6482	1.863	**16.665**	8	**0.034**			
Higher	100	127	57	284	94.67	136.29	53.04	284	0.3	0.6337	0.296	1.2297			0.55	-0.80	0.54
Lower	41	76	22	139	46.33	66.707	25.96	139	0.614	1.2947	0.604	2.5126			-0.78	1.14	-0.78
	141	203	79	423	141	203	79	423	0.914	1.9283	0.9	3.7423	2	0.154			

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Pig	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	61	85	22	168	62.21	83.546	22.25	168	0.023	0.0253	0.003	0.0514			-0.15	0.16	-0.05
Axial	7	11	1	19	7.035	9.4486	2.516	19	2E-04	0.2547	0.914	1.1685			-0.01	0.50	-0.96
Lower Limb	49	66	22	137	50.73	68.13	18.14	137	0.059	0.0666	0.82	0.9452			-0.24	-0.26	0.91
Upper Limb	10	17	3	30	11.11	14.919	3.973	30	0.111	0.2903	0.238	0.6391			-0.33	0.54	-0.49
Foot	10	5	1	16	5.924	7.9568	2.119	16	2.804	1.0987	0.591	4.4935			1.67	-1.05	-0.77
	137	184	49	370	137	184	49	370	2.997	1.7356	2.565	7.2978	8	0.505			
Very High	19	27	6	52	19.09	26.329	6.582	52	4E-04	0.0171	0.052	0.069			-0.02	0.13	-0.23
High	45	58	17	120	44.05	60.759	15.19	120	0.02	0.1253	0.216	0.3615			0.14	-0.35	0.46
Medium	15	16	5	36	13.22	18.228	4.557	36	0.241	0.2723	0.043	0.5564			0.49	-0.52	0.21
Low	27	54	11	92	33.77	46.582	11.65	92	1.358	1.1812	0.036	2.575			-1.17	1.09	-0.19
Very Low	10	5	1	16	5.873	8.1013	2.025	16	2.899	1.1872	0.519	4.6055			1.70	-1.09	-0.72
	116	160	40	316	116	160	40	316	4.519	2.7831	0.865	8.1674	8	0.417			
Higher	79	101	28	208	76.35	105.32	26.33	208	0.092	0.1769	0.106	0.3746			0.30	-0.42	0.33
Lower	37	59	12	108	39.65	54.684	13.67	108	0.177	0.3407	0.204	0.7215			-0.42	0.58	-0.45
	116	160	40	316	116	160	40	316	0.268	0.5176	0.31	1.0961	2	0.578			
Cattle	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Head	26	51	18	95	27.46	53.066	14.47	95	0.078	0.0805	0.86	1.0179			-0.28	-0.28	0.93
Axial	4	3	1	8	2.313	4.4688	1.219	8	1.231	0.4827	0.039	1.7534			1.11	-0.69	-0.20
Lower Limb	19	44	11	74	21.39	41.336	11.27	74	0.267	0.1717	0.007	0.4455			-0.52	0.41	-0.08
Upper Limb	15	31	7	53	15.32	29.605	8.074	53	0.007	0.0657	0.143	0.2153			-0.08	0.26	-0.38
Foot	10	14	2	26	7.516	14.523	3.961	26	0.821	0.0189	0.971	1.8109			0.91	-0.14	-0.99
	74	143	39	256	74	143	39	256	2.404	0.8195	2.019	5.243	8	0.731			
Very High	6	14	5	25	6.726	14.35	3.924	25	0.078	0.0085	0.295	0.3822			-0.28	-0.09	0.54
High	18	26	7	51	13.72	29.274	8.004	51	1.334	0.3661	0.126	1.8259			1.15	-0.61	-0.36
Medium	6	22	4	32	8.61	18.368	5.022	32	0.791	0.7183	0.208	1.7176			-0.89	0.85	-0.46
Low	18	37	15	70	18.83	40.179	10.99	70	0.037	0.2516	1.466	1.7547			-0.19	-0.50	1.21
Very Low	12	29	4	45	12.11	25.83	7.063	45	1E-03	0.3891	1.328	1.7183			-0.03	0.62	-1.15
	60	128	35	223	60	128	35	223	2.241	1.7336	3.424	7.3985	8	0.494			
Higher	30	62	16	108	29.06	61.991	16.95	108	0.031	1E-06	0.053	0.0838			0.17	0.00	-0.23
Lower	30	66	19	115	30.94	66.009	18.05	115	0.029	1E-06	0.05	0.0787			-0.17	0.00	0.22
	60	128	35	223	60	128	35	223	0.059	3E-06	0.103	0.1626	2	0.922			

	Observed Values				**Expected Values**				**Chi Square Values**				**df**	**p**	**Standardized Residuals**		
Horse	**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**		**Ph 3**	**Ph 4**	**Ph 5**				**Ph 3**	**Ph 4**	**Ph 5**
Very High	7	39	6	52	10.72	36.718	4.565	52	1.289	0.1419	0.451	1.8825			-1.14	0.38	0.67
High	13	49	6	68	14.02	48.015	5.969	68	0.074	0.0202	2E-04	0.0939			-0.27	0.14	0.01
Medium	15	69	10	94	19.37	66.374	8.252	94	0.988	0.1039	0.37	1.4617			-0.99	0.32	0.61
Low	9	15	0	24	4.947	16.947	2.107	24	3.322	0.2236	2.107	5.652			1.82	-0.47	-1.45
Very Low	10	13	1	24	4.947	16.947	2.107	24	5.163	0.9191	0.582	6.6632			**2.27**	-0.96	-0.76
	54	185	23	262	54	185	23	262	10.83	1.4086	3.51	**15.753**	8	**0.046**			
Higher	35	157	22	214	44.11	151.11	18.79	214	1.88	0.2298	0.55	2.6599			-1.37	0.48	0.74
Lower	19	28	1	48	9.893	33.893	4.214	48	8.383	1.0247	2.451	11.859			**2.90**	-1.01	-1.57
	54	185	23	262	54	185	23	262	10.26	1.2545	3.001	**14.519**	2	**0.001**			

note: statistically significant values in **bold**

APPENDIX 9.11: Chi-square tests, body part representation, Late Period

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammals (all)	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	339	714	1053	291.3061	761.6939	1053	7.8086	2.9864	10.7950			**2.79**	-1.73
Axial	279	678	957	264.7483	692.2517	957	0.7672	0.2934	1.0606			0.88	-0.54
Lower Limb	127	338	465	128.6395	336.3605	465	0.0209	0.0080	0.0289			-0.14	0.09
Upper Limb	305	1022	1327	367.1066	959.8934	1327	10.5071	4.0184	14.5255			**-3.24**	**2.00**
Foot	48	119	167	46.19955	120.8005	167	0.0702	0.0268	0.0970			0.26	-0.16
	1098	2871	3969	1098	2871	3969	19.1740	7.3330	**26.5070**	4	**0.000**		
Very High	244	696	940	256.7109	683.2891	940	0.6294	0.2365	0.8658			-0.79	0.49
High	328	927	1255	342.7364	912.2636	1255	0.6336	0.2380	0.8717			-0.80	0.49
Medium	102	314	416	113.6082	302.3918	416	1.1861	0.4456	1.6317			-1.09	0.67
Low	268	581	849	231.8591	617.1409	849	5.6334	2.1165	7.7499			**2.37**	-1.45
Very Low	66	165	231	63.08534	167.9147	231	0.1347	0.0506	0.1853			0.37	-0.22
	1008	2683	3691	1008	2683	3691	8.2172	3.0872	**11.3044**	4	**0.023**		
Higher	674	1937	2611	713.0555	1897.944	2611	2.1392	0.8037	2.9428			-1.46	0.90
Lower	334	746	1080	294.9445	785.0555	1080	5.1716	1.9430	7.1146			**2.27**	-1.39
	1008	2683	3691	1008	2683	3691	7.3108	2.7466	**10.0574**	1	**0.002**		
Ovicaprid	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	56	184	240	53.9207	186.0793	240	0.0802	0.0232	0.1034			0.28	-0.15
Axial	4	2	6	1.348018	4.651982	6	5.2173	1.5118	6.7291			**2.28**	-1.23
Lower Limb	41	209	250	56.1674	193.8326	250	4.0958	1.1868	5.2826			**-2.02**	1.09
Upper Limb	46	125	171	38.4185	132.5815	171	1.4961	0.4335	1.9297			1.22	-0.66
Foot	6	8	14	3.145374	10.85463	14	2.5908	0.7507	3.3415			1.61	-0.87
	153	528	681	153	528	681	13.4802	3.9062	**17.3863**	4	**0.002**		
Very High	7	32	39	8.081081	30.91892	39	0.1446	0.0378	0.1824			-0.38	0.19
High	30	160	190	39.36937	150.6306	190	2.2298	0.5828	2.8126			-1.49	0.76
Medium	24	92	116	24.03604	91.96396	116	0.0001	0.0000	0.0001			-0.01	0.00
Low	46	144	190	39.36937	150.6306	190	1.1167	0.2919	1.4086			1.06	-0.54
Very Low	8	12	20	4.144144	15.85586	20	3.5876	0.9377	4.5253			1.89	-0.97
	115	440	555	115	440	555	7.0788	1.8501	8.9290	4	0.063		
Higher	61	284	345	71.48649	273.5135	345	1.5383	0.4021	1.9403			-1.24	0.63
Lower	54	156	210	43.51351	166.4865	210	2.5272	0.6605	3.1877			1.59	-0.81
	115	440	555	115	440	555	4.0655	1.0626	**5.1280**	1	**0.024**		

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Pig	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	72	116	188	55.78862	132.2114	188	4.7108	1.9878	6.6986			**2.17**	-1.41
Axial	0	5	5	1.48374	3.51626	5	1.4837	0.6261	2.1098			-1.22	0.79
Lower Limb	45	168	213	63.20732	149.7927	213	5.2447	2.2131	7.4578			**-2.29**	1.49
Upper Limb	16	41	57	16.91463	40.08537	57	0.0495	0.0209	0.0703			-0.22	0.14
Foot	13	16	29	8.605691	20.39431	29	2.2439	0.9468	3.1907			1.50	-0.97
	146	346	492	146	346	492	13.7326	5.7947	**19.5273**	4	**0.001**		
Very High	4	43	47	13.6689	33.3311	47	6.8394	2.8048	9.6443			**-2.62**	1.67
High	57	135	192	55.83893	136.1611	192	0.0241	0.0099	0.0340			0.16	-0.10
Medium	11	43	54	15.7047	38.2953	54	1.4094	0.5780	1.9874			-1.19	0.76
Low	45	80	125	36.35347	88.64653	125	2.0565	0.8434	2.8999			1.43	-0.92
Very Low	13	16	29	8.434004	20.566	29	2.4719	1.0137	3.4857			1.57	-1.01
	130	317	447	130	317	447	12.8015	5.2498	**18.0513**	4	**0.001**		
Higher	72	221	293	85.21253	207.7875	293	2.0487	0.8401	2.8888			-1.43	0.92
Lower	58	96	154	44.78747	109.2125	154	3.8978	1.5985	5.4962			**1.97**	-1.26
	130	317	447	130	317	447	5.9464	2.4386	**8.3850**	1	**0.004**		
Cattle	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Head	33	73	106	27.0129	78.9871	106	1.3270	0.4538	1.7808			1.15	-0.67
Axial	4	6	10	2.548387	7.451613	10	0.8269	0.2828	1.1096			0.91	-0.53
Lower Limb	14	57	71	18.09355	52.90645	71	0.9261	0.3167	1.2429			-0.96	0.56
Upper Limb	19	56	75	19.1129	55.8871	75	0.0007	0.0002	0.0009			-0.03	0.02
Foot	9	39	48	12.23226	35.76774	48	0.8541	0.2921	1.1462			-0.92	0.54
	79	231	310	79	231	310	3.9347	1.3456	5.2804	4	0.260		
Very High	3	11	14	3.141732	10.85827	14	0.0064	0.0019	0.0082			-0.08	0.04
High	8	46	54	12.11811	41.88189	54	1.3995	0.4049	1.8044			-1.18	0.64
Medium	15	36	51	11.44488	39.55512	51	1.1043	0.3195	1.4239			1.05	-0.57
Low	20	62	82	18.40157	63.59843	82	0.1388	0.0402	0.1790			0.37	-0.20
Very Low	11	42	53	11.8937	41.1063	53	0.0672	0.0194	0.0866			-0.26	0.14
	57	197	254	57	197	254	2.7162	0.7859	3.5021	4	0.478		
Higher	26	93	119	26.70472	92.29528	119	0.0186	0.0054	0.0240			-0.14	0.07
Lower	31	104	135	30.29528	104.7047	135	0.0164	0.0047	0.0211			0.13	-0.07
	57	197	254	57	197	254	0.0350	0.0101	0.0451	1	0.832		
Horse	**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**		**Ph 1**	**Ph 2**				**Ph 1**	**Ph 2**
Higher	5	31	36	7.2	28.8	36	0.6722	0.1681	0.8403			-0.82	0.41
Lower	9	25	34	6.8	27.2	34	0.7118	0.1779	0.8897			0.84	-0.42
	14	56	70	14	56	70	1.3840	0.3460	1.7300	1	0.188		

note: statistically significant values in **bold**

APPENDIX 9.12: Chi-square tests, body part representation, period comparisons (on-tell)

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Mammals (all)	**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Head	1053	1393	293	2739	1163.06	1299.03	276.918	2739	10.4143	6.7984	0.9339	18.1467			**-3.23**	**2.61**	0.97
Axial	957	1173	131	2261	960.084	1072.32	228.592	2261	0.0099	9.4520	41.6643	51.1262			-0.10	**3.07**	**-6.45**
Lower Limb	465	473	142	1080	458.598	512.211	109.19	1080	0.0894	3.0018	9.8588	12.9500			0.30	-1.73	**3.14**
Upper Limb	1327	1232	344	2903	1232.7	1376.81	293.499	2903	7.2145	15.2299	8.6895	31.1339			**2.69**	**-3.90**	**2.95**
Foot	167	162	35	364	154.565	172.634	36.8011	364	1.0005	0.6551	0.0881	1.7437			1.00	-0.81	-0.30
	3969	4433	945	9347	3969	4433	945	9347	18.7286	35.1371	61.2347	**115.1004**	8	**0.000**			
Very High	940	1150	186	2276	976.487	1072.26	227.256	2276	1.3633	5.6367	7.4896	14.4896			-1.17	**2.37**	**-2.74**
High	1255	1311	314	2880	1235.62	1356.81	287.565	2880	0.3038	1.5467	2.4301	4.2807			0.55	-1.24	1.56
Medium	416	369	82	867	371.975	408.456	86.569	867	5.2107	3.8115	0.2411	9.2633			**2.28**	-1.95	-0.49
Low	849	1000	231	2080	892.396	979.919	207.686	2080	2.1103	0.4115	2.6172	5.1390			-1.45	0.64	1.62
Very Low	231	223	46	500	214.518	235.557	49.9244	500	1.2663	0.6694	0.3085	2.2442			1.13	-0.82	-0.56
	3691	4053	859	8603	3691	4053	859	8603	10.2544	12.0758	13.0866	**35.4168**	8	**0.000**			
Higher	2611	2830	582	6023	2584.09	2837.52	601.39	6023	0.2803	0.0200	0.6252	0.9254			0.53	-0.14	-0.79
Lower	1080	1223	277	2580	1106.91	1215.48	257.61	2580	0.6544	0.0466	1.4594	2.1604			-0.81	0.22	1.21
	3691	4053	859	8603	3691	4053	859	8603	0.9347	0.0665	2.0846	3.0858	2	0.214			
Ovicaprid	**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Head	240	214	105	559	214.226	228.696	116.078	559	3.1010	0.9444	1.0573	5.1027			1.76	-0.97	-1.03
Axial	6	4	1	11	4.21553	4.50028	2.28419	11	0.7554	0.0556	0.7220	1.5330			0.87	-0.24	-0.85
Lower Limb	250	329	180	759	290.872	310.519	157.609	759	5.7431	1.0999	3.1810	10.0240			**-2.40**	1.05	1.78
Upper Limb	171	173	80	424	162.49	173.465	88.045	424	0.4457	0.0012	0.7351	1.1821			0.67	-0.04	-0.86
Foot	14	7	3	24	9.19752	9.8188	4.98368	24	2.5076	0.8092	0.7896	4.1064			1.58	-0.90	-0.89
	681	727	369	1777	681	727	369	1777	12.5528	2.9103	6.4850	**21.9481**	8	**0.005**			
Very High	39	73	44	156	58.0684	65.3924	32.5392	156	6.2617	0.8851	4.0366	11.1834			**-2.50**	0.94	**2.01**
High	190	258	141	589	219.245	246.898	122.856	589	3.9011	0.4992	2.6794	7.0798			**-1.98**	0.71	1.64
Medium	116	85	38	239	88.9638	100.184	49.8518	239	8.2163	2.3014	2.8176	13.3354			**2.87**	-1.52	-1.68
Low	190	198	85	473	176.066	198.273	98.6606	473	1.1027	0.0004	1.8915	2.9945			1.05	-0.02	-1.38
Very Low	20	11	3	34	12.6559	14.2522	7.09188	34	4.2617	0.7421	2.3609	7.3647			**2.06**	-0.86	-1.54
	555	625	311	1491	555	625	311	1491	23.7434	4.4282	13.7861	**41.9578**	8	**0.000**			
Higher	345	416	223	984	366.278	412.475	205.247	984	1.2361	0.0301	1.5355	2.8017			-1.11	0.17	1.24
Lower	210	209	88	507	188.722	212.525	105.753	507	2.3990	0.0585	2.9801	5.4375			1.55	-0.24	-1.73
	555	625	311	1491	555	625	311	1491	3.6350	0.0886	4.5156	**8.2392**	2	**0.016**			

Pig	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
	Late (	Flor.	Early		Late	Flor.	Early		Late	Flor.	Early				Late	Flor.	Early
Head	188	245	40	473	196.717	219.907	56.3762	473	0.3863	2.8633	4.7570	8.0065			-0.62	1.69	**-2.18**
Axial	5	20	3	28	11.645	13.0178	3.33728	28	3.7918	3.7450	0.0341	7.5709			-1.95	1.94	-0.18
Lower Limb	213	223	77	513	213.352	238.504	61.1437	513	0.0006	1.0078	4.1120	5.1204			-0.02	-1.00	**2.03**
Upper Limb	57	41	17	115	47.8276	53.4658	13.7067	115	1.7591	2.9064	0.7913	5.4568			1.33	-1.70	0.89
Foot	29	21	4	54	22.4582	25.1057	6.43618	54	1.9056	0.6714	0.9221	3.4991			1.38	-0.82	-0.96
	492	550	141	1183	492	550	141	1183	7.8433	11.1940	10.6164	**29.6538**	8	**0.000**			
Very High	47	70	18	135	57.1991	61.0379	16.763	135	1.8186	1.3159	0.0913	3.2257			-1.35	1.15	0.30
High	192	211	63	466	197.443	210.694	57.8635	466	0.1500	0.0004	0.4560	0.6064			-0.39	0.02	0.68
Medium	54	52	18	124	52.5384	56.0645	15.3972	124	0.0407	0.2947	0.4400	0.7753			0.20	-0.54	0.66
Low	125	123	28	276	116.94	124.789	34.2711	276	0.5555	0.0256	1.1475	1.7286			0.75	-0.16	-1.07
Very Low	29	21	4	54	22.8796	24.4152	6.70521	54	1.6372	0.4777	1.0914	3.2063			1.28	-0.69	-1.04
	447	477	131	1055	447	477	131	1055	4.2020	2.1143	3.2262	9.5425	8	0.299			
Higher	293	333	99	725	307.18	327.796	90.0237	725	0.6546	0.0826	0.8950	1.6322			-0.81	0.29	0.95
Lower	154	144	32	330	139.82	149.204	40.9763	330	1.4381	0.1815	1.9664	3.5860			1.20	-0.43	-1.40
	447	477	131	1055	447	477	131	1055	2.0927	0.2641	2.8614	5.2182	2	0.074			

Cattle	Late (	Flor.	Early		Late	Flor.	Early		Late	Flor.	Early		df	p	Late	Flor.	Early
Head	106	143	46	295	112.901	143.858	38.2407	295	0.4218	0.0051	1.5744	2.0014			-0.65	-0.07	1.25
Axial	10	11	4	25	9.5679	12.1914	3.24074	25	0.0195	0.1164	0.1779	0.3138			0.14	-0.34	0.42
Lower Limb	71	111	19	201	76.9259	98.0185	26.0556	201	0.4565	1.7193	1.9106	4.0863			-0.68	1.31	-1.38
Upper Limb	75	82	20	177	67.7407	86.3148	22.9444	177	0.7779	0.2157	0.3779	1.3715			0.88	-0.46	-0.61
Foot	48	48	16	112	42.8642	54.6173	14.5185	112	0.6153	0.8017	0.1512	1.5683			0.78	-0.90	0.39
	310	395	105	810	310	395	105	810	2.2911	2.8582	4.1919	9.3412	8	0.314			
Very High	14	28	7	49	18.384	24.1743	6.44165	49	1.0455	0.6054	0.0484	1.6993			-1.02	0.78	0.22
High	54	72	30	156	58.5288	76.9631	20.5081	156	0.3504	0.3201	4.3932	5.0636			-0.59	-0.57	2.10
Medium	51	60	11	122	45.7725	60.1891	16.0384	122	0.5970	0.0006	1.5828	2.1804			0.77	-0.02	-1.26
Low	82	104	18	204	76.5377	100.644	26.8183	204	0.3898	0.1119	2.8996	3.4014			0.62	0.33	-1.70
Very Low	53	70	23	146	54.777	72.0295	19.1935	146	0.0576	0.0572	0.7549	0.8697			-0.24	-0.24	0.87
	254	334	89	677	254	334	89	677	2.4404	1.0952	9.6789	13.2144	8	0.105			
Higher	119	160	48	327	122.685	161.326	42.9882	327	0.1107	0.0109	0.5843	0.7059			-0.33	-0.10	0.76
Lower	135	174	41	350	131.315	172.674	46.0118	350	0.1034	0.0102	0.5459	0.6595			0.32	0.10	-0.74
	254	334	89	677	254	334	89	677	0.2141	0.0211	1.1302	1.3654	2	0.505			

	Observed Values				Expected Values				Chi Square Values				df	p	Standardized Residuals		
Horse	**Late**	**Flor.**			**Late**	**Flor.**			**Late**	**Flor.**					**Late**	**Flor.**	
Head	20	126	146		24.6761	121.324	146		0.8861	0.1802	1.0663				-0.94	0.42	
Axial	4	17	21		3.5493	17.4507	21		0.0572	0.0116	0.0689				0.24	-0.11	
Lower Limb	23	170	193		32.6197	160.38	193		2.8369	0.5770	3.4139				-1.68	0.76	
Upper Limb	22	68	90		15.2113	74.7887	90		3.0298	0.6162	3.6460				1.74	-0.79	
Foot	15	32	47		7.94366	39.0563	47		6.2681	1.2749	7.5430				**2.50**	-1.13	
	84	413	497		84	413	497		13.0782	2.6600	**15.7381**		4	**0.003**			
Very High	8	61	69		11.8966	57.1034	69		1.2763	0.2659	1.5421				-1.13	0.52	
High	13	84	97		16.7241	80.2759	97		0.8293	0.1728	1.0021				-0.91	0.42	
Medium	15	116	131		22.5862	108.414	131		2.5480	0.5308	3.0789				-1.60	0.73	
Low	19	43	62		10.6897	51.3103	62		6.4606	1.3460	7.8066				**2.54**	-1.16	
Very Low	15	32	47		8.10345	38.8966	47		5.8694	1.2228	7.0922				**2.42**	-1.11	
	70	336	406		70	336	406		16.9836	3.5383	**20.5219**		4	**0.000**			
Horse	**Late (**	**Flor.**	**arly**		**Late**	**Flor.**	**Early**		**Late**	**Flor.**	**Early**				**Late**	**Flor.**	**Early**
Higher	36	261	13	310	51.5439	247.411	11.0451	310	4.6875	0.7464	0.3460	5.7799			**-2.17**	0.86	0.59
Lower	34	75	2	111	18.4561	88.5891	3.95487	111	13.0913	2.0845	0.9663	16.1421			**3.62**	-1.44	-0.98
	70	336	15	421	70	336	15	421	17.7789	2.8309	1.3123	**21.9220**	2	**0.000**			

note: statistically significant values in **bold**

APPENDIX 9.13: Chi-square tests, body part representation, on- versus off-tell

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammals (all)	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Head	840	36	876	828.303	47.6968	876	0.1652	2.8684	3.0336			0.41	-1.69
Axial	670	48	718	678.906	39.094	718	0.1168	2.0289	2.1457			-0.34	1.42
Lower Limb	287	25	312	295.012	16.9879	312	0.2176	3.7788	3.9964			-0.47	1.94
Upper Limb	755	35	790	746.986	43.0142	790	0.0860	1.4932	1.5792			0.29	-1.22
Foot	105	9	114	107.793	6.20712	114	0.0724	1.2567	1.3290			-0.27	1.12
	2657	153	2810	2657	153	2810	0.6579	11.4260	**12.0839**	4	**0.017**		
Very High	669	29	698	662.254	35.7459	698	0.0687	1.2731	1.3418			0.26	-1.13
High	772	41	813	771.365	41.6353	813	0.0005	0.0097	0.0102			0.02	-0.10
Medium	221	8	229	217.272	11.7275	229	0.0639	1.1848	1.2487			0.25	-1.09
Low	623	39	662	628.098	33.9023	662	0.0414	0.7665	0.8079			-0.20	0.88
Very Low	142	14	156	148.011	7.98905	156	0.2441	4.5226	4.7667			-0.49	2.13
	2427	131	2558	2427	131	2558	0.4187	7.7567	8.1754	4	0.085		
Higher	1662	78	1740	1650.89	89.1087	1740	0.0747	1.3849	1.4596			0.27	-1.18
Lower	765	53	818	776.109	41.8913	818	0.1590	2.9458	3.1048			-0.40	1.72
	2427	131	2558	2427	131	2558	0.2338	4.3306	**4.5644**	1	**0.033**		
Ovicaprid	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Very High	41	2	43	39.4352	3.56477	43	0.0621	0.6869	0.7489			0.25	-0.83
High	139	13	152	139.399	12.601	152	0.0011	0.0126	0.0138			-0.03	0.11
Medium	52	5	57	52.2746	4.72539	57	0.0014	0.0160	0.0174			-0.04	0.13
Low	115	11	126	115.554	10.4456	126	0.0027	0.0294	0.0321			-0.05	0.17
Very Low	7	1	8	7.33679	0.66321	8	0.0155	0.1710	0.1865			-0.12	0.41
	354	32	386	354	32	386	0.0828	0.9159	0.9987	4	0.910		
Higher	232	20	252	231.109	20.8912	252	0.0034	0.0380	0.0415			0.06	-0.19
Lower	122	12	134	122.891	11.1088	134	0.0065	0.0715	0.0780			-0.08	0.27
	354	32	386	354	32	386	0.0099	0.1095	0.1194	1	0.730		

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Pig	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Higher	185	12	197	185.18	11.82	197	0.0002	0.0027	0.0029			-0.01	0.05
Lower	97	6	103	96.82	6.18	103	0.0003	0.0052	0.0056			0.02	-0.07
	282	18	300	282	18	300	0.0005	0.0080	0.0085	1	0.927		
Cattle	**On Tell**	**Off Tell**		**On Tell**	**Off Tell**		**On Tell**	**Off Tell**				**On Tell**	**Off Tell**
Higher	93	0	93	89.3168	3.68317	93	0.1519	3.6832	3.8351			0.39	-1.92
Lower	101	8	109	104.683	4.31683	109	0.1296	3.1425	3.2721			-0.36	1.77
	194	8	202	194	8	202	0.2815	6.8257	**7.1072**	1	**0.008**		

note: statistically significant values in **bold**

APPENDIX 10.1: Wild plant communities represented at Pecica (classification follows Ellenberg 1988)

Type I	Type II	Community Name	Type III	Taxon	Common name	Late	Flor.
freshwater and mire	reed/tall sedge swamp	Magnocaricion	tall sedge swamp	*Galium cf. palustre*	common marsh-bedstraw		1
herbaceous/frequently disturbed	bur marigold mud bank	Bidention tripatitae	bur marigold (narrow)	*Polygonum cf. hydropiper*	swamp smartweed		1
		Chenopodium rubri	Orache community	*Chenopodium glaucum*	oak-leaved goosefoot		2
	arable/waste land and garden weeds	Chenopodietea		*cf. Solanum nigrum*	black nightshade		1
				Portulaca oleracea	common purslane	1	1
				Chenopodium album	white goosefoot	56	71
		Sisymbrietalia	short-lived ruderals	*Chenopodium cf. hybridum*	maple-leaved goosefoot		6
				Malva cf. neglecta	common mallow	3	2
				Bromus cf. tectorum	downy brome		4
				Hordeum murinum	wall barley	1	
				Brassica sp.	mustard (non ID)	1	2
		Polygono-Chenopodietalia	rich arable soils and garden weeds	*Chenopodium cf. polyspermum*	many-seeded goosefoot		6
		Fumario-Euphorbion	demanding arable and garden, base rich soils	*Atriplex cf. patula*	common orache		1
	persistent nitrophilous ruderals	Calystegion	veil and riverbank	*Rubus caesius*	European dewberry	1	
				Saponaria officinalis cf.	common soapwort		1
				Cucubalus cf.	bladder campion	1	
		Aegopodion	semi-shade fringe adj. to woody plants	*Sambucus cf. ebulus*	European dwarf elder	3	9
	couch grass pioneer dry habitats	Convolvulo-Agropyrion		*Poa cf. compressa*	flattened meadowgrass		1
	swards pathways and flooded	Agrostietalia stoloniferae	pioneer swards flooded and damp	*Rumex crispus*	curley dock		1
heaths/grassslands human/animal activity	matgrass pastures/dwarf shrub heath	Violo-Nardion	matgrass swards lower levels	*Festuca cf. tenuifolia/ pseudovina*	sheep's fescue	1	
	more or less arid poor Ca soils	Festucetalia valesiaceae	continental more or less arid	*Stipa sp.*	needlegrass	3	1
	cultivated meadow and pasture	Molinio-Arrhenatheretea		*Plantago cf. lanceolata*	ribwort platain	2	
				Festuca pratensis	meadow fescue		1
				Rumex acetosella	sheep's sorrel		4
		Molinietalia	moist meadow and stream bank	*Lychnis flos-cuculi*	ragged robin		1
		Arrhenatherion	oatgrass meadows	Arrhenatherum cf.	oat grass	3	
		Cynosurion	ryegrass-crested dogstail meadows	*Hordeum cf. secalinum*	knotted barley grass		1
				Trifolium cf. repens	white clover		1
woodland herbaceous perennial/shrub	woodland clearing	Epilobietea augustifolii, Atropetalia		*Fragaria vesca/potentilla*	wild strawberry	1	
		Sambuco-Salicion capreae	woodland clearing shrub	*Sambucus cf. racemosa*	European red elder		5
broadleaf woodland	broadleaved woods and scrub fertile soils	Querco-Fagetea		*Moehringia trinervia cf.*	three-nerved sandwort	12	27
(multiple but narrow ecological range)		(woodland)		*Teucrium cf. scorodonia*	woodland germander	3	6
				Carex cf. flacca	blue sedge	1	1
				Silene dioica	red campion	1	
		(woodland/fens/ clearances)		*Deschampsia caespitosa cf.*	tussock grass		1
				Rubus cf. idaeus	European red raspberry		1
		(fens/floodplain)		*Solanum cf. dulcamara*	bitter nightshade		2
		(semi-arid grassland)		*cf. Brachypodium pinnatum*	tor-grass	4	

APPENDIX 10.2: Chi-square statistics, period comparisons, general botanical assemblage (all Florescent Period contexts)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
einkorn wheat	69	369	438	75.6754	362.325	438	0.5888	0.1230	0.7118			-0.77	0.35
other ID wheat	8	16	24	4.1466	19.8534	24	3.5809	0.7479	4.3289			1.89	-0.86
barley	22	89	111	19.178	91.822	111	0.4152	0.0867	0.5020			0.64	-0.29
	99	474	573	99	474	573	4.5850	0.9576	5.5427	2	0.063		
wheats (all)	132	470	602	134.165	467.835	602	0.0349	0.0100	0.0450			-0.19	0.10
barley	22	67	89	19.835	69.165	89	0.2363	0.0678	0.3041			0.49	-0.26
	154	537	691	154	537	691	0.2712	0.0778	0.3490	1	0.555		
grain	245	701	946	225.098	720.902	946	1.7596	0.5494	2.3091			1.33	-0.74
chaff	61	279	340	80.902	259.098	340	4.8959	1.5287	6.4247			**-2.21**	1.24
	306	980	1286	306	980	1286	6.6556	2.0782	**8.7337**	1	**0.003**		
crop seeds	309	1005	1314	369.146	944.854	1314	9.7998	3.8287	13.6285			**-3.13**	**1.96**
wild seeds	245	413	658	184.854	473.146	658	19.5698	7.6457	27.2155			**4.42**	**-2.77**
	554	1418	1972	554	1418	1972	29.3695	11.4744	**40.8439**	1	**0.000**		
chenopod	98	155	253	91.5619	161.438	253	0.4527	0.2567	0.7094			0.67	-0.51
grass	68	131	199	72.019	126.981	199	0.2243	0.1272	0.3515			-0.47	0.36
carnation	15	30	45	16.2857	28.7143	45	0.1015	0.0576	0.1591			-0.32	0.24
buckwheat	26	10	36	13.0286	22.9714	36	12.9145	7.3247	20.2392			**3.59**	**-2.71**
other	21	76	97	35.1048	61.8952	97	5.6672	3.2142	8.8814			**-2.38**	1.79
	228	402	630	228	402	630	19.3602	10.9804	**30.3406**	4	**0.000**		
rose/elderberry	6	22	28	6.06186	21.9381	28	0.0006	0.0002	0.0008			-0.03	0.01
sedges	5	6	11	2.38144	8.61856	11	2.8793	0.7956	3.6749			1.70	-0.89
clover/wild legumes	3	18	21	4.54639	16.4536	21	0.5260	0.1453	0.6713			-0.73	0.38
nightshade/mint	7	30	37	8.01031	28.9897	37	0.1274	0.0352	0.1626			-0.36	0.19
	21	76	97	21	76	97	3.5333	0.9763	4.5096	3	0.211		
annual	63	99	162	61.8423	100.158	162	0.0217	0.0134	0.0351			0.15	-0.12
perennial	29	50	79	30.1577	48.8423	79	0.0444	0.0274	0.0719			-0.21	0.17
	92	149	241	92	149	241	0.0661	0.0408	0.1069	1	0.744		
winter weeds	0	6	6	2.34437	3.65563	6	2.3444	1.5035	3.8478			-1.53	1.23
spring weeds	59	86	145	56.6556	88.3444	145	0.0970	0.0622	0.1592			0.31	-0.25
	59	92	151	59	92	151	2.4414	1.5657	**4.0070**	1	**0.045**		

note: statistically significant values in **bold**

APPENDIX 10.3: Chi-square statistics, period comparisons, general botanical assemblage (on-tell Florescent Period contexts only, no platform)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
einkorn wheat	69	229	298	78.672	219.328	298	1.1891	0.4265	1.6156			-1.09	0.65
other ID wheat	8	6	14	3.696	10.304	14	5.0120	1.7978	6.8098			**2.24**	-1.34
barley	22	41	63	16.632	46.368	63	1.7325	0.6215	2.3540			1.32	-0.79
	99	276	375	99	276	375	7.9336	2.8458	**10.7794**	2	**0.005**		
wheats (all)	132	356	488	136.392	351.608	488	0.1414	0.0549	0.1963			-0.38	0.23
barley	22	41	63	17.608	45.392	63	1.0955	0.4250	1.5205			1.05	-0.65
	154	397	551	154	397	551	1.2369	0.4798	1.7168	1	0.190		
grain	245	542	787	229.136	557.864	787	1.0983	0.4511	1.5494			1.05	-0.67
chaff	61	203	264	76.8639	187.136	264	3.2742	1.3448	4.6190			-1.81	1.16
	306	745	1051	306	745	1051	4.3725	1.7959	**6.1684**	1	**0.013**		
crop seeds	309	755	1064	389.08	674.92	1064	16.4819	9.5015	25.9835			**-4.06**	**3.08**
wild seeds	245	206	451	164.92	286.08	451	38.8842	22.4161	61.3003			**6.24**	**-4.73**
	554	961	1515	554	961	1515	55.3661	31.9176	**87.2837**	1	**0.000**		
chenopod	98	72	170	90.1395	79.8605	170	0.6855	0.7737	1.4591			0.83	-0.88
grass	68	67	135	71.5814	63.4186	135	0.1792	0.2022	0.3814			-0.42	0.45
carnation	15	21	36	19.0884	16.9116	36	0.8757	0.9884	1.8640			-0.94	0.99
buckwheat	26	4	30	15.907	14.093	30	6.4041	7.2283	13.6324			**2.53**	**-2.69**
other	21	38	59	31.2837	27.7163	59	3.3805	3.8156	7.1961			-1.84	1.95
	228	202	430	228	202	430	11.5249	13.0083	**24.5331**	4	**0.000**		
rose/elderberry	6	7	13	4.62712	8.37288	13	0.4073	0.2251	0.6324			0.64	-0.47
sedges	5	6	11	3.91525	7.08475	11	0.3005	0.1661	0.4666			0.55	-0.41
clover/wild legumes	3	11	14	4.98305	9.01695	14	0.7892	0.4361	1.2253			-0.89	0.66
nightshade/mint	7	14	21	7.47458	13.5254	21	0.0301	0.0167	0.0468			-0.17	0.13
	21	38	59	21	38	59	1.5272	0.8440	2.3711	3	0.499		

note: statistically significant values in **bold**

APPENDIX 10.4: Chi-square statistics, on- versus off-tell comparisons, general botanical assemblage (Florescent Period)

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	On Tell	Off Tell		On Tell	Off Tell		On Tell	Off Tell				On Tell	Off Tell
einkorn wheat	94	56	150	93.75	56.25	150	0.0007	0.0011	0.0018			0.03	-0.03
other ID wheat	4	2	6	3.75	2.25	6	0.0167	0.0278	0.0444			0.13	-0.17
barley	12	8	20	12.5	7.5	20	0.0200	0.0333	0.0533			-0.14	0.18
	110	66	176	110	66	176	0.0373	0.0622	0.0996	2	0.951		
wheats (all)	157	83	240	156	84	240	0.0064	0.0119	0.0183			0.08	-0.11
barley	12	8	20	13	7	20	0.0769	0.1429	0.2198			-0.28	0.38
	169	91	260	169	91	260	0.0833	0.1548	0.2381	1	0.626		
crop seeds	157	113	270	164.531	105.469	270	0.3447	0.5378	0.8825			-0.59	0.73
chaff	116	62	178	108.469	69.5313	178	0.5229	0.8157	1.3387			0.72	-0.90
	273	175	448	273	175	448	0.8676	1.3535	2.2212	1	0.136		
crop seeds	274	176	450	262.832	187.168	450	0.4746	0.6664	1.1409			0.69	-0.82
wild seeds	56	59	115	67.1681	47.8319	115	1.8569	2.6076	4.4646			-1.36	1.61
	330	235	565	330	235	565	2.3315	3.2740	**5.6055**	1	**0.018**		
chenopod	23	26	49	23.8496	25.1504	49	0.0303	0.0287	0.0590			-0.17	0.17
grass	14	14	28	13.6283	14.3717	28	0.0101	0.0096	0.0197			0.10	-0.10
other	18	18	36	17.5221	18.4779	36	0.0130	0.0124	0.0254			0.11	-0.11
	55	58	113	55	58	113	0.0534	0.0507	0.1041	2	0.949		

note: statistically significant values in **bold**

APPENDIX 10.5: Chi-square statistics, period comparisons, wild plant taxa characteristics

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
shade/half shade	12	27	39	13.26	25.74	39	0.1197	0.0617	0.1814			-0.35	0.25
half to partial shade	10	20	30	10.2	19.8	30	0.0039	0.0020	0.0059			-0.06	0.04
partial shade	10	22	32	10.88	21.12	32	0.0712	0.0367	0.1078			-0.27	0.19
partial shade to light loving	4	3	7	2.38	4.62	7	1.1027	0.5681	1.6707			1.05	-0.75
light loving	15	27	42	14.28	27.72	42	0.0363	0.0187	0.0550			0.19	-0.14
LIGHT	51	99	150	51	99	150	1.3338	0.6871	2.0209	4	0.732		
cool to warm	0	5	5	1.71756	3.28244	5	1.7176	0.8987	2.6163			-1.31	0.95
fairly warm	24	53	77	26.4504	50.5496	77	0.2270	0.1188	0.3458			-0.48	0.34
fairly warm to warm	16	26	42	14.4275	27.5725	42	0.1714	0.0897	0.2611			0.41	-0.30
warm	5	2	7	2.40458	4.59542	7	2.8014	1.4659	4.2673			1.67	-1.21
TEMPERATURE	45	86	131	45	86	131	4.9174	2.5730	7.4904	3	0.058		
oceanic	4	7	11	3.84553	7.15447	11	0.0062	0.0033	0.0095			0.08	-0.06
oceanic to suboceanic	26	44	70	24.4715	45.5285	70	0.0955	0.0513	0.1468			0.31	-0.23
suboceanic to intermediate	7	12	19	6.64228	12.3577	19	0.0193	0.0104	0.0296			0.14	-0.10
subcontinental to continental	6	17	23	8.04065	14.9593	23	0.5179	0.2784	0.7963			-0.72	0.53
CONTINENTALITY	43	80	123	43	80	123	0.6388	0.3434	0.9822	3	0.806		
dry	3	6	9	3.36614	5.63386	9	0.0398	0.0238	0.0636			-0.20	0.15
dry to moist	66	79	145	54.2323	90.7677	145	2.5534	1.5256	4.0791			1.60	-1.24
moist	22	53	75	28.0512	46.9488	75	1.3054	0.7799	2.0853			-1.14	0.88
moist to damp	2	13	15	5.61024	9.38976	15	2.3232	1.3881	3.7113			-1.52	1.18
damp to wet	2	8	10	3.74016	6.25984	10	0.8096	0.4837	1.2934			-0.90	0.70
WATER	95	159	254	95	159	254	7.0315	4.2012	**11.2327**	4	**0.024**		
acid to fairly acid	4	12	16	5.1134	10.8866	16	0.2424	0.1139	0.3563			-0.49	0.34
neutral	22	33	55	17.5773	37.4227	55	1.1128	0.5227	1.6355			1.05	-0.72
neutral to basic	5	21	26	8.30928	17.6907	26	1.3180	0.6190	1.9370			-1.15	0.79
REACTION	31	66	97	126	225	351	2.6732	1.2556	3.9288	2	0.140		

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
	Late	Florescent		Late	Florescent		Late	Florescent				Late	Florescent
nitrogen poor	4	2	6	2.29344	3.70656	6	1.2699	0.7857	2.0556			1.13	-0.89
poor to average nitrogen	7	12	19	7.26255	11.7375	19	0.0095	0.0059	0.0154			-0.10	0.08
average nitrogen	6	7	13	4.96911	8.03089	13	0.2139	0.1323	0.3462			0.46	-0.36
average to rich nitrogen	77	113	190	72.6255	117.375	190	0.2635	0.1630	0.4265			0.51	-0.40
nitrogen rich	5	26	31	11.8494	19.1506	31	3.9592	2.4498	6.4090			**-1.99**	1.57
NITROGEN	99	160	259	99	160	259	5.71595	3.53674	9.25269	4	0.055		
forest/riparian	23	58	81	30.5308	50.4692	81	1.85755	1.1237	2.98126			-1.36	1.06
grassland/pasture	13	10	23	8.66923	14.3308	23	2.16346	1.30876	3.47222			1.47	-1.14
crop weed/disturbed	62	94	156	58.8	97.2	156	0.17415	0.10535	0.2795			0.42	-0.32
GENERAL ECOLOGY	98	162	260	98	162	260	4.1952	2.5378	**6.7330**	2	**0.035**		
large seed	5	11	16	6.16867	9.83133	16	0.22141	0.13892	0.36033			-0.47	0.37
medium seed	59	86	145	55.9036	89.0964	145	0.1715	0.10761	0.27911			0.41	-0.33
small seed		5	5	1.92771	3.07229	5	1.92771	1.20954	3.13725			-1.39	1.10
SEED SIZE	64	102	166	64	102	166	2.32062	1.45608	3.7767	2	0.151		

note: statistically significant values in **bold**

APPENDIX 11.1: Worked Osseous Materials

The worked bone typology used in this dissertation is presented in Table 11.1A. This system takes into account several variables, including raw material, degree of modification, standardization, and final form to infer the item's function. This classification system is adapted from Choyke (Choyke 1982, 1983, 1984a, 1997, 1999, 2000, 2001; Choyke and Schibler 2007; Sofaer, et al. 2013), who has worked extensively on Bronze Age assemblages in the study region, to maintain inter-site comparability (see also Chapter 7). Additional considerations of use wear follow Christidou (2008).

Table 11.1A: Pecica worked bone typology (major classes)

Type	Modification	Material	Taxon	Element	Function
hammer (flat end)	formal	antler	red deer	beam/burr	various heavy-duty tasks, wood working, metalworking
adze/mattock (angled end)	formal	antler	red deer	beam/burr	various heavy-duty tasks, wood working, agriculture
antler pick	formal	antler	red deer	tine	agriculture, digging
planer	semi-formal	bone	horse	pelvis	wood working
scraper (flat end)	semi-formal	bone	large mammal	rib	hide working, ceramics?
scraper (flat end)	expedient	bone	large mammal	flat bone	hide working
scraper (gouge)	expedient	bone	various	long bone	hide working, wood working? marrow extraction?
smoother (rounded)	semi-formal	antler	red deer	tine	burnishing, ceramic decoration
smoother (flat)	semi-formal	bone	various	astragalus	burnishing, hide working?
awl/punch	expedient	bone/tooth	medium mammal	long bone	hide working, ceramic decoration
needle/pin	formal	bone	medium mammal	long bone	hide working, textile production, ornament?
"skate"/beamer	semi-formal	bone	red deer	radius	transportation? hide working?
harpoon/toggle	formal	antler	red deer	beam/tine	fishing
cheek piece	formal	antler	red deer	beam	horse harness, transportation, ornament
worked shell	formal	shell	various	shell	ornament

Heavy-duty hafted antler tools (Figure 11.1A) are fairly common items from Pecica. These include hammers, mattocks/adzes, and picks. Mattocks and hammers are very similar in form and often cannot be distinguished if fragmented. Hammers have flattened ends on both sides while mattocks have one end that is angled. It is possible that some of the flat ended pieces with one end hollowed out may have been used as sockets for heavy metal or stone tools, such as axes. Both flat- and angled-end forms are made from large beam and burr sections of red deer antler. Picks are made from tines. Unfinished examples show that the antler beam was cut around its circumference with a sharp implement (stone or metal) in a sawing manner then snapped through the cortical interior (Figure 11.2A). The working ends are then further cut and ground to create the desired shape. These tools were likely used in a variety of activities, including carpentry and metallurgy, and for the mattocks/adzes, perhaps agricultural activities as well. Use wear studies have shown abrasions consistent with wood splitting (Christidou 2008). In ore and salt producing regions, picks are associated with mining (Boroffka 2006). Note that none of these antler tools are billets for chipped stone tool manufacture.

Figure 11.1A: Heavy-duty antler tools. Left, unfinished antler hammer/socket; right: antler mattock.

Figure 11.2A: Antler working debitage. Left, beam and burr with tines in various stages of removal; right, cut and snapped antler tine fragment.

Scrapers are bevel-ended tools (Figure 11.3A, upper left). They are the most common worked bone form at Pecica and generally are dominant at other settlements as well (Sofaer, et al. 2013). They are found in several forms. The most frequent type is made from ribs of large mammals, generally cattle. They are standardized in shape, but require little to no bone modification their manufacture. The proximal half of the rib is either broken or cut off and the wider, flatter distal end is used as a scraper. Often, the medial (inside) surface of the working end is cut at an angle to create a shaper edge. Flat-ended scrapers are also sometimes made on larger flat bones, especially mandibles, pelves, and scapulae. These show little modification other than using the broken edge as a scraping surface. The examples from Pecica do no show the level of polish as seen on the rib scrapers and appear to be more expedient-type tools. Both of these flat-ended scraper types were probably utilized in hide working, but their use in other activities that require scraping cannot be excluded, including ceramics manufacture (for at least the smaller rib type). Gouge-like scrapers are more ambiguous in their function. They are expediently made from transversely or diagonally fractured mammal long bones of various types and sizes. Some have been shaped to some degree creating a more uniform u-shaped working edge while others are left rough and angular and show only light use wear. They may have been used in a wide variety of tasks. The last scraper type is unique. It may be a planer used to smooth the surface of posts. It is made on a horse pelvis that has been shaped to form a concave working edge, the same diameter at most posts on site. It is also possible that this is a thong smoother.

Figure 11.3A: Smaller bone tools. Upper left, cattle rib scraper; lower left, awl/punch fragment; right, astragalus smoother/burnisher.

Smoothers are another frequent tool type, falling into two general classes. The first and more abundant type are made from red deer tines. These are manufactured in the same way as the heavy-duty antler tools, with the cut-and-snap method. The tine tips are polished to varying degrees from use and often show light burning to harden the working surface. Note that antler tines may become polished by the deer itself through rubbing, so only specimens with a moderate to high degree of polish over significant areas, including handling wear, are considered to be worked, rather than debitage. I would argue that are likely used in ceramic manufacture, to smooth or burnish surfaces as well as to create the deep channeling characteristic of Maros pottery, which is the same thickness as tine tips.[18] It is also important to note that none of these show tip damage associated with their use as pressure flakers. This type tool type is not common at other sites and it is possible that these may be lumped in with debitage in some collections. Other "smoothers" are made on astragali (Figure 11.3A, right),[19] with the anterior side cut and ground down to create a flat surface. These probably used as smoothers, although it has been suggested that these are "gaming pieces," especially those made on ovicaprid astragali. It has also been argued that these are used for burnishing ceramics, but given that their broad working surface is flat rather than concave, it seems more likely that these were used in hide working or for smoothing daub walls.

Awls (or punches) are thin, pointed tools (Figure 11.3A, lower left). They span a range of sizes and end forms, with varying degrees of sharpness. They generally are made on long bones of small to medium sized mammals and either use naturally pointed elements or use a fractured long bone that is further cut and ground to a point. Awls and made on ulnae and horse peripheral metapodia are a fairly standardized classes as their natural shape requires little additional modification. Awls made on other long bones are highly variable and generally made expediently. There is a single specimen manufactured from a deciduous pig incisor with its root cut to an extremely sharp, needle-like point. These items are used for piercing and were likely used in hide working and perhaps textile manufacture. Use-wear studies from other sites show evidence for contact with both animal hide and plant-based materials (Christidou 2008). They can also be used for making fine incisions on materials such as ceramics or wood.

[18]It is possible that some of the more fragmented specimens may be portions of picks. Further examination of use wear should be able to distinguish these as the size and orientation of the striae would differ (thin and horizontal in burnishing, larger and vertical in digging, also battering)

[19] At other sites, these are also made on phalanges, usually phalanx 1, from a variety of species.

The remaining classes of worked bone occur singly or in low numbers. There are three bone "needles." This is in quotations as they superficially resemble needles but their location in graves (on the shoulder) suggests that they may have been used as clothing pins (O'Shea 1996:189). There is a fragment of what is termed a "skate" (Choyke 1982, 1983), in this case made from a red deer radius. The posterior surface, primarily of the articular ends, are cut and smoothed to make a flat, level surface. Based on ethnohistoric analogs, it has been argued that these are either used as sled runners or strapped to the bottom of shoes like ice skates. While this is possible, I am not excluding alternative uses, for example as large smoothers or beamers used in hide working. There are several composite antler tools. There are two small cut and drilled antler tine artifacts that superficially resemble harpoons but lack a sharpened tip. These have been described as "toggles" that may have been used to manufacture fishing nets (O'Shea 1996:228). While not included in this study, a finely crafted toggle-head harpoon and a tool handle, presumably for a metal item such as an awl or chisel, were recovered in 2013 (Figure 11.4A).[20]

Figure 11.4A: Composite antler tools. Left, toggle-head harpoon; right, handle (for metal tool?)

Other than the incisor awl described above, there are few worked animal teeth from Pecica. There is a modified boar tusk from deep deposits in Trench 1 (Early Period), but it has not been analyzed. Little can be said about its form and function. They are sometimes used as scrapers (Sofaer, et al. 2013). But they are also commonly used in ornamentation, often being

[20] Note that both of these were recovered from E layer fill (Phase 4) immediately under the burned platform (D0), underscoring the qualitative difference in the worked bone industries between Florescent and Late period occupations.

split and drilled at both ends for suspension or mounting. A number of these from the contemporary Ottomány/ Gyulavarsánd tell site Sarkad Peckes (Körös region) were described by the author (Nicodemus 2009). They do not appear to have been used extensively by the Maros people and are absent from Lower Maros cemeteries. Instead, carnivore teeth are typically used for ornamentation, one of which was found at Pecica in 2013.[21] While not included in this study, the highly polished dog canine pendent deserves mention (Figure 11.5A). Similar items have also been found at Százhalombatta with some frequency (Choyke 2000; Sofaer 2010).

Figure 11.5A: Dog canine pendant

Of particular interest is a horse harness cheek piece recovered from the platform (Figure 11.6A). It is bar-type piece made from a red deer antler tine. It has one large central oval shaped hole and a second, smaller round hole below, off-set by 90 degrees. There would have been one (or more) small holes at the proximal end in line with the central aperture, but this portion is broken. It is a Füzesabony Type A piece, which was used both in the Early and Middle Bronze Ages and is common throughout the Carpathian Basin (Hüttel 1981). Although it has been calcined, it is still possible to discern traces of decoration. There are several bands of chevrons around its circumference. It should also be noted that two other harness pieces were recovered from Pecica by Dömötör during his excavations at the turn of the last century. It is not clear what their exact contexts were, but images are provided by Crişan (1978), which are reprinted in Figure 11.6A. The piece to the left is similar to the one from the platform, although it is not decorated (Füzesabony Type A). The right piece is of the Spiš type, which has a wider distribution, with specimens being found as far as Moldavia, Ukraine, and Switzerland (Hüttel 1981).

[21] In lower E layer fill, Phase 5, Florescent Period.

It is interesting to note that these bar-type cheek pieces appear to be local inventions in the Carpathian Basin. Disk-shaped pieces are only found in the final Early Bronze Age and first part of the Middle Bronze Age, when they are eventually replaced by bar types (Hüttel 1981). The disk pieces have analogs throughout Eurasia and may have been imported (at least stylistically; local varieties lack the interior pegs) from the steppes along with chariotry technology at the end of the Early Bronze Age. Bar pieces in the Early and Middle Bronze Age are strongly concentrated in the Carpathian Basin region, eventually spreading to the rest of Europe (and back into Eurasia to some degree) in the Late Bronze Age. This westward spread of cheek pieces may track the spread of chariots into these areas. The cheek piece from the platform at Pecica is among the earliest examples in Europe, dating to sometime before 1750 cal. BC.[22] This, along with the relatively large number of check pieces compared to most sites, the presence of a model chariot wheel,[23] and very large number of horses, underscores Pecica's importance in horse husbandry and early chariotry.

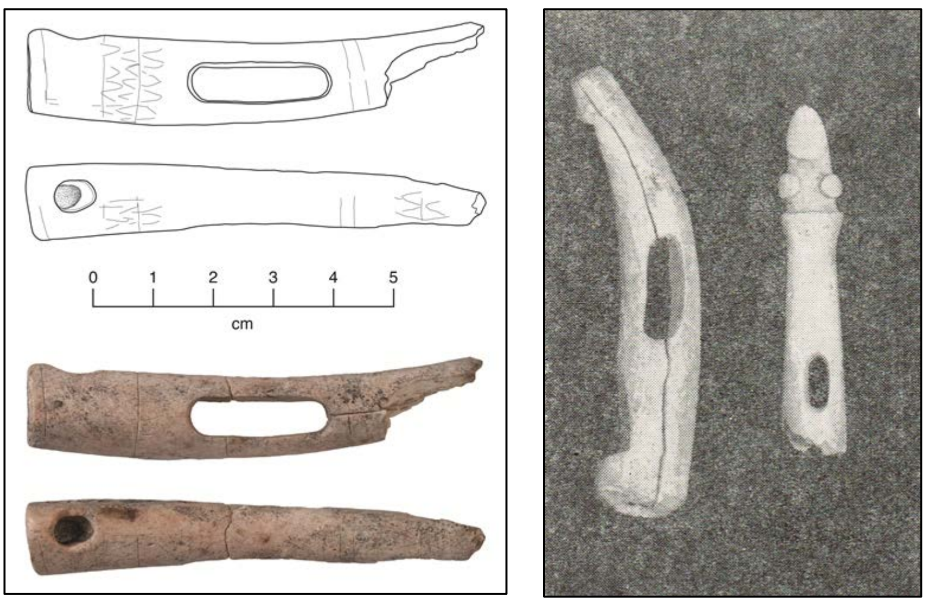


Figure 11.6A: ***left*** **Horse harness cheek piece from the platform in 2008,** ***right*** **cheek pieces recovered by Dömötör (Crişan 1978)**

[22] It cannot be directly dated since it is within redeposited sediments. C14 dates from overlying deposits place it sometime before 1750 cal BC and associated ceramics show it to post-date c. 2000 BC. It is hoped that more detailed analysis of the ceramics will be able to more precisely place this deposit's origin.

[23] A possible second clay chariot wheel fragment was recovered in 2013 in the upper E layer fill (Phase 4, Florescent Period).

Lastly, there are four classes of worked shells present at Pecica, two of which are more likely to been made locally given their respective species distribution. Unfortunately, there is no direct evidence of local manufacture via debitage. The first is an *Unio sp*. (freshwater mussel) valve that has hole punched through its umbo, presumably for suspension (Figure 11.7A, left). One was found in Phase 5 (Florescent Period) between Structures 4 and 5 and the other from Structure 0 in Phase 2 (Late Period). The holes on the two specimens identified are still fairly rough and the do not show use wear. It is possible these were unfinished. This genus is very abundant in the Maros River and was a common food source prehistorically. There are not many examples of these *Unio* shell "medals," but they have been found at other prehistoric sites in the Carpathian Basin (Gulyás and Sümegi 2004).

There is a highly unusual worked snail shell, from outside of the structures in Phase 4 (Florescent Period). It is large, purple, and shows marks over its entire surface where the outer layer appears to have cut off and polished. It appears to be *Planorbarius corneus* (great ramshorn snail), a member of the planorbid snail family. These are freshwater gastropods that are abundant in the plains region in calm, richly vegetated waters (Grossu 1993), which would have been present in the floodplains below the site. The purple color may be due to burning/heat treating. The purpose of this item is not known as it has no drill marks for suspension, but it is assumed to be some sort of display item or trinket. I have not been able to find any analogs for this item in the archaeological literature. Lastly, there are also several marine shell ornaments present (*Columbella* beads, Figure 11.7A right, *Cardium* pendant). These are import goods, either as a raw material or as finished items, and are discussed in the trade section of Chapter 11.

Figure 11.7A: Left: freshwater mussel valve medallion; right: *Columbella* bead.

APPENDIX 11.2: Representative images of stone, weaving, and metalworking artifacts

Figure 11.8A: Groundstone items. Upper left: polished axe fragment; upper right: quern fragment; lower left: small pestle; lower center: square bead; lower right: pendant/weight.

Figure 11.9A: left: denticulated sickle blade, burned (platform/D0); center: obsidian prismatic blade fragment (F 171, Ph 4); right: point (lower E fill, Ph 5).

Figure 11.10A: Weaving tools. Upper left: flat disk whorl fragment; upper right, ovoid whorl fragment; lower left: loom weight; lower right, needle fragment (pig fibula).

Figure 11.11A: Metal and metallurgical items from Pecica. Left, bronze spear head; right, fish plate crucible with scorching.

APPENDIX 11.3: Inventory of metal and molds from previous Pecica excavations (from Gogâltan 1999:100-101)

Molds	Type	Count
	axe- flat	6
	axe- Hajdúsámson type	11
	axe- unspecified	4
	dagger	1
	spear head	1
	chisel	7
	awl	2
	buckles	2
		34

Metal	Type	Count
	axe	1
	chisel	4
	bracelet- simple	1
	pin- pod shaped head	2
	pendant- spectacle	5
	button- bronze	1
	button- gold	1
	spiral tube	5
	sheet	2
	casting debris/scrap	6
		28

APPENDIX 11.4: Imported artifacts

Figure 11.12A: Left: *Cardium* shell pendant fragment; right: raw amber nodule.

Appendix 13.1: Chi-Square Tests, Body Part Representation

	Observed Values			**Expected Values**			**Chi Square Values**			**df**	**p**	**Standardized Residuals**	
Mammal	**Pecica**	**Klara.**		**Pecica**	**Klara.**		**Pecica**	**Klara.**				**Pecica**	**Klara.**
Very High/High	5156	2953	8109	5077.3	3031.7	8109	1.2207	2.0444	3.2651			1.10	-1.43
Med/Low	2947	1779	4726	2959.1	1766.9	4726	0.0493	0.0826	0.1319			-0.22	0.29
Very Low	500	405	905	566.65	338.35	905	7.8385	13.1273	20.9659			**-2.80**	**3.62**
	8603	5137	13740	8603	5137	13740	9.1086	15.2543	**24.3629**	2	**0.000**		
Ovicaprid													
Very High/High	745	346	1091	751.7	339.3	1091	0.0597	0.1323	0.1921			-0.24	0.36
Med/Low	712	293	1005	692.45	312.55	1005	0.5521	1.2232	1.7754			0.74	-1.11
Very Low	34	34	68	46.852	21.148	68	3.5255	7.8106	11.3361			-1.88	**2.79**
	1491	673	2164	1491	673	2164	4.1374	9.1662	**13.3035**	2	**0.001**		
Pig													
Very High/High	601	317	918	557.56	360.44	918	3.3837	5.2343	8.6180			1.84	**-2.29**
Med/Low	400	239	639	388.11	250.89	639	0.3643	0.5636	0.9279			0.60	-0.75
Very Low	54	126	180	109.33	70.674	180	27.9988	43.3120	71.3108			**-5.29**	**6.58**
	1055	682	1737	1055	682	1737	31.7469	49.1099	**80.8567**	2	**0.000**		
Cattle													
Very High/High	205	89	294	219.93	74.069	294	1.0137	3.0100	4.0238			-1.01	1.73
Med/Low	326	68	394	294.74	99.262	394	3.3158	9.8457	13.1616			1.82	**-3.14**
Very Low	146	71	217	162.33	54.67	217	1.6428	4.8781	6.5209			-1.28	**2.21**
	677	228	905	677	228	905	5.9724	17.7338	**23.7062**	2	**0.000**		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Kisz.**		**Pecica**	**Kisz.**		**Pecica**	**Kisz.**				**Pecica**	**Kisz.**
Very High/High	5156	569	5725	5076.5	648.5	5725	1.2451	9.7466	10.9917			1.12	**-3.12**
Med/Low	2947	429	3376	2993.6	382.42	3376	0.7248	5.6740	6.3988			-0.85	**2.38**
Very Low	500	101	601	532.92	68.079	601	2.0337	15.9201	17.9538			-1.43	**3.99**
	8603	1099	9702	8603	1099	9702	4.0036	31.3407	**35.3443**	2	**0.000**		
Ovicaprid													
Very High/High	745	163	908	741.42	166.58	908	0.0173	0.0771	0.0944			0.13	-0.28
Med/Low	712	154	866	707.12	158.88	866	0.0336	0.1497	0.1834			0.18	-0.39
Very Low	34	18	52	42.46	9.54	52	1.6856	7.5023	9.1880			-1.30	**2.74**
	1491	335	1826	1491	335	1826	1.7366	7.7291	**9.4657**	2	**0.009**		
Pig													
Very High/High	601	68	669	595.11	73.895	669	0.0584	0.4702	0.5286			0.24	-0.69
Med/Low	400	47	447	397.63	49.374	447	0.0142	0.1141	0.1283			0.12	-0.34
Very Low	54	16	70	62.268	7.7319	70	1.0979	8.8416	9.9394			-1.05	**2.97**
	1055	131	1186	1055	131	1186	1.1704	9.4259	**10.5963**	2	**0.005**		
Cattle													
Very High/High	205	35	240	204.63	35.365	240	0.0007	0.0038	0.0044			0.03	-0.06
Med/Low	326	40	366	312.07	53.932	366	0.6220	3.5990	4.2210			0.79	-1.90
Very Low	146	42	188	160.3	27.703	188	1.2752	7.3787	8.6539			-1.13	**2.72**
	677	117	794	677	117	794	1.8978	10.9815	**12.8793**	2	**0.002**		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Tarhos**		**Pecica**	**Tarhos**		**Pecica**	**Tarhos**				**Pecica**	**Tarhos**
Very High/High	5156	372	5528	5150.8	377.19	5528	0.0052	0.0715	0.0768			0.07	-0.27
Med/Low	2947	205	3152	2936.9	215.07	3152	0.0345	0.4717	0.5062			0.19	-0.69
Very Low	500	53	553	515.27	37.733	553	0.4523	6.1770	6.6293			-0.67	**2.49**
	8603	630	9233	8603	630	9233	0.4921	6.7202	**7.2123**	2	**0.027**		
Ovicaprid													
Very High/High	745	63	808	735.49	72.513	808	0.1230	1.2480	1.3710			0.35	-1.12
Med/Low	712	74	786	715.46	70.538	786	0.0167	0.1699	0.1866			-0.13	0.41
Very Low	34	10	44	40.051	3.9487	44	0.9143	9.2734	10.1877			-0.96	**3.05**
	1491	147	1638	1491	147	1638	1.0541	10.6912	**11.7453**	2	**0.003**		
Pig													
Very High/High	601	33	634	589.83	44.168	634	0.2114	2.8237	3.0351			0.46	-1.68
Med/Low	400	31	431	400.97	30.026	431	0.0024	0.0316	0.0340			-0.05	0.18
Very Low	54	15	69	64.193	4.8069	69	1.6185	21.6148	23.2334			-1.27	**4.65**
	1055	79	1134	1055	79	1134	1.8324	24.4701	**26.3024**	2	**0.000**		
Cattle													
Very High/High	205	25	230	213.01	16.99	230	0.3012	3.7759	4.0770			-0.55	1.94
Med/Low	326	9	335	310.25	24.747	335	0.7992	10.0201	10.8193			0.89	**-3.17**
Very Low	146	20	166	153.74	12.263	166	0.3894	4.8820	5.2714			-0.62	**2.21**
	677	54	731	677	54	731	1.4898	18.6779	**20.1677**	2	**0.000**		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Sarkad**		**Pecica**	**Sarkad**		**Pecica**	**Sarkad**				**Pecica**	**Sarkad**
Very High/High	5156	1779	6935	5261.6	1673.4	6935	2.1212	6.6699	8.7911			-1.46	**2.58**
Med/Low	2947	827	3774	2863.4	910.63	3774	2.4427	7.6808	10.1236			1.56	**-2.77**
Very Low	500	130	630	477.99	152.01	630	1.0138	3.1878	4.2016			1.01	-1.79
	8603	2736	11339	8603	2736	11339	5.5778	17.5385	**23.1163**	2	**0.000**		
Ovicaprid													
Very High/High	745	288	1033	789.04	243.96	1033	2.4579	7.9495	10.4074			-1.57	**2.82**
Med/Low	712	162	874	667.59	206.41	874	2.9544	9.5553	12.5097			1.72	**-3.09**
Very Low	34	11	45	34.372	10.628	45	0.0040	0.0131	0.0171			-0.06	0.11
	1491	461	1952	1491	461	1952	5.4163	17.5179	**22.9343**	2	**0.000**		
Pig													
Very High/High	601	303	904	599.45	304.55	904	0.0040	0.0079	0.0119			0.06	-0.09
Med/Low	400	200	600	397.86	202.14	600	0.0115	0.0226	0.0341			0.11	-0.15
Very Low	54	33	87	57.69	29.31	87	0.2360	0.4646	0.7006			-0.49	0.68
	1055	536	1591	1055	536	1591	0.2515	0.4951	0.7466	2	0.688		
Cattle													
Very High/High	205	52	257	205.9	51.096	257	0.0040	0.0160	0.0200			-0.06	0.13
Med/Low	326	73	399	319.67	79.328	399	0.1253	0.5048	0.6300			0.35	-0.71
Very Low	146	43	189	151.42	37.576	189	0.1943	0.7828	0.9771			-0.44	0.88
	677	168	845	677	168	845	0.3235	1.3036	1.6271	2	0.443		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Pecica**	**Szaz.**		**Pecica**	**Szaz.**		**Pecica**	**Szaz.**				**Pecica**	**Szaz.**
Very High/High	5156	1690	6846	5239.9	1606.1	6846	1.3424	4.3796	5.7220			-1.16	**2.09**
Med/Low	2947	815	3762	2879.4	882.6	3762	1.5869	5.1772	6.7641			1.26	**-2.28**
Very Low	500	132	632	483.73	148.27	632	0.5474	1.7859	2.3333			0.74	-1.34
	8603	2637	11240	8603	2637	11240	3.4768	11.3427	**14.8194**	2	**0.001**		
Ovicaprid													
Very High/High	745	413	1158	770.11	387.89	1158	0.8185	1.6250	2.4435			-0.90	1.27
Med/Low	712	315	1027	682.99	344.01	1027	1.2325	2.4469	3.6793			1.11	-1.56
Very Low	34	23	57	37.907	19.093	57	0.4026	0.7994	1.2020			-0.63	0.89
	1491	751	2242	1491	751	2242	2.4536	4.8712	**7.3248**	2	**0.026**		
Pig													
Very High/High	601	182	783	599.9	183.1	783	0.0020	0.0066	0.0086			0.04	-0.08
Med/Low	400	131	531	406.83	124.17	531	0.1147	0.3757	0.4904			-0.34	0.61
Very Low	54	9	63	48.268	14.732	63	0.6807	2.2303	2.9110			0.83	-1.49
	1055	322	1377	1055	322	1377	0.7974	2.6125	3.4099	2	0.182		
Cattle													
Very High/High	205	385	590	271.72	318.28	590	16.3834	13.9868	30.3702			**-4.05**	**3.74**
Med/Low	326	320	646	297.51	348.49	646	2.7279	2.3289	5.0568			1.65	-1.53
Very Low	146	88	234	107.77	126.23	234	13.5638	11.5797	25.1435			**3.68**	**-3.40**
	677	793	1470	677	793	1470	32.6751	27.8954	**60.5705**	2	**0.000**		

note: statistically significant values in **bold**

	Observed Values			Expected Values			Chi Square Values			df	p	Standardized Residuals	
Mammal	**Klara.**	**Kisz.**		**Klara.**	**Kisz.**		**Klara.**	**Kisz.**				**Klara.**	**Kisz.**
Very High/High	2953	569	3522	2901.3	620.7	3522	0.9212	4.3061	5.2273			0.96	**-2.08**
Med/Low	1779	429	2208	1818.9	389.13	2208	0.8741	4.0858	4.9600			-0.93	**2.02**
Very Low	405	101	506	416.83	89.175	506	0.3355	1.5681	1.9036			-0.58	1.25
	5137	1099	6236	5137	1099	6236	2.1308	9.9600	**12.0908**	2	**0.002**		
Ovicaprid													
Very High/High	346	163	509	339.84	169.16	509	0.1117	0.2244	0.3362			0.33	-0.47
Med/Low	293	154	447	298.44	148.56	447	0.0993	0.1995	0.2987			-0.32	0.45
Very Low	34	18	52	34.718	17.282	52	0.0149	0.0299	0.0447			-0.12	0.17
	673	335	1008	673	335	1008	0.2259	0.4538	0.6796	2	0.712		
Pig													
Very High/High	317	68	385	322.96	62.036	385	0.1101	0.5734	0.6836			-0.33	0.76
Med/Low	239	47	286	239.92	46.084	286	0.0035	0.0182	0.0217			-0.06	0.13
Very Low	126	16	142	119.12	22.881	142	0.3974	2.0692	2.4666			0.63	-1.44
	682	131	813	682	131	813	0.5111	2.6608	3.1719	2	0.205		
Cattle													
Very High/High	89	35	124	81.948	42.052	124	0.6069	1.1827	1.7895			0.78	-1.09
Med/Low	68	40	108	71.374	36.626	108	0.1595	0.3108	0.4703			-0.40	0.56
Very Low	71	42	113	74.678	38.322	113	0.1812	0.3531	0.5342			-0.43	0.59
	228	117	345	228	117	345	0.9475	1.8465	2.7941	2	0.247		

note: statistically significant values in **bold**

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