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TAXONOMY OF OSTRACODA AND THE POSITION OF *MICROCHEILINELLA* GEIS

By

Robert V. Kesling

Abstract.—The content, arrangement, and rank of suprafamilial taxa of Ostracoda are presently far from settled. Phylogenies based on living ostracods differ seriously from those based on fossil forms. The genus *Saipanetta* has been suggested to be a surviving relict of the metacopidan superfamily Healdiacea because of its muscle scar pattern and narrow duplicature; nevertheless, it differs from the Metacopida in its more complex hingement, lack of a distinct contact groove, exaggerated domiciliar asymmetry, and lack of posterior ridges or angulations. The shell morphology and dimorphic structures in the male, such as the clasper on the first thoracic leg and the internal Zenker's organ, strongly support placement of the genus *Saipanetta* in the Podocopida. Thus, the Metacopida is here still regarded as an extinct order of the superorder Podocopa.

Phylogenetic relationships of extinct Ostracoda have been much debated among micropaleontologists, with some relying upon adductor muscle scars as an infallible character and others depending more upon hingement, duplicature, overlap, closure, nature of dimorphism, and/or domiciliar symmetry. Further, no general accord exists on the rank to be given to particular suprafamilial taxa. The same Ostracoda are considered by one author to be a superorder, by another to be an order, and by a third to be only a suborder. All such problems of taxonomy bear directly upon the classification of *Microcheilinella* and related genera.

Taxonomic confusion has surrounded the ostracod genus *Microcheilinella* and reached the extent that the same species is assigned by different authors to *Microcheilinella*, *Tubulibairdia*, *Pachydomella*, or *Bairdiocypris*. Nor is the uncertainty confined to the generic level, for in the last two decades *Microcheilinella* and *Tubulibairdia* have been assigned to the families Healdiidae, Bairdiidae, and Pachydomellidae, to the superfamilies Bairdiocypridacea, Bairdiacea, and Healdiacea, and the suborders Podocopa, Metacopina, Platycopina, and Cypridocopina. Like *Microcheilinella*, the genus *Tubulibairdia* has a duplicature, strong domiciliar asymmetry, and a ventral bow-shaped projection and lacks a contact groove. It has been distinguished by tubules penetrating into the valve wall from the interior; yet the presence or absence of such tubules is often impossible to discern in complete carapaces. Even in the same sample, some specimens show tubules clearly, whereas others display no external evidence of them whatever. For the present and immediate future, it is recommended that (1) all species of the general form and characters of *Microcheilinella* and *Tubulibairdia* be carefully examined for the presence of tubules; (2) the genus *Tubulibairdia* be used for all species in which tubules are confirmed and (until the nature of the type, *Microcheilinella distorta*, is settled) *Microcheilinella* be used for all species in which tubules are convincingly demonstrated to be absent; and (3) in cases of doubt, *Tubulibairdia* be applied

to Silurian and Devonian forms and *Microcheilinella* to Carboniferous forms, with the generic uncertainty indicated by a question mark. If at some time it should be confirmed that small tubules are present in the small Carboniferous type species, then *Microcheilinella* would prevail as the senior synonym of *Tubulibairdia* and be the valid name of all ostracods of the lineage. Both genera as currently known belong in the family Pachydomellidae and the superfamily Bairdiocypridacea of the order Podocopida and superorder Podocopa.

INTRODUCTION

ALMOST FROM THE TIME of its erection by Geis in 1933, *Microcheilinella* has been a poorly understood genus. Probably no other genus that has been in existence for over forty-five years is still assigned to so many families, superfamilies, and even suborders.

In the last couple of decades, controversies have issued and entwined from at least five questions concerning this common ostracod. First, what are the essential qualifications, the applicable characters, and the necessary limitations of the genus? Second, is *Microcheilinella* Geis 1933 actually distinct from the later described genus *Tubulibairdia* Swartz 1936? Third, to which family does it belong: Healdiidae Harlton 1933, Pachydomellidae Berdan & Sohn 1961, Bairdiidae Sars 1888, some other, or uncertain? Fourth, which is the superfamily most suitable for the genus and its family: Bairdiacea Sars 1888, Bairdiocypridacea Shaver 1961, Healdiacea Harlton 1933, or some other? And fifth, to which higher taxa should the selected superfamily be assigned in order to best express the relation of *Microcheilinella* and its close genera to other ostracods? To best address these questions, criteria must be established for distinguishing the various taxa, from the highest down to the generic level.

Still another question, encompassing and pervasive, might be added to the list: have we enough information to make a meaningful decision on any or all of the foregoing questions at this time? Few micropaleontologists would claim that everything is ever known about any fossil ostracod. New techniques evolve for examination of carapaces, and the anticipation persists that rare forms of preservation will permit discovery of appendages and soft organs. Any taxonomic revision, therefore, has the innate nature of a progress report rather than finality. This is very likely no exception. Nevertheless, the descriptions of *Microcheilinella* and *Tubulibairdia* in numerous mid-Paleozoic formations of Europe, North America, and Asia by more than a score of responsible investigators would appear to justify reviewing the taxonomy.

STATUS OF OSTRACOD TAXONOMY

Inasmuch as the ranks of suprafamilial taxa and their arrangement are presently far from standardized, the classification used in this paper is presented in Table 1. It expresses my concepts of phylogeny and relationships and differs in particulars from any previous system.

Currently, two very different phylogenies are being postulated, one based primarily on living ostracods and the other primarily on fossil forms. The living genus *Saipanetta* plays a key role in phylogenetic considerations. This ostracod was discovered, dissected, and described by K. G. McKenzie in 1967. Its anatomical features led McKenzie to propose (1972, Fig. 4) a phylogeny in

TABLE 1 — Classification of the class Ostracoda to superfamilies, as referred to in this paper. In agreement with Kornicker & Sohn (1976, p. 6), Myodocopa is recognized as a superorder and other taxa are adjusted in rank accordingly.

Superorder ARCHAEOCOPA Sylvester-Bradley 1961	Order PODOCOPIDA Sars 1865
Superfamily Bradoriacea Matthew 1902	Suborder Bairdiocopina Gründel 1967
Superfamily Hipponicharionacea	Superfamily Bairdiacea Sars 1888
Sylvester-Bradley 1961	Superfamily Bairdiocypridacea Shaver 1961
Superfamily Indianacea Ulrich &	Family Pachydomellidae Berdan & Sohn 1961
Bassler 1931	<i>Microcheilinella</i> Geis 1933
	<i>Tubulibairdia</i> Swartz 1936
Superorder LEPERDITIOCOPA Scott 1961	Suborder Cypridocopina Jones 1901
Superfamily Leperditiacea Jones 1856	Superfamily Cypridacea Baird 1845
Superfamily Isochilinacea Swartz 1936	Superfamily Darwinulacea Brady & Norman
	1889
Superorder PALAEOCOPA Henningsmoen 1953	Suborder Cytherocopina Gründel 1967
	Superfamily Cytheracea Baird 1850
Order PALAEOCOPIDA Henningsmoen 1953	
Suborder Beyrochicopina Scott 1961	Order METACOPIDA Sylvester-Bradley 1961
Superfamily Beyrichiacea Matthew 1886	Superfamily Healdiaea Harlton 1933
Superfamily Hollinacea Swartz 1936	Superfamily Quasillitacea Coryell & Malkin
Superfamily Primitiopsacea Swartz 1936	1936
Superfamily Oepikellacea Jaanusson 1957	Superfamily Thlipsuracea Ulrich 1894
?Superfamily Punciacea Hornibrook 1949	
Suborder Kirkbyocopina Gründel 1969	Superorder MYODOCOPA Sars 1865
Superfamily Kirkbyacea Ulrich & Bassler 1906	
Superfamily Drepanellacea Ulrich & Bassler 1923	Order MYODOCOPIDA Sars 1865
Superfamily Aechminacea Swartz 1936	Suborder Myodocopina Sars 1865
Superfamily Leperditellacea Ulrich & Bassler	Superfamily Cypridinacea Baird 1850
1906	?Suborder Entomozocopina Gründel 1969
Superfamily Youngiellacea Kellett 1933	Superfamily Entomozoacea Jones 1873
Suborder Leiocopina Schallreuter 1973	
Superfamily Aparchitacea Swartz 1936	Order HALOCYPRIDIDA Dana 1853
?Superfamily Paraparchitacea Scott 1959	Suborder Halocypridina Dana 1853
Order PLATYCOPIDA Sars 1865	Superfamily Halocypridacea Dana 1852
Superfamily Cytherellacea Sars 1865	Superfamily Entomoconchacea Brady 1868
Superfamily Kloedenellacea Ulrich & Bassler	Superfamily Thaumatoocypridacea Müller 1906
1908	Suborder Cladocopina Sars 1865
Superorder PODOCOPA Sars 1865	Superfamily Polycopacea Sars 1865

which the Platycopida is more closely allied to the Podocopida than to the Palaeocopida, and the latter more closely related to the Myodocopida than to any other ostracods.

A very different classification and phylogeny are endorsed by Adamczak (1967a) and others, who are convinced that close relationships of the Palaeocopida and Platycopida are indicated by their symmetrical domicilium, contact groove in the overlapping valve, and lack of any duplicature. As clearly indicated in Table 1, the arrangement suggested by Adamczak is endorsed and forms the basis for further discussion.

For classifying *Microcheilinella* and its relatives, three superorders can be summarily dismissed: Archaeocopa, Eridostraca, and Leperditiocopa. The Archaeocopa were formerly thought to be restricted to Cambrian strata, but one genus is now known from Ordovician (Copeland (1974b, p. 13) and may even extend to Silurian (Copeland (1978, p. 66). Ostracods of this superorder have only slightly calcified, phosphatic carapaces. The Eridostraca incorporate

the partly molted valves of earlier instars into the carapace. And the Leperditiocopa, from Ordovician to Devonian, are large entomostracans with a very extensive adductor muscle field composed of numerous small scars; McKenzie (1972, p. 177) has again raised the question of whether they are really ostracods.

That leaves the Palaeocopa, Podocopa, and Myodocopa. As shown in Table 1, the system adopted here includes two orders in each of these. Only two orders, the Palaeocopida and the Metacopida, lack an unquestioned Recent record, and knowledge of their anatomy would go far toward clarification and confirmation of superorders and orders.

Evidence from Living Ostracoda

Sars published his classification of living ostracods in 1865. He based his dichotomies primarily on the number and nature of appendages, the presence or absence of a heart, and the presence or absence of eyes. Whereas the placement of some of his taxa has been changed, modern taxonomists still recognize the validity of most of his distinctions.

"Furca" and anus.—When living ostracods are compared on basic body organization, they form two distinct groups according to the position of the posterior appendage-like structure relative to the anus: in the Podocopida and Platycopida the "furca" is below and in front of the anus, whereas in the Myodocopina, Halocypridina, and Cladocopina the "furca" is above and behind the anus (Kornicker, 1975, p. 81). These two structures termed "furca" are not homologous, and Bowman (1971) suggested that the myodocopan structure above and behind the anus be called the *telson* and the structure below and in front of the anus in podocopidans and platycopidans be called the *uropod*. Whatever the terminology, the two structures do not occur together in ostracods, and must be presumed to have had a long history of separation from each other.

If, as widely supposed but unproved, the fossil forms possessed body organization like that of their presumed descendants, then it is conceivable that both telson and uropod may have been present in a long-bodied, many-appendaged ancestor from which one descendant group (Myodocopa) preserved the telson and the other (Podocopa and Platycopida) preserved the uropod. It might not be necessary to invoke later origin of the telson from an anal flap, as proposed by Bowman (1971, p. 165). At any rate, this important feature indicates a close alliance between Podocopa and Platycopida, distinct from the Myodocopa.

Appendages in Podocopida, Platycopida, Myodocopina, Halocypridina, and Cladocopina.—Appendages are commonly used by zoologists to separate living ostracods into orders and suborders. Such fine details as the number of segments (podomeres) and even the number of setae on certain parts of an appendage assume importance at generic and specific levels.

The number of appendages is not constant within a superorder. Within the Myodocopa, the suborder Cladocopina has only one pair of thoracic legs whereas the Halocypridina and Myodocopina have three pairs, as do the Podocopida. The Platycopida, assumed to be the only Palaeocopa in which appendages are known, is unique in having two pairs of thoracic legs.

Antennules in the Platycopida bear clawlike setae, whereas those in other living ostracods are provided with long setae, commonly natatory and "feathered." Only in the Myodocopida are the antennules dimorphic, with suckorial setae in the male. The antennae show distinctive characters: those in the Platycopida are biramous, with stout exopod and endopod bearing stiff setae; those in the Myodocopa have endopod and exopod, the latter long with 8 or 9 podomeres, both with natatory setae; those in the Podocopa have a much reduced exopod with at most two podomeres and commonly reduced to a single seta, and an endopod that is more adapted for walking than swimming.

The mandibles have only minor variations in these ostracods, and feature a large, strongly

chitinized coxa. The maxillae, on the other hand, show considerable differences: in the Podocopa and Platycopida, the exopod is developed as a large respiratory plate, but the Cladocopina have no plate and the other Myodocopa have a plate in some and not in others. This appendage is more leglike in the Cladocopina than in other living ostracods.

Thoracic appendages differ not only in number but in general form and function. In contrast to those in other ostracods, those in the Platycopida are pediform or leglike and serve little if at all in advancing food to the mouth. The second thoracic appendage can be used to distinguish Myodocopida, in which it is flat and platelike, from the Halocypridina, in which it is elongate and leglike. The third thoracic appendage, absent in both Cladocopina and Platycopida, is jointed and pediform in Podocopa, very reduced and short in Halocypridina, and a long vermiform, unjointed structure in Myodocopida. In the Podocopa, this leglike limb may be used solely for walking or it may be reflexed and used to clean the interior of the carapace. Dimorphism in the Podocopa involves only the first thoracic leg, which in the male forms a clasper, whereas in the Platycopida both thoracic legs are modified in the male as claspers. In the Halocypridina, the second thoracic appendage is dimorphic, being greatly elongate and less pediform in the male; but in the Myodocopina, none of the thoracic appendages exhibit dimorphic differences.

Posterior structures.—The telson of the Myodocopa is a flattened structure bearing clawlike setae. The uropod of the Platycopida is similarly shaped, but the uropod of the Podocopa is elongate and pediform or reduced.

Heart and eyes.—Eyes are absent in the Cladocopina and Platycopida; Myodocopida have a median eye but the Halocypridina do not.

A heart is found only in some of the Myodocopida. The presence or absence of eyes and/or heart is presently accorded little taxonomic weight.

Relationships of the Saipanettidae.—Because *Microcheilinella* has been suggested to be a member of the Metacopida by some authorities and because it has certain features resembling those of *Saipanetta*, it is important to decide if the Saipanettidae are actually living ostracods of that order.

The major reason for considering *Saipanetta* to be a metacopidan of the superfamily Healdiacea was expressed by McKenzie (1967, p. 104) in his original description of the Saipanettidae: "The muscle scar pattern separates genera in this family from all other modern genera and links them with the predominantly Palaeozoic Healdiacea." In this he was followed by Szczechura & Blaszyk (1968), McKenzie (1970, 1972, 1975), and Maddocks (1972, 1973). His assignment of *Saipanetta* to the otherwise extinct Metacopida was disputed by Schornikov & Gramm (1974), who interpreted the muscle scar pattern as more seriate than aggregate. Whereas I would agree that the pattern is better described as aggregate, I am not convinced that the genus *Saipanetta* is thereby a living metacopidan.

Saipanetta has the following additional characteristics: (1) its antennule is most nearly like that of the Bairdiacea, with trailing sensory setae at or near the end (McKenzie, 1967, p. 111), (2) its antenna is very similar to that of the Cypridacea (Podocopida), but its endopod has five podomeres as compared to four in the Podocopida and three in the Platycopida (McKenzie, 1967, p. 111), (3) its mandible has a smaller and weaker coxa than that of any other living ostracod group (McKenzie, 1967, p. 106), (4) the first thoracic leg has a setose epipod structure like that of the Darwinulidae and Platycopida and dimorphic clasper like that of the Cyprididae but with a jointed palp like that of the Platycopida (McKenzie, 1967, p. 111), (5) its two rear thoracic appendages are pediform, like those of Podocopa (McKenzie, 1967, p. 104), (6) the valves are strongly asymmetrical (Maddocks, 1973, p. 196), with the "ventrolateral region of the left valve sagging well below the ventral commissure" (Maddocks, 1973, p. 200), (7) the valves close with overlap around the entire margin (McKenzie, 1967, p. 104), but apparently without a

contact groove, (8) the hinge is distinctly merodont (McKenzie, 1967, p. 104), most closely resembling that of the Cytheracea, (9) the duplicature is fairly narrow and fused to the outer lamella, with little or no vestibule (McKenzie, 1967, p. 104), (10) the uropods are flattened and broad (Kornicker, 1975, p. 82), more like those of Platycopida than Podocopa (see Maddocks, 1973, p. 5, fig. 10), (11) the ventral edge of the overlapping left valve has a slight bulge outward, but not as strongly bow-shaped as those in Bairdiacea and Cypridacea, to judge from photographs (Maddocks, 1973, Pl. 2, fig. 15: Pl. 3, figs. 1,2), and (12) a form of Zenker's organ is present in the male, less chitinized than that in the Cypridacea (Maddocks, 1973, p. 194, 195).

Despite his placement of *Saipanetta* in the Metacopida on the basis of its aggregate adductor muscle scar (McKenzie, 1967, p. 104), McKenzie later (1972, p. 178) transferred the well-established and much-studied Darwinulidae and Cyprididae also to the Metacopida, even though neither has a scar pattern remotely resembling the aggregate scars of typical Healdiacea.

Briefly reviewed, Saipanettidae have resemblance to the Paleozoic Metacopida in their adductor muscle scar pattern and narrow duplicature but differ in their more complex hingement and lack of a distinct contact groove; in addition, their exaggerated carapace asymmetry and lack of any posterior ridges or angulations further distinguish them from the Healdiacea. Appendages are rather similar in gross form to those of the Podocopida, and the complex ejaculatory Zenker's organ like that of the Cypridacea probably did not arise by convergence. Nevertheless, the Platycopida-type uropod would indicate a long evolutionary history of separation from the other Podocopida, and the aggregate muscle scar is likely retained as a primitive character.

The shell morphology of Saipanettidae has so many strong resemblances to that of the Podocopida and such significant contrasts to that of the Metacopida as to discourage the recognition of this family as a surviving relict of the latter. Certainly, the transfer of the Darwinulacea and Cypridacea to the Metacopida creates a most unnatural association in my view. It seems difficult enough to separate the suborders Cypridocopina and Bairdiocopina in either living or fossil forms.

In general, the most difficult ostracods to classify are those with no ornamentation, smoothly convex valves, a hinge that is appreciably shorter than the dorsal border, and a narrow duplicature. *Microcheilinella* shows resemblances to *Saipanetta* in its general shape, overlap, closure, muscle scars, and strong carapace asymmetry, regardless of how they may be related.

Evidence from Fossil Ostracoda

That classification of fossil ostracods in general is far from stabilized is shown by the rather recent assignment of the superfamily Healdiacea to three different suborders (Table 2). Further, this superfamily, widespread (Europe, Asia, Africa, North America) and long-lived (Silurian possibly to Cretaceous), has been studied by numerous ostracodologists around the world.

For several reasons, major uncertainties still persist concerning classification of the Paleozoic ostracods, particularly those of the superorders Palaeocopa and Podocopa (Table 1): (1) different characters have been selected as diagnostic, including dorsal border, muscle scars, hingement, duplicature, contact groove, domiciliar symmetry, dimorphism, overlap, and others; (2) many of these characters have been examined in very few ostracods, particularly such internal features as muscle scars, contact groove, and duplicature; and (3) some characters, such as contact groove, hingement, and symmetry vary in many ways, so that their usage is not simply a choice of presence or absence. Each of the following characters has been thought by one or more taxonomists to signify some degree of relationship.

Dorsal border and hinge line.—For nearly a century the division of Paleozoic ostracods into those with straight and those with convex dorsal borders was informally recognized and

TABLE 2 — Some recent classifications of *Microcheilinella* and *Tubulibairdia*.

	Zanina, Kashevarova, & Polenova <i>in</i> Orlov 1960	Berdan & Sohn in Moore 1960	Becker 1965	Gailite 1967
Suborder	Podocopa	Metacopina	Platycopina	Podocopa
Superfamily	Healdiacea	Healdiacea	Healdiacea	Healdiacea
Family	Healdiidae	Pachydomellidae	Pachydomellidae	Healdiidae
Genus	<i>Microcheilinella</i>	<i>Tubulibairdia</i>	<i>Tubulibairdia</i>	<i>Microcheilinella</i>

	Berdan & Copeland 1973	Bandel & Becker 1975	Adamczak 1976a	Kesling & Chilman 1978
Suborder	Metacopina	Cypridocopina	Podocopa	Metacopina
Superfamily	Healdiacea	Bairdiocypridacea	Bairdiacea	Healdiacea
Family	Pachydomellidae	Pachydomellidae	Pachydomellidae	Healdiidae
Genus	<i>Tubulibairdia</i>	<i>Microcheilinella</i>	<i>Microcheilinella</i>	<i>Microcheilinella</i>

mentioned in descriptions. It was not until 1953, however, that the "straight-hinged" ostracods were identified as a distinct taxon, which Henningsmoen (1953, p. 188) called the suborder Paleocopa. In it he included the Kloedenellidae (here in the Platycopida, Table 1) and Leperditiacea (here in the superorder Leperditiocopa). The *Treatise on Invertebrate Paleontology* (Moore, 1961) changed the spelling, but retained the kloedenellids in the new suborder Kloedenellocopina. Four years later, Henningsmoen (1965) included the kloedenellids and leperditiids in the Palaeocopa with question.

The combination of kloedenellids and cytherellids (Adamczak, 1966) in the Platycopida and assignment to the Palaeocopa (Table 1) is certainly reasonable, even though the hinge of platycopidans is considerably modified and the cardinal corners less angular than those of the Palaeocopida. The leperditiids are excluded from the superorder Palaeocopa by nearly all current workers, and some, as mentioned, question whether they are actually Ostracoda.

The group not clearly set off as either long- or short-hinged or as either straight- or round-backed is the Metacopida. At its erection in the *Treatise* (1961, p. Q88) as a suborder, it was placed in the "round-backed" Podocopa. Bandel & Becker (1975) attempted to avoid the problem by making an order Metacopida on a taxonomic par with Palaeocopida, Platycopida, and Podocopida. Adamczak (1976a) returned the suborder Metacopina to its original position under the order Podocopida. Apart from raising the taxonomic rankings, this classification is followed here.

Adductor muscle scars.—Although literature abounds with references to the importance of adductor muscle scars in classification and phylogeny, it is nevertheless true that they are known in comparatively few Paleozoic ostracods. Even by a generous estimate, muscle scars have been described and/or illustrated in no more than ten percent of genera, and the figure for species is far less. Thorough studies are rare.

Even when muscle scars become known, they do not always support or disprove a particular classification or stand out as taxonomically significant. For example, the *Treatise* (Moore, 1961) put kloedenellid ostracods in the suborder Kloedenellocopina because of their relatively straight

dorsal border and strong overlap, and it put the cavellinids (with question) in the Healdiacea of the suborder Metacopina, order Podocopida, because "the muscle scar and tendency toward arching of the dorsum are typical of the Healdiidae . . ." (p. Q369). Yet when Adamczak (1966) reported on the kloedenellid genus *Nyhamnella* and the cavellinid genus *Gotlandella*, he placed them both in the Platycopa, the former in the family Kloedenellidae and the latter in the Cavellininae, which he considered a subfamily of Cytherellidae. He found that the adductor muscle field of *Nyhamnella* "consists of many individual scars" (1966, p. 17), but chose the development of the contact margin as sufficient basis for assignment to the Platycopa. Adamczak concluded (1966, p. 13) that

... this type of adductor field [oval aggregate of scars] seems to be a homeomorphic phenomenon, as it occurs both in Metacopa, Podocopa and Palaeocopa iteratively in Paleozoic or Mesozoic times.

He suggested that Coryell's placement of *Cavellina* in the Cytherellidae "appears to be correct," and stated (1966, p. 14), "The contact groove of Kloedenellidae shows strong similarities with that of the Cytherellidae."

If, as Adamczak claims above, ostracods presently assigned to Metacopida, Podocopida, Platycopida, and Palaeocopida have closing muscle scars arranged in similar aggregates of small scars, then this character is inconsistent with current schemes of classification. Either (1) the aggregate scar is significant, in which case the ordinal assignments of lower taxa need drastic revision to reflect types of adductor scars, or (2) the aggregate scar is, as he suggests, homeomorphic and without diagnostic value at the ordinal level.

Even within a major group of ostracods, the muscle scars may be reduced in the evolutionary succession, as suggested by Gründel (1967, p. 322), McKenzie (1967, p. 111), and others. This appears to be substantiated by some investigations.

The importance of scar patterns is interpreted differently by various authors. Scars were not used by Gründel (1967) in his definitions of Platycopida and Podocopa (which he used as orders), although he noted (1967, p. 322, 325) a phylogenetic reduction of muscle scars in each. Gründel did, however, create two new suborders, the Cytherocopina (1967, p. 328), based in part on the presence of cytherid-type muscle scars, and the Bairdiocopina (1967, p. 325), in which the scars are "bairdiid or cypridid, rarely otherwise (never cytherid)" [my translation].

In his revised diagnoses of the order Podocopida (= superorder Podocopa, Table 1), Adamczak (1967a, p. 317) said only, "Adductor muscle pattern with many scars in more primitive members and reduced number of scars in more advanced members."

Whether it is desirable to divide the traditional Podocopida into suborders, as has been done by Gründel (1967), could be debated. If Podocopa are to be divided into orders and suborders, then muscle scars might well be included in the diagnoses, being (to use Gründel's terms) "healdiid, rarely cytherellid" (that is, numerous and aggregated in a large subcircular cluster but rarely so close-set and crowded that boundaries become polygonal) in the Metacopida, "bairdiid" (a limited number of scars in an irregular cluster) in the Bairdiocopina, "cypridid" (a limited number in a subcircular rosette, tending to be radially disposed) in the Cypridocopina, and "cytherid" (few, discrete in vertical rows except for antennal and mandibular scars in front) in the Cytherocopina. Among living ostracods, the appendages of bairdiids, cypridids, and cytherids are so nearly alike that subordinal distinction could be regarded as unnecessary.

Recently, Adamczak (1967a, p. 314, 315) set forth his opinion:

Although its [the muscle scar field's] importance both in phylogeny and systematics should not be ignored, its classificatory value, however, does not seem to be of

such high taxonomic rank (suborder, superfamily and presumably even family) as has been suggested . . .

This relegation of scars to a minor role in systematics is in stark contrast to the regard they received in the *Treatise*. In it, Scott (*in* Moore, 1961, p. Q89) said:

. . . it seems more desirable to give a high priority to muscle-scar pattern in classification than it does to shape. By including the cavellinids in the metacopines we are bringing together a group of ostracodes with a common muscle-scar pattern and excluding the cytherellids because of a difference in this pattern.

He also wrote (1961, p. Q81):

The Palaeocopida are a group of Paleozoic ostracodes . . . possessing characters that clearly distinguish them from more recent genera. Chief among these are the nature of muscle scars. . . differences of the muscle-scar pattern from that seen in the Podocopina serves to distinguish the Metacopina.

More studies of muscle scars are required to substantiate or negate their value.

Duplicature.—That a well-developed duplicature characterizes the Podocopida is agreed by all workers. The problem concerns whether a duplicature is confined to this order. Scott (*in* Moore, 1961, p. Q89) reported a “calcified primitive inner lamella” in some Metacopida; in discussion of the Podocopida in the same source (1961, p. Q201), Swain & Howe reported a calcified inner lamella in certain Thlipsuracea (Metacopida).

Gründel (1967, p. 327) reported that in the Metacopida a calcified inner lamella was generally unrecognizable or small, but in a few was distinct and broad. He also stated (1967, p. 322) that in the Platycopida an inner lamella is developed only in the marginal rim, and that the Kloedenellocopina (= Kloedenellacea, Table 1) and Platycopina (= Cytherellacea, Table 1) share, among other characters, the occasional formation of a broad calcified inner lamella.

Adamczak (1967a, p. 358) disagreed. He diagnosed the Metacopida as “medium-sized podocopids without duplicature,” although in the same article (1976a, p. 315) he qualified this claim by stating that “as a rule the free margin lacks the duplicature in form of a calcareous inner lamella.” He further (1976a, p. 314) denied the existence of a calcified inner lamella in any of the Palaeocopida or Platycopida (including kloedenellaceans).

Whether a duplicature is present or not may involve interpretation. If a calcified inner lamella projects from the outer lamella to form a vestibule, clearly it is a duplicature. Yet if the inner rim of the valve is thickened, a distinction must be drawn between an attached calcareous rim of the inner lamella and a localized increase in thickness of the outer lamella. This has been done in too few cases and too inexactly to permit taxonomic assessment. At present, a well-developed and distinct duplicature with vestibule is confirmed only in the Podocopida.

Hingement.—Like muscle scars, hingement needs to be examined in more living and fossil ostracods. Although the terminology is formidable enough, its application and interpretation are excessively complicated. My late friend Sylvester-Bradley in 1956 identified hinges as simple and compound, with the latter divided into six types. In the *Treatise* (Moore, 1961, p. Q31–Q36), Scott identified 15 kinds of hingement and ended by saying, “Most of the named hingements may be found in the Cytheracea.”

In general, the hinge of Myodocopa is simple, thin, and inconspicuous; that of Palaeocopida is long, conspicuous, and simple (although the ends may be more strongly developed, they are never denticulate or dentate); and that of the Cytherellacea consists of little more than a

rabbetted depression in the larger valve to receive the edge of the smaller. Variations exist in all other major taxa.

In the Metacopida, the superfamilies Healdiacea and Quasillitacea have hinges typically differentiated into median and terminal elements, with the latter simply widened to complexly striated or denticulate (Scott, *in* Moore, 1961, p. Q358, Q359).

Among the Podocopida, hingement reaches its greatest complexity in the Cytherocopina, with numerous forms of differentiated elements involving interlocking teeth and sockets (Sylvester-Bradley, 1956); this suborder also shows an evolutionary trend toward increasing complexity (Gründel, 1967). The Bairdiocopina and Cypridocopina remain much simpler than the Palaeocopida.

The Kloedenellacea differ somewhat from the rabbetted arrangement in the Cytherellacea, and show a transformation from a simple ridge-and-groove to a more differentiated hinge of the *Poloniella*-type.

Generally, hingement is not accorded much significance at suprafamilial levels, and is known to vary within families.

Overlap.—This can differ both in direction and degree. The direction, right/left or left/right, is considered to be a rather stable character at high taxonomic levels, although there are known exceptions, such as *Sansabella* (R/L) and *Reversabella* (L/R), which were synonymized in the *Treatise* by Sohn (*in* Moore, 1961, p. Q187). Recently Rome (1971) described *Microcheilinella inversa* in which the overlap was R/L instead of the L/R normally found in the genus.

Overlap direction is usually R/L in the Platycopida and L/R in all other orders.

Overlap is very weak and may even be absent in some Myodocopa and Palaeocopida which have valves almost or exactly equal. It is particularly well developed in the Podocopida, in which the thin edge of the left valve extends around the edge of the smaller right valve when the carapace closes, thus forming an effective seal. The Platycopida and perhaps most of the Metacopida have a different sort of closure, involving a contact groove.

In the Bairdiocopina as well as many Cypridocopina the overlapping edge of the left valve is especially developed in the mid-ventral region where it forms a bow-shaped projection (Adamczak, 1976a). This thin projecting convexity of the outer lamella causes the commissure of a closed carapace, as viewed ventrally, to be distinctly sinuous. In contrast, the commissure in Palaeocopa and Myodocopa is nearly straight, and in Metacopida may have, at most, a slight sinuosity.

Contact groove.—Attention has been directed to this feature of the carapace subsequent to the *Treatise* volume on Ostracoda in 1961. A contact groove is characteristic of all Cytherellacea (Platycopida) and Healdiacea (Metacopida), and is weakly developed in the Palaeocopa. It is not found in the Podocopida.

Back in 1950, Erich Triebel published his observations on *Ogmoconcha* from the Lias of the Jura, comparing it with *Healdia* and finding no clear duplicature in either. Because of the development of a "flache Kontaktfurche" (1950, p. 116) similar to that of *Cytherella*, he placed *Ogmoconcha* in the family Healdiidae under the Platycopa. Triebel concluded (1950, p. 120):

A comparison of recent and fossil ostracods shows that the suborder Platycopa can be recognized primarily by the simple structure of its free-edge zone. Insofar as known to date, it includes the families Cytherellidae and Healdiidae. [My translation.]

The closeness of the cytherellids and healdiids has since been questioned, although Becker (1965) still retained the superfamily Healdiacea in the suborder Platycopina (=Platycopida, Table 1). Bandel & Becker (1975) and Adamczak (1976a) placed the healdiaceans under Metacopa

(=Metacopida, Table 1), and the latter expressed doubts that the structure was actually simple. Adamczak found incipient contact grooves in early metacopidans, and wrote (1976a, p. 315):

From the early podocopes, however, these metacopes may be distinguished by the two stop-ridges at the interior part of the ventral margin of the larger valve . . . The stop-ridges . . . may theoretically extend towards the dorsal margin producing a contact groove.

The valve contact in both Healdiacea and Cytherellacea was termed "capsula-type" by Adamczak, who concluded that it represented convergence in these "phylogenetically distant groups" (1976b, p. 316). Some differences may be noted, however, in Paleozoic representatives. The entire thick edge of the cytherellacean ostracod is rabbetted to receive the edge of the smaller left valve, so that in left lateral view the larger valve can be seen to overreach the smaller around the complete periphery. As seen in interior view, the rabbetted contact groove of the right valve around the free edge continues without separation into the hinge. In contrast, the Metacopida have the hinge distinctly set off from the contact groove around the free edge and much less overreach dorsally. Another difference, not universal, involves the ventral edge of the larger valve: in the Platycopida the contact groove continues uninterrupted through this region, but in many Paleozoic Metacopida it tapers out at the place corresponding to that where the Podocopida develop a bow-shaped projection.

The rabbetted edges of the valves in Palaeocopida are much narrower, and the larger left valve does not normally show an overreach in a right lateral view of the carapace.

Domiciliar symmetry.—As emphasized by Adamczak (1976a) the ventral part of the two valves may be nearly alike in shape and spaciousness, producing a symmetrical domicilium, or they may have very different shapes with one valve enclosing much greater space, producing a strongly asymmetrical domicilium.

Asymmetry is strongly developed in the Podocopa and particularly in the Bairdiocopina. As the carapace is seen from the end, there is a marked tendency for the ventral part of the overlapping left valve to bulge far out from the commissure as compared to that part of the right valve, and even to protrude appreciably below the free edge. *Microcheilinella* is a good example.

On the other hand, the valves of Palaeocopida have similar overlap but very little departure from symmetry. Even in Platycopida, with capsula-type closure in the Cytherellacea, the domicilia of the two valves occupy nearly equal space. Adamczak (1976a, p. 314) considered that the Palaeocopida and Platycopida are closely allied because of their symmetrical arrangement of the ventral part of the domicilium.

With few exceptions, the domicilia of the Metacopida, Cypridocopina, and Cytherocopina show fairly weak asymmetry compared to the Bairdiocopina. Although the Healdiacea have valves that differ in both length and height, the cross section of the carapace reveals relatively slight departure from symmetry in the domicilium.

Dimorphism.—In fossil forms, dimorphism is apparent only in differences in adult carapaces, where it may be manifested in structures, such as the crumina in Beyrichiacea, posterior flanges in Primitiopsiacea, or velar structures in Hollinacea, or in gross differences in the posterior region, as in the Platycopida.

Living forms may reproduce parthenogenetically (females only) or syngamically (males and females). In the syngamic forms, dimorphism extends to the form and function of appendages as well as the sex organs themselves, but in the carapace dimorphism may be expressed only as subtle differences in proportions or may be indiscernible. It seems likely, therefore, that dimorphism in many extinct forms has gone undetected. Lack of definite carapace dimorphism in extinct forms is no evidence of parthenogenesis. Further, to differentiate the small differences

in proportions of the carapace which are individual variations from those which are dimorphic, requires a large and well-preserved sample of a species.

Strong arguments for including the Kloedenellacea with Cytherellacea in the Platycopida are their same kloedenellid dimorphism and same R/L overlap, even in the earliest known representatives.

Dimorphism in the earliest Podocopida was absent or so weak as to be indiscernible (Gründel, 1967, p. 325, 326), whereas that in many later forms became pronounced.

In general, dimorphism is a reliable character at family and superfamily rank in Palaeocopida and Myodocopa, at ordinal level in Platycopida, but only at about generic level in the Podocopa.

Ordinal Classification of Carapaces

Based only on carapaces, the orders of Palaeocopa, Podocopa, and Myodocopa may be distinguished by the following key.

KEY TO ORDERS OF PALAEOCOPA, PODOCOPA, AND MYODOCOPA (based on carapaces only)

1. Ventral part of domicilium developed asymmetrically except in a few early forms and some advanced metacopidans. Duplicature present or absent. Contact groove present or absent. Overlap typically L/R. Hinge typically tripartite Superorder PODOCOPA 3

Ventral part of domicilium developed with nearly symmetrical halves. Duplicature never present. Contact grooves present or absent. Overlap poorly to strongly developed, L/R or R/L. Hinge typically simple, not strongly differentiated into complex terminal elements 2
2. Contact groove in outer lamella of larger valve to accommodate edge (list) of smaller valve. Overlap distinct. Hinge conspicuous, typically a simple bar and groove but may be more pronounced at ends. Dorsal border and hinge straight, usually long. No rostrum or permanent domiciliar openings Superorder PALAEOCOPA 4

No contact groove. Overlap typically weak if discernible. Hinge not conspicuous, simple, undifferentiated. Dorsal border usually convex or slightly sinuate if long. May have anterior rostrum and incisur and, in some, a posterior siphon forming permanent domiciliar openings Superorder MYODOCOPA 5
3. Duplicature present except perhaps in earliest forms, typically large anteriorly and posteriorly and there set off from outer lamella by a vestibule. Contact groove not well developed if at all, at most a simple depression in inner lamella Order PODOCOPIDA

Duplicature absent or very narrow and fused to outer lamella, no vestibule. Contact groove or stop-ridges in outer lamella of larger valve Order METACOPIDA
4. Overlap typically L/R, rarely conspicuous. Dimorphism, if present, not involving posterior part of domicilium and no limen present. Adventral structures (frills, velar ridges, etc.) well developed in many forms but absent in a few Order PALAEOCOPIDA

Overlap typically R/L, conspicuous, the closure tending to include entire periphery of smaller valve. Dimorphism always present and always involving posterior part of domicilium, with a limen marking front border of brood space in the female. Adventral structures absent or very weakly developed Order PLATYCOPIDA
5. Rostrate forms with rostrum deflected downward, commonly with a cordiform incisur; dorsal border convex. Forms with rostrum weakly developed or absent, with or without incisur, bearing posterior caudal process with or without siphon. (The questionable Entomozocopina not included in this key.) Order MYODOCOPIDA

Rostrate forms with rostrum directed forward, incisur if present not conspicuous or cordiform; dorsal border elongate and nearly straight. Non-rostrate forms lacking caudal process Order HALOCYPRIDIDA

CURRENT ASSIGNMENTS OF *MICROCHEILINELLA* AND *TUBULIBAIRDIA*

Within the last two decades, the genera *Microcheilinella* and *Tubulibairdia*, which are very closely related if not identical, have been assigned to diverse suborders of the Ostracoda (Table 2). These include Platycopina (Becker, 1965), Cypridocopina (Bandel & Becker, 1975), Podocopa (Adamczak, 1976a), and Metacopina (Kesling & Chilman, 1978). If diagnostic characters were fully understood, one might expect agreement at such a high taxonomic level.

These two genera have been placed in various superfamilies and families during the same interval (Table 3). The most popular superfamily for their reception is Healdiacea, and the most popular family is Healdiidae. In the *Treatise* volume on Ostracoda (1961), Berdan & Sohn put *Tubulibairdia* in the Pachydomellidae of the Healdiacea, whereas Shaver in the same publication put *Microcheilinella* in the family and superfamily uncertain.

It may be pointed out (Table 3) that *Tubulibairdia* is used more by North American micropaleontologists, and *Microcheilinella* more by the Europeans.

Surprisingly little attention has been paid to the type species of *Microcheilinella*, a very small ostracod from the Mississippian of Indiana. Most generic interpretations have been based on the larger species from Devonian strata of North America, Europe, and Asia.

CHARACTERS OF *MICROCHEILINELLA* AND/OR *TUBULIBAIRDIA*

The following brief notes are not intended to be complete descriptions. Instead, they emphasize the characters considered generically significant in placement of *Microcheilinella* and the closely related or identical genus *Tubulibairdia* in higher taxa.

Duplicature.—Species from the Devonian are known to have a distinct duplicature (Adamczak, 1976a, p. 334). Drawings of cross sections of *Microcheilinella distorta*, the type species from the Mississippian of Indiana by Shaver (*in* Moore, 1961, Fig. 310B, 3a, 3b) appear to be somewhat exaggerated in respect to the valve margins as compared with my material from the same formation. Nevertheless, a broken specimen of the type species shows what I interpret as a calcified rim of the inner lamella with a small vestibule.

From examination of a European species, Adamczak wrote (1976a, p. 215):

An undoubted calcified inner lamella has been discovered in Middle Devonian material of *Bairdiocypris* Kegel and *Microcheilinella* Geis. It is very thin, slightly calcified and may represent a direct continuation of the outer lamella . . .

Even though his species is one which may prove to belong in *Tubulibairdia*, it is very closely related to *Microcheilinella* and forms part of the lineage.

Therefore, the genus *Microcheilinella* does have a duplicature and, if the key presented above is accepted, is thereby excluded from the Metacopida.

Contact groove.—No such structure is present in *Tubulibairdia* or in Devonian species assigned to *Microcheilinella*, nor has one been detected in the type species of the latter.

When Adamczak assigned *Microcheilinella* to the family Pachydomellidae Berdan & Sohn 1961, he stated (1976a, p. 334):

The Pachydomellidae are in the present paper excluded from the Healdiacea Harlton sensu Shaver (in Moore, 1961) because of the fundamental differences in the arrangement of the free margin of the carapace. . . This margin appears in representatives of pachydomellids quite distinct from that of the healdiids by being provided with a distinct calcified inner lamella (duplicature) and by lacking a contact groove in the outer lamella of the larger valve. The latter element is an important feature of the Healdiidae.

In the type species, *M. distorta*, no specimen has been found with the left valve isolated to determine if any kind of groove or stop-ridge is present. The cross section illustrated by Sohn (1960, Pl. 5, fig. 13) shows no groove ventrally, nor do broken carapaces I have examined. Closure apparently was effected by the bow-shaped lip of the larger left valve sliding over the edge of the smaller valve as far as it could be accommodated.

Domiciliar symmetry.—As carapaces of *Microcheilinella* are viewed from the end, the larger left valve occupies a much greater volume than the right. This is true in the type species, *M. distorta* (Pl. 1, fig. 13; Pl. 2, fig. 4), as well as in related Devonian ostracods I have seen (Pl. 1, fig. 5; Pl. 2, fig. 7). It is highly probable that this asymmetry on the exterior is reflected in the domicilium. This feature resembles the valve differences known in *Bairdiocypris* (see Kesling & Chilman, 1978, Vol. 2, Pls. 90–92 for photographs of *Bairdiocypris gongylus* and *B. transptyxis*), and *Microcheilinella* would seem to fit well into the superfamily Bairdiocypridae.

Bow-shaped projection.—The overlapping ventral edge of the left valve is extended into a bow-shaped projection, although the extent of projection varies from species to species in the lineage (Pl. 2, figs. 2, 6, 8, 16). That in the Middle Devonian species called *M. mariettensis* Kesling & Chilman 1978 is no more than that in the healdiid *Cytherellina* species from the same formation, but in most species it is extensive.

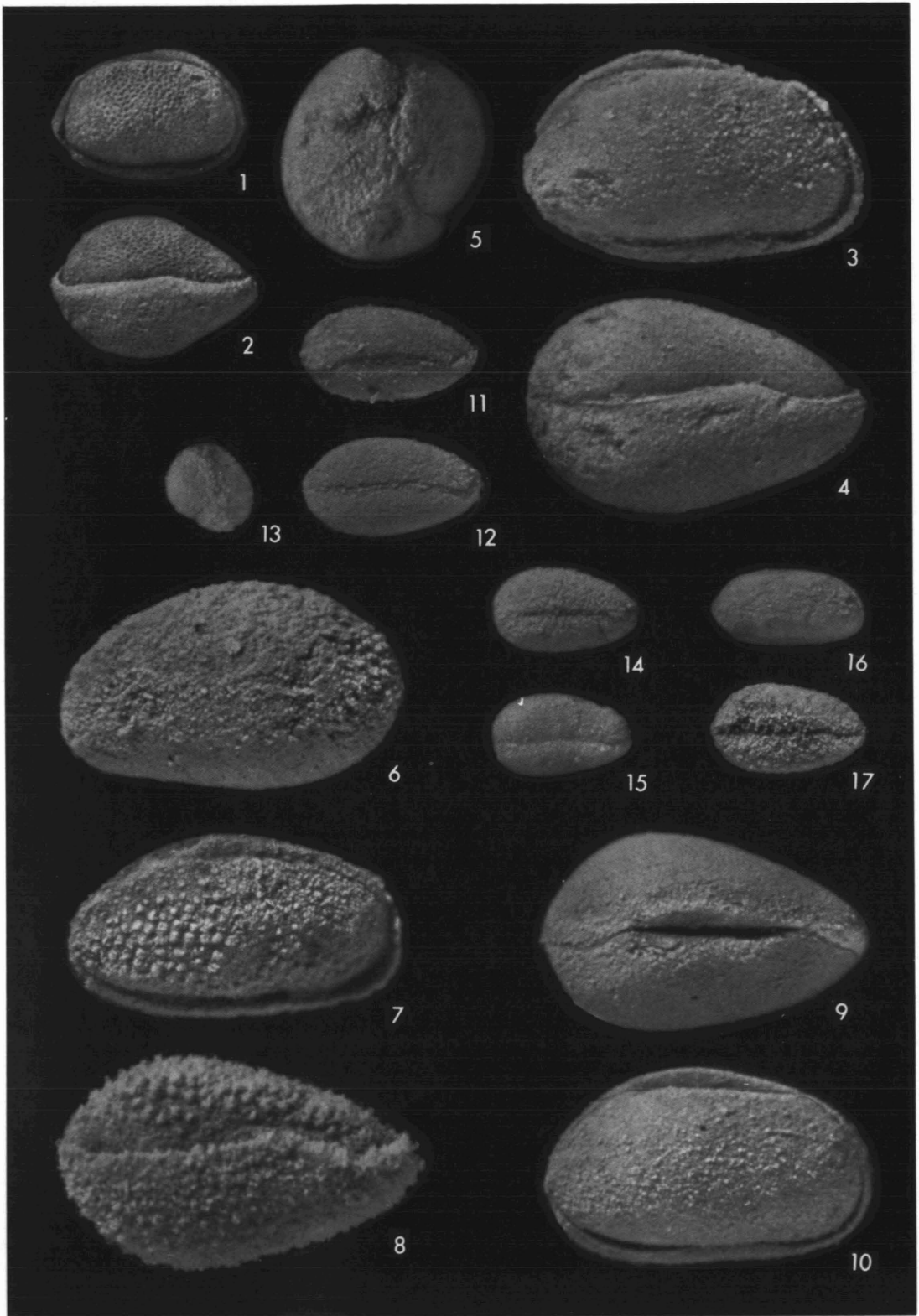
Tubules.—Tubules extending into the outer lamella from the interior are known in many Devonian species presently assigned to *Microcheilinella* and are definitely present in the type and many other species assigned to *Tubulibairdia*. Such tubules are not externally evident except in seriously worn or corroded valves; even interiors may not clearly show tubules which apparently may be filled with carbonate having the same properties as the valve material.

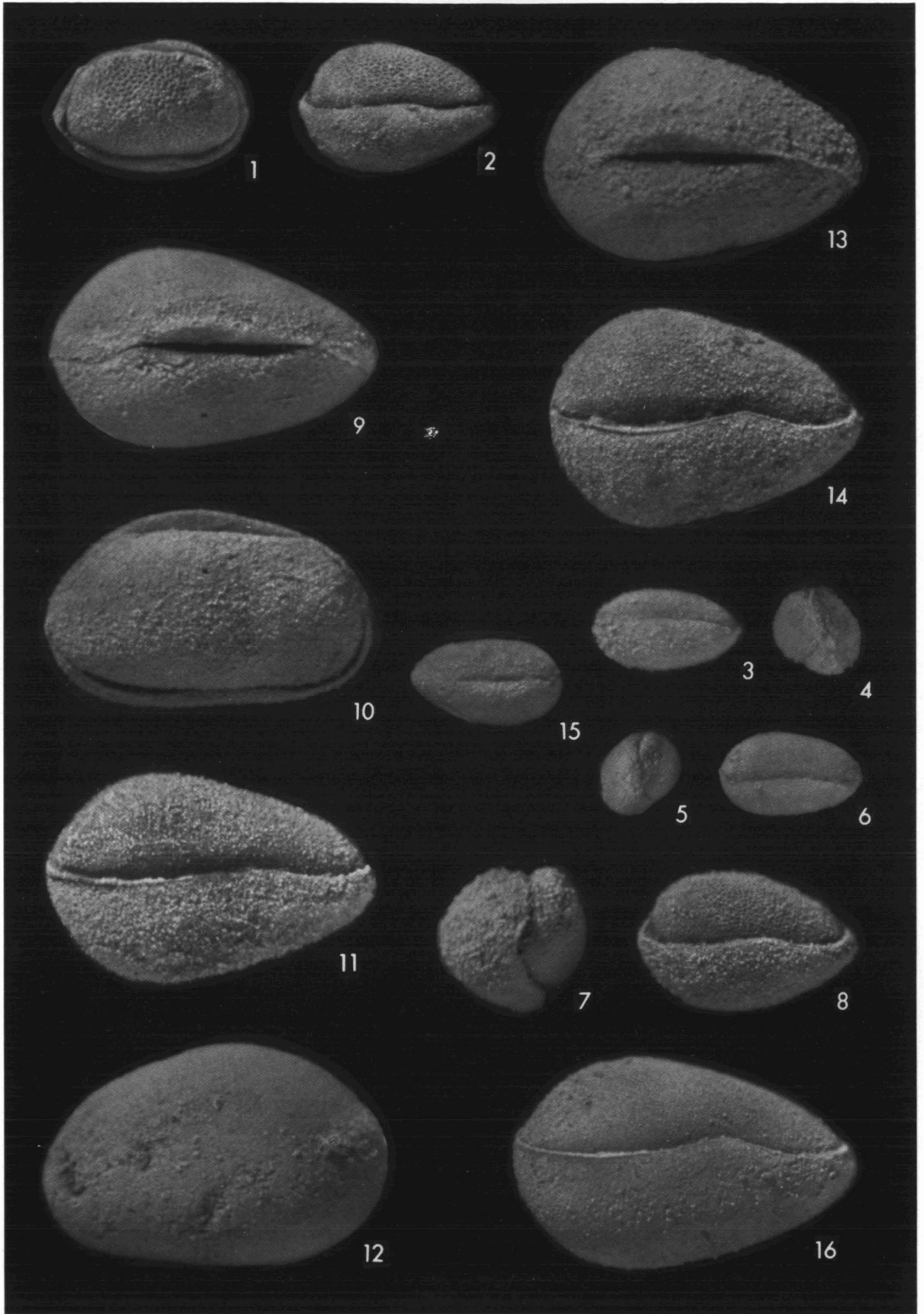
Specimens of the type species of *Microcheilinella*, unfortunately, are not found well preserved.

(opposite page)

EXPLANATION OF PLATE 1

- Figures 1, 2 — *Tubulibairdia windomensis* Swartz & Oriel. 1, right view view of carapace, UMMP 60148. 2, ventral view of carapace, UMMP 60147. Both specimens from Centerfield Limestone (Middle Devonian), two miles northeast of Darien, Genesee County, New York.
- Figures 3–10 — *Tubulibairdia* sp. 3–5, right, ventral, and posterior views of carapace with little wear, UMMP 60153. 6–8, left, right, and ventral views of carapace with outer layer of shell worn away on most of right valve and the posterior part of left valve to show tubules, UMMP 60151. 9, 10, dorsal and right views of well-preserved carapace, UMMP 60110. All Middle Devonian. 3–8, Hungry Hollow Formation at type locality, banks of Ausable River, about two miles east and one-fourth mile north of Arkona, Ontario; 9, 10, Wanakah Formation, two miles southeast of East Bethany, Genesee County, New York.
- Figures 11–17 — *Microcheilinella distorta* (Geis). 11–13, dorsal, ventral, and anterior views of carapace, UMMP 64147. 14, 15, dorsal and ventral views of carapace, UMMP 64152. 16, 17, right and ventral views of carapace, UMMP 64148. All from Salem Limestone (Mississippian) in Indiana. 11–13, north side of cut of Southern Railroad, about 1 mile west-southwest of Georgetown, SE 1/4 SE 1/4 sec. 31, T 2 S, R 5 E, Harrison County; 14, 15, Old Cleveland Quarry, NE 1/4 SE 1/4 NW 1/4 sec. 20, T 7 N, R 1 W, Monroe County; 16, 17, road cuts along Indiana 37, 4/10 mile north of Clear Creek, E 1/2 SE 1/4 SE 1/4 sec. 20, T 7 N, R 1 W, Monroe County.





All specimens appear to have been replaced with porous calcium carbonate that absorbs moisture like a blotter. Wetting and dyeing of the carapaces do not reveal any traces of tubules.

The difficulty of detecting tubules in *Tubulibairdia* is here shown by photographs of specimens from the Middle Devonian Hungry Hollow Formation of Ontario. In one carapace, the right valve is worn or corroded and clearly shows the tubules as projecting papillae, whereas the left valve is relatively unworn and shows few such structures (Pl. 1, figs. 6-8).

MICROCHEILINELLA AND TUBULIBAIRDIA—ONE GENUS OR TWO?

The extent of confusion between these two genera is exemplified by the classification of two species described by Kegel in 1932 as *Bythocypris* (*Bairdiocypris*) *clava* and *B. (B.) clava antecedens* (Table 4). Even apart from the synonyms introduced later, Kegel's species have been assigned to *Bairdiocypris*, *Microcheilinella*, *Pachydomella*, and *Tubulibairdia*. Of these, *Bairdiocypris*, with its short dorsal border and anterodorsal and posterodorsal slopes down to the ends of the valves, has a bairdiid aspect in outline and appears to be a distinct genus; *Pachydomella*, with its massive valves and peculiar dorsal humplike ridge on the larger valve, also seems to be generically valid. *Microcheilinella* and *Tubulibairdia*, however, raise serious doubts (Tables 2-4).

If *Microcheilinella* had been based on one of the robust Middle Devonian species instead of the diminutive Mississippian *M. distorta*, and if it had been thoroughly described, then the genus *Tubulibairdia* should never have been proposed.

Swartz (1936, p. 581) described *Tubulibairdia* as follows:

Carapace subovoid in side view, the posterior margin obtusely angulated; strongly inequivalved, the left the larger, overlapping the right along the free margin, and projecting above it dorsally. Actual hinge margin straight, apparently without specialized hinge structures. Carapace smooth externally, but pierced by coarse pores which open on the internal surface.

He compared his new genus, type *Tubulibairdia tubulifera*, only with *Bairdia*. The emphasis on internal tubules was occasioned by the preservation of the specimens from the Lower Devonian

(opposite page)

EXPLANATION OF PLATE 2

- Figures 1,2,7,8 — *Tubulibairdia windomensis* Swartz & Oriol. 1, right view of carapace, showing reticulation, UMMP 60148. 2, ventral view of carapace, showing slight bow-shaped projection or lip on left valve, UMMP 60147. 7,8, posterior and ventral views of carapace, showing exceptional overlap, UMMP 60149. All from Centerfield Limestone (Middle Devonian), two miles northeast of Darien, Genesee County, New York.
- Figures 3-6,15 — *Microcheilinella distorta* (Geis). 3,4, ventral and anterior views of carapace, UMMP 64149. 5,6, posterior and ventral views of carapace, UMMP 64150. 15, dorsal view of carapace, UMMP 64151. All from Salem Limestone (Mississippian), Old Cleveland Quarry, NE 1/4 SE 1/4 NW 1/4 sec. 20, T 7 N, R 1 W, Monroe County, Indiana.
- Figures 9-14,16 — *Tubulibairdia* sp. 9-12, dorsal, right, ventral, and left views of carapace, UMMP 60110. 13,14, dorsal and ventral views of carapace, UMMP 60150. 16, ventral view of carapace, UMMP 60152. 9-14, Wanakah Formation (Middle Devonian), two miles southeast of East Bethany, Genesee County, New York. 16, Hungry Hollow Formation (Middle Devonian) at type locality, banks of Ausable River, about two miles east and one-fourth mile north of Arkona, Ontario.

TABLE 3 — Some recent familial and superfamilial assignments of *Microcheilinella* (M) and *Tubulibairdia* (T).

	Family				Superfamily			
	Bairdiidae	Healdiidae	Pachydomellidae	Uncertain	Bairdiacea	Bairdiocypridacea	Healdiacea	Uncertain
1960 Zanina <i>et al.</i> *		M					M	
1960 Polenova		M						
1961 Berdan & Sohn*			T				T	
1961 Shaver				M				M
1962 Rozhdestvenskaja		M						
1964 Shi	M				M			
1965 Becker			T				T	
1967 Gailite		M					M	
1970 Polenova		M					M	
1971 Abushik		M						
1972 Rozhdestvenakaja		M					M	
1973 Berdan & Copeland			T				T	
1974 Polenova		M						
1975 Bandel & Becker			M			M		
1976 Adamczak*			M		M			
1977 Michailova			T				T	
1977 Copeland			T	M			T	M
1978 Kesling & Chilman		M					M	

*see Table 2

Shriver Chert. As Swartz correctly explained, the surfaces of casts made from internal molds were spinose, with the spines representing fillings of the tubules, and his specimens evidently suffered from extensive solution.

Swain (1953, p. 280–281) put *Tubulibairdia* in synonymy with *Pachydomella* Ulrich 1891 (type *Pachydomella tumida*) on the grounds that both have similar shape, overlap, and “deep normal canals . . . not opening to exterior.”

In a detailed study of *Bairdia* and related ostracods, Sohn (1960, p. 74) carefully compared *Tubulibairdia* and *Microcheilinella*, recognizing both genera. He noted some of what he considered synonyms by European authors, and distinguished *Microcheilinella*, as represented by the type species, from *Tubulibairdia* by its less incised hinge line, smaller size, and lack of tubules in the shell wall. He illustrated cross sections of *Tubulibairdia* sp. from the Manlius Limestone (1960, Pl. 5, fig. 12) and *Microcheilinella distorta* Geis from the Salem Limestone (1960, Pl. 5, fig. 13) for comparison. His figure of *M. distorta* does not reveal any sure indication of tubules. On the other hand, it does not bear out Sohn's contention that the hinge line is less incised than that of *Tubulibairdia*. In fact, the cross sections of both genera are remarkably similar in domiciliar asymmetry, ventral closure, and hinge position.

If tubules were not included as generic characters, no problem would exist, for, apart from size and degree of elongation, nearly all species assigned to *Tubulibairdia* could easily qualify for *Microcheilinella*. The function of tubules has never been determined. Inasmuch as no openings from their ends to the exterior of the valve wall have been discovered, they do not appear to be specialized normal pore canals leading to sensory setae.

Tubules are rarely demonstrated so positively as those in *Tubulibairdia tubulifera* Swartz, the type, which owe their form to an unusual but poor type of preservation. Generally, for specimens

TABLE 4 — Synonymies of two species, showing various generic re-assignments.

YEAR	AUTHOR	<i>Tubulibairdia clava</i>	<i>Tubulibairdia antecedens</i>
1932	Kegel	<i>Bythocypris (Bairdiocypris) clava</i> Kegel 1932	<i>Bairdiocypris (Bairdiocypris) clava antecedens</i> Kegel 1932
1950	Pokorný	<i>Bairdiocypris clava tenuisulcata</i> Pokorný 1950	
1953	Kummerow	<i>Microcheilinella clava</i> (Kegel)	<i>Microcheilinella amaliae</i> Kummerow 1953
1955	Krömmelbein	<i>Pachydomella clava</i> (Kegel)	<i>Pachydomella antecedens antecedens</i> (Kegel)
1960	Sohn	<i>Tubulibairdia clava</i> (Kegel)	<i>Tubulibairdia antecedens</i> var. <i>antecedens</i> (Kegel) <i>Tubulibairdia amaliae</i> (Kummerow)
1961	Ochs & Wolfart	<i>Pachydomella clava</i> (Kegel)	<i>Pachydomella antecedens</i> (Kegel)
1965	Becker	<i>Tubulibairdia clava</i> (Kegel)	<i>Tubulibairdia antecedens antecedens</i> (Kegel)
1969	Groos	<i>Tubulibairdia clava</i> (Kegel)	
1971	Berdan	<i>Tubulibairdia punctulata</i> (Ulrich)	
1976	Adamczak	<i>Microcheilinella clava</i> (Kegel)	<i>Microcheilinella antecedens antecedens</i> (Krömmelbein)

of the same species from the same sample, it can be truthfully said that the worse the preservation the better the expression of tubules. It is not surprising, therefore, that tubules have not been adequately substantiated in all ostracods classified as *Tubulibairdia* nor in all Devonian ostracods classified as *Microcheilinella*; in addition, the absence of tubules in all Carboniferous ostracods classified as *Microcheilinella* has not been absolutely demonstrated. After studying *M. distorta* from the type formation near the type locality, I question whether the absence of small tubules can be conclusively proved or disproved in such material; even the boundary between valves and steinkern is poorly defined.

Sohn (1960, Pl. 5, figs. 5, 7-9) demonstrated that in at least some Devonian specimens the presence of tubules within carapace walls can be detected by radiographs; however, micropaleontologists can not be expected to X-ray each ostracod as a diagnostic prelude to classification.

It is my opinion that the small Carboniferous forms comparable to the type of *Microcheilinella* represent a direct continuation of the lineage which included the type of *Tubulibairdia*, a lineage marked by diminution or disappearance of tubules in the valve walls as well as diminution in the size of the carapace. Insofar as known from records, the time of change from the large tubule-bearing forms to the small and perhaps tubule-less forms corresponds to the boundary between Devonian and Carboniferous.

The case offers several options. First, the laissez faire choices of generic name could be continued, perhaps with the hope that techniques will be found in the future to easily distinguish *Microcheilinella* from *Tubulibairdia*. Second, an arbitrary size limit could be imposed to

separate the generally large *Tubulibairdia* from the generally smaller *Microcheilinella*; this would not only be contrary to good classificatory practice, but would not separate species of the lineage into evolutionary entities (Table 5). Third, *Tubulibairdia* could be suppressed as a junior synonym of *Microcheilinella*, disregarding tubules as a generic character; yet if tubules are absent in the latter, this might reflect genetic differences at the genus level. Even though a rather formidable project, a definite effort needs to be made to search for tubules in all species concerned. Synonymy is a quick and absolute solution, but not necessarily a good one. Fourth, the generic name *Tubulibairdia* could be applied only to ostracods in which tubules are clearly discerned and *Microcheilinella* applied to others of the same shape in which they cannot be confirmed; thus, classification would become dependent upon preservation to an even greater degree than it is usually. Or fifth, based on current knowledge of ranges, an arbitrary time boundary could be set to separate the Silurian-Devonian *Tubulibairdia* from the Carboniferous *Microcheilinella*; such a boundary could be shifted earlier or later as the range of tubuliferous forms was refined.

The search for tubules in each and every species of the lineage should be intensified. At least for the present, the species in which tubules can be discerned should be classified as *Tubulibairdia*, and those well-preserved specimens which can be shown convincingly not to have any kind of tubules should be called *Microcheilinella*. For taxonomic convenience, it is recommended that those ostracods in which tubules cannot be determined definitely, because of preservation or scarcity of specimens, should be temporarily assigned generically according to age—*Tubulibairdia* for Silurian and Devonian forms and *Microcheilinella* for Carboniferous forms—with the generic uncertainty indicated by a question mark.

Eventually, one may hope, the presence or absence of tubules (or any sort) in *Microcheilinella distorta* and other similar Carboniferous species will be definitely settled. The investigation by Sohn (1960) would seem to show absence of tubules in *Microcheilinella* but, as explained above, the preservation of specimens of the type species leaves appreciable room for doubt. Admittedly, age is illogical and meaningless as an ultimate solution to a taxonomic problem: nevertheless, current indications are that the pre-Carboniferous forms have tubules and the Carboniferous forms do not, and until the occurrences and distributions of tubule-bearing members of this lineage are fully understood this offers an interim procedure.

It must be emphasized that the recommendation is neither for imposition of a preconceived stratigraphic boundary between genera nor for promotion of a quickly punctuated equilibrium. It is a realistic admission of the uncertainties surrounding actual characters in *Tubulibairdia* and/or *Microcheilinella*.

RECOMMENDED CLASSIFICATION

Based on the characters of *Microcheilinella* and *Tubulibairdia* as presently known, the following classification is here proposed (see also Table 1):

Superorder PODOCOPA Sars 1865

Order PODOCOPIDA Sars 1865

Suborder BAIRDIOCOPINA Gründel 1967

Superfamily Bairdiocypridacea Shaver 1961

Family Pachydomellidae Berdan & Sohn 1961

In 1975, Gramm (p. 86) proposed the family Microcheilinellidae, containing only the type genus. He assigned it only to the "suborder Podocopa."

Until the presence or absence of tubules in the type series is established beyond doubt, *Microcheilinella* might better be retained in the Pachydomellidae, where it was placed by Berdan & Sohn (*in* Moore, 1961), Becker (1965), Berdan & Copeland (1973), Bandel & Becker (1975), Adamczak (1976a), and others. Such retention emphasizes the relationship of the genus to *Tubulibairdia* and *Pachydomella*. Meanwhile, however, the family Microcheilinellidae Gramm 1975 remains available, even as a monogeneric family, should *Microcheilinella distorta* (Geis 1932) be demonstrated to lack tubules entirely and should the presence or absence of tubules be regarded as a familial character.

STRATIGRAPHIC HISTORY

The lineage as recorded (Tables 5 and 6) shows clearly a slight increase in size from Silurian to Devonian and a drastic decrease thereafter. It also shows a notable increase in the ratio of width/height.

The largest species insofar as documented is that called *Tubulibairdia punctulata* (Ulrich, 1891) by Berdan (1971), which Adamczak (1976a) considered to be a junior synonym of *Microcheilinella clava* (Kegel, 1932), as indicated in Table 4. Whatever its status, one specimen from the Lower Devonian of New York reported by Berdan measures 1.75 mm long, 1.10 mm high, and 1.15 mm wide. The smallest specimen presumed to be an adult is the Lower Mississippian form from Belgium classified as *Microcheilinella inversa* by Rome (1971); it is only 0.38 mm long, 0.25 mm high, and 0.27 mm wide.

The narrowest carapace belongs to *Microcheilinella* (?) *bicarinata* Rozhdestvenskaja 1962 from the Middle Devonian of the Urals, with width/height ratio of 0.64 (Table 4); it probably does not belong in the genus. The widest carapace is the Pennsylvanian *Microcheilinella bicornuta* Cooper 1946 from Illinois, with width/height ratio of 1.54.

The species definitely from Lower Silurian strata are all from the Baltic area, but Silurian species are known from Oklahoma, Alabama, and Quebec. This would indicate an early spread of the lineage. The Devonian continuation is distributed in North America (Yukon Territory, Oklahoma, Tennessee, Ohio, Michigan, Ontario, New York, and New Brunswick), Europe (Poland, Germany, and USSR), and Asia (China). Except for one or two species (Belgium and USSR) of Mississippian age, all Carboniferous species are from North America.

The average of Pennsylvanian species that are documented is less than half the average of Devonian species in length, height, and width; the average product of the three dimensions for Pennsylvanian forms is less than one tenth that of Devonian forms (Table 6).

Even though smooth Ostracoda are generally so difficult to classify that some micro-paleontologists hesitate to employ them in correlation, *Tubulibairdia* and *Microcheilinella* have been listed by enough competent workers that their overall record can scarcely be ignored or even doubted. Their reported distribution would suggest that during Silurian time Laurentia and Baltica were in very close proximity and that during Devonian time China may have been considerably closer to Larussia than indicated by a recent paleogeographic map (Ziegler *et al.*, 1979, Fig. 5).

TABLE 5 — Measurements of some species of *Microcheilinella*, *Tubulibairdia*, and some closely related ostracods. Most measurements are quoted from the reference cited; others are computed from the stated magnifications of photographic illustrations.

SPECIES	Length x Height x Width (mm)	SOURCE	LOCALITY
SILURIAN			
<i>Microcheilinella anticostiensis</i> Copeland 1974	0.75 x 0.50 x 0.50	Copeland 1974a	Anticosti Is., Quebec
<i>Daleiella</i> cf. <i>D. corbuloides</i> (Jones & Holl) 1869	0.76 x 0.50 x 0.55	Copeland 1974a	Anticosti Is., Quebec
<i>Microcheilinella</i> cf. <i>M. rozhdestvenskaja</i> Neckaja 1966	1.05 x 0.60 x 0.52	Copeland 1974a	Anticosti Is., Quebec
<i>Tubulibairdia</i> cf. <i>longula</i> (Ulrich & Bassler) 1913	1.20 x 0.72 x 0.75	Lundin 1965	Oklahoma
<i>Tubulibairdia alabamensis</i> Lundin & Newton 1970	1.20 x 0.68 x 0.67	Lundin & Newton 1970	Alabama
<i>Tubulibairdia copelandi</i> Lundin & Newton 1970	1.28 x 0.65 x 0.71	Lundin & Newton 1970	Alabama
<i>Tubulibairdia</i> sp. A	1.35 x 0.88 x 0.93	Lundin & Newton 1970	Alabama
LOWER SILURIAN			
<i>Daliella ovata</i> Neckaja 1960	0.72 x 0.45 x 0.43	Neckaja <i>in</i> Abushik <i>et al.</i> 1960	Lithuania, USSR
* <i>Daleiella variolaris</i> Neckaja 1960	0.75 x 0.49 x 0.45	Neckaja <i>in</i> Abushik <i>et al.</i> 1960	Lithuania, USSR
* <i>Daleiella semibulbosa</i> Neckaja 1960	0.76 x 0.45 x 0.42	Neckaja <i>in</i> Abushik <i>et al.</i> 1960	Lithuania, USSR
<i>Microcheilinella variolaris</i> (Neckaja) 1960	0.81 x 0.49 x 0.49	Gailite 1967	Baltic area, USSR
<i>Microcheilinella acutafinis</i> (Neckaja) 1960	1.01 x 0.68 x 0.72	Gailite 1967	Latvia, USSR
<i>Microcheilinella mobile</i> Gailite 1967	1.40 x 0.60 x 0.70	Gailite 1967	Latvia, USSR
MIDDLE SILURIAN			
<i>Microcheilinella lacrima</i> Gailite 1967	0.80 x 0.50 x 0.50	Gailite 1967	Prebaltic
<i>Tubulibairdia parva</i> Michailova 1977	0.90 x 0.65 x 0.60	Michailova 1977	Turkestan
* <i>Daleiella acutafinis</i> Neckaja 1960	0.97 x 0.65 x 0.66	Neckaja <i>in</i> Abushik <i>et al.</i> 1960	Esthonia, USSR
<i>Daleiella ianica</i> Neckaja 1960	1.22 x 0.80 x 1.00	Neckaja <i>in</i> Abushik <i>et al.</i> 1960	Esthonia USSR
DEVONIAN			
<i>Microcheilinella mandelstami</i> Polenova 1952	0.45 x 0.21 x 0.25	Polenova 1952	USSR
<i>Microcheilinella regularis</i> Polenova 1968	1.27 x 0.80 x 0.77	Polenova 1974	Urals, USSR
LOWER DEVONIAN			
<i>Microcheilinella</i> sp.	0.60 x 0.34 x 0.35	Berdan & Copeland 1973	Yukon Terr., Canada
<i>Microcheilinella decaturi</i> Wilson 1935	0.62 x 0.36 x 0.37	Wilson 1935	Tennessee

Tennessee
 Altai, USSR
 Salaira USSR
 Kuznetsk
 Kuznetsk Basin USSR
 Maryland
 Salaira USSR
 Alaska
 Oklahoma
 New York
 N. Brunswick

Sohn 1960
 Polenova 1970
 Polenova 1968
 Polenova 1960
 Polenova 1960
 Berdan 1971
 Polenova 1968
 Berdan & Copeland 1973
 Lundin 1968
 Berdan 1971
 Copeland 1962

Tubulibairdia decaturi (Wilson) 1935
Microcheilinella insueta Polenova 1970
Microcheilinella regularis Polenova 1968
Microcheilinella obitqua Polenova 1960
Microcheilinella malobaischatskiensis Polenova 1960
Tubulibairdia longula (Ulrich & Bassler) 1913
Microcheilinella obitqua Polenova 1960
Tubulibairdia sp.
Tubulibairdia simplex (Roth) 1929
Tubulibairdia punctulata (Ulrich) 1891
Tubulibairdia chaleurensis Copeland 1962

MIDDLE DEVONIAN

Kuznetsk Basin USSR
 Urals USSR
 China
 Urals USSR
 China
 Kuznetsk Basin USSR
 Salaira USSR
 Michigan Basin
 Urals USSR
 Urals USSR
 Kuznetsk Basin USSR
 Kuznetsk Basin USSR
 Bashkiri, USSR
 Penzensk Basin, USSR
 Urals USSR
 Salaira USSR
 Bashkiri, USSR
 New York
 Holy Cross Mts., Pol.
 Urals USSR
 Bashkiri, USSR
 Bashkiri, USSR
 Central Russian
 Plattform
 Eifel, Germany
 New York
 Eifel, Germany
 Urals USSR

Polenova 1960
 Rozhdestvenskaja 1962
 Shi 1964
 Rozhdestvenskaja 1962
 Shi 1964
 Polenova 1960
 Polenova 1960
 Kesling & Chillum 1978
 Rozhdestvenskaja 1962
 Rozhdestvenskaja 1962
 Polenova 1960
 Polenova 1960
 Egorova 1960
 Egorova 1960
 Rozhdestvenskaja 1962
 Polenova 1960
 Egorova 1960
 Swartz & Oriol 1948
 Adamczak 1976a
 Rozhdestvenskaja 1962
 Egorova 1960
 Egorova 1960
 Krömmelbein 1955
 Stover 1956
 Krömmelbein 1955
 Rozhdestvenskaja 1962

Microcheilinella ? *monospinosa* Polenova 1960
Microcheilinella (?) *monospinosa* Polenova 1960
Microcheilinella opima Shi 1964
Microcheilinella affinis Polenova 1955
Microcheilinella decora Shi 1964
Microcheilinella notabilis var. *umbonata* Polenova 1960
Microcheilinella notabilis Polenova 1955
Microcheilinella mariettensis Kesling & Chillum 1978
Microcheilinella convexa Rozhdestvenskaja 1962
Microcheilinella modica Rozhdestvenskaja 1962
Microcheilinella dorsoconvexa Polenova 1960
Microcheilinella lartionovae Polenova 1955
Microcheilinella (?) *sculpta* Egorova 1960
Microcheilinella subparallelata Egorova 1960
Microcheilinella lartionovae Polenova 1955
Microcheilinella lartionovae var. *elongata* Polenova 1960
Microcheilinella postnicovae Egorova 1960
Tubulibairdia windomensis Swartz & Oriol 1948
Microcheilinella antecedens antecedens (Kegel) 1932
Microcheilinella (?) *chlupaci* Rozhdestvenskaja 1962
Microcheilinella lartionovae Polenova 1955
Microcheilinella ischigevae Egorova 1960
Microcheilinella pusilla Egorova 1960
Pachydomeilla antecedens antecedens wolfarri Krömmelbein 1955
Tubulibairdia windomensis Swartz & Oriol 1948
Pachydomeilla antecedens antecedens (Kegel) 1932
Microcheilinella infradomanica Rozhdestvenskaja 1962

0.62 x 0.36 x 0.37
 1.00 x 0.70 x 0.75
 1.07 x 0.50 x 0.65
 1.10 x 0.66 x 0.73
 1.14 x 0.85 x 0.90
 1.15 x 0.60 x 0.70
 1.17 x 0.80 x 0.82
 1.25 x 0.75 x 0.80
 1.45 x 0.88 x 0.80
 1.60 x 1.00 x 1.10
 1.70 x 1.05 x 1.15
 1.75 x 1.10 x 1.15
 1.70 x 1.10 x 1.10
 0.47 x 0.27 x 0.30
 0.49 x 0.27 x 0.33
 0.57 x 0.35 x 0.45
 0.63 x 0.33 x 0.34
 0.65 x 0.28 x 0.36
 0.67 x 0.46 x 0.57
 0.67 x 0.50 x 0.52
 0.68 x 0.35 x 0.40
 0.72 x 0.36 x 0.48
 0.74 x 0.34 x 0.37
 0.79 x 0.60 x 0.58
 0.80 x 0.55 x 0.52
 0.80 x 0.46 x 0.47
 0.81 x 0.46 x 0.52
 0.84 x 0.51 x 0.54
 0.87 x 0.42 x 0.43
 0.88 x 0.40 x 0.56
 0.89 x 0.62 x 0.65
 0.90 x 0.58 x 0.58
 0.94 x 0.57 x 0.57
 0.94 x 0.58 x 0.66
 0.95 x 0.58 x 0.68
 0.98 x 0.64 x 0.70
 1.15 x 0.73 x 0.75
 0.98 x 0.56 x 0.61
 1.00 x 0.65 x 0.65
 1.08 x 0.65 x 0.68
 1.10 x 0.75 x 0.75
 1.13 x 0.66 x 0.68

TABLE 5 —Continued

SPECIES	Length x Height x Width (mm)	SOURCE	LOCALITY
MIDDLE DEVONIAN, continued			
<i>Microcheilinella</i> (?) <i>bicarinata</i> Rozhdestvenskaja 1962	1.15 x 0.70 x 0.45	Rozhdestvenskaja 1962	Urals USSR
<i>Microcheilinella chigevae</i> Egorova 1960	1.30 x 0.77 x 0.89	Rozhdestvenskaja 1962	Urals USSR
<i>Pachydomella clava</i> (Kegel) 1932	1.34 x 0.84 x 0.87	Krömmelbein 1955	Germany
<i>Microcheilinella mendymensis</i> Rozhdestvenskaja 1962	1.35 x 0.69 x 0.81	Rozhdestvenskaja 1962	Urals USSR
<i>Microcheilinella ventrosa</i> Polenova 1960	1.36 x 0.96 x 1.01	Rozhdestvenskaja 1962	Urals USSR
<i>Microcheilinella enormis</i> Rozhdestvenskaja 1962	1.39 x 0.88 x 0.99	Rozhdestvenskaja 1962	Urals USSR
<i>Microcheilinella</i> cf. <i>secunda</i> (Pribyl & Snajdr) 1950	1.40 x 0.80 x 0.85	Adamczak 1976a	Holy Cross Mts., Pol.
<i>Microcheilinella ventrosa</i> Polenova 1960	1.54 x 1.12 x 1.05	Polenova 1960	Kuznetsk
<i>Microcheilinella clava</i> (Kegel) 1932	1.62 x 1.00 x 1.06	Adamczak 1976a	Poland
UPPER DEVONIAN			
<i>Microcheilinella prunum</i> Rozhdestvenskaja 1972	0.82 x 0.60 x 0.60	Rozhdestvenskaja 1972	Bashkiri, USSR
<i>Microcheilinella peculiaris</i> Rozhdestvenskaja & Netchaeva 1972	0.93 x 0.54 x 0.60	Rozhdestvenskaja 1972	Urals USSR
MISSISSIPPIAN			
<i>Microcheilinella</i> (?) <i>nasuta</i> Rozhdestvenskaja 1972	0.84 x 0.40 x 0.46	Rozhdestvenskaja 1972	Bashkiri, USSR
LOWER MISSISSIPPIAN			
<i>Microcheilinella inversa</i> Rome 1971	0.38 x 0.25 x 0.27	Rome 1971	Belgium
UPPER MISSISSIPPIAN			
<i>Microcheilinella cordata</i> Cooper 1941	0.45 x 0.22 x 0.20	Cooper 1941	Illinois
<i>Microcheilus spinosus</i> Geis 1932	0.48 x 0.26 x 0.32	Geis 1932	Indiana
<i>Microcheilinella tumida</i> Cooper 1941	0.52 x 0.25 x 0.28	Cooper 1941	Illinois
<i>Microcheilinella</i> ? <i>exilis</i> Cooper 1941	0.53 x 0.18 x 0.15	Cooper 1941	Illinois
<i>Microcheilinella obesa</i> Cooper 1941	0.58 x 0.30 x 0.37	Cooper 1941	Illinois
<i>Microcheilus distortus</i> Geis 1932	0.68 x 0.37 x 0.41	Geis 1932	Indiana
PENNSYLVANIAN			
<i>Microcheilinella unispinosa</i> Cooper 1946	0.41 x 0.19 x 0.22	Cooper 1946	Illinois
<i>Microcheilinella minuta</i> Cooper 1946	0.41 x 0.22 x 0.22	Cooper 1946	Illinois
<i>Microcheilinella inflata</i> Cooper 1946	0.45 x 0.26 x 0.38	Cooper 1946	Illinois
<i>Microcheilinella bicornuta</i> Cooper 1946	0.49 x 0.24 x 0.37	Cooper 1946	Illinois
<i>Microcheilinella quadrata</i> Cooper 1946	0.75 x 0.36 x 0.44	Cooper 1946	Illinois

* These species of *Daleiella* were transferred to *Microcheilinella* by Gailite (1967).

TABLE 6 — Average measurements and ratios of species listed in table 4 according to age. Note that the average dimensions of Devonian species are more than twice those of Pennsylvanian species, but that the latter are proportionally much wider.

Age	No. Meas.	Average Length x Height x Width	Product L x H x W	Ratio W/H	
				Ave.	Range
Pennsylvanian	5	0.502 x 0.254 x 0.326	0.0416	1.28	1.00-1.54
Mississippian	8	0.558 x 0.279 x 0.308	0.0480	1.10	0.91-1.23
Devonian	57	1.017 x 0.622 x 0.660	0.4175	1.06	0.64-1.40
Silurian	17	0.996 x 0.605 x 0.624	0.3760	1.03	0.86-1.25

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