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TWO LATE PLEISTOCENE FAUNAS FROM SOUTHWESTERN KANSAS

BY

CLAUDE W. HIBBARD and DWIGHT W. TAYLOR

MUSEUM OF PALEONTOLOGY
THE UNIVERSITY OF MICHIGAN
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TWO LATE PLEISTOCENE FAUNAS FROM SOUTHWESTERN KANSAS

BY

CLAUDE W. HIBBARD and DWIGHT W. TAYLOR[1]

INTRODUCTION

AN UNUSUALLY FULL HISTORY of Pliocene and Pleistocene times is to be found recorded in southwestern Kansas and northwestern Oklahoma. The stratigraphic and paleontologic work by Claude W. Hibbard and field parties, from the University of Kansas (1936–1946) and University of Michigan (1947–1958), has revealed there the most nearly complete latest Cenozoic faunal succession that is known for a small area anywhere in the world. The two late Pleistocene faunas described in this paper are from long-recognized localities, but they have not previously been studied in detail. These assemblages, the Butler Spring and Cragin Quarry local faunas, add considerably to our knowledge of Illinoian and early Sangamon history in the southern Great Plains. No precise equivalent to the early Sangamon Cragin Quarry local fauna has been found elsewhere in the Great Plains, but the Berends local fauna of northwestern Oklahoma is probably a correlative of the Illinoian Butler Spring local fauna.

Acknowledgments

The authors are indebted to the various field parties who helped collect the fossils, to the local residents who permitted access to the localities or provided living quarters, and to many others who helped in the laboratory study of the specimens. Special credit is due to the 1956 University of Michigan party for initiative in carrying out the washing technique with little supervision.[2] The members of it were Michael J. Barie, Allen S. Hunt, and Michael O. Woodburne all of The University of Michigan, and David S. F. Winsted, of Bismarck, North Dakota. As in previous years, Dave Leahy, Director of the Kansas State Forestry, Fish and Game Commission, and Harry Smith, Superintendent of Meade County State Park, gave the field crew permission to live in the park and to wash the fossil-bearing matrix there. Arthur D. Sanders and Jack T. Sanders, Big Springs Ranch, and Horace G. Adams II and Horace G. Adams III, XI Ranch, allowed

[1] U. S. Geological Survey, Washington, D.C. Publication authorized by the Director, U. S. Geological Survey.

[2] For a description of the washing technique employed, see Hibbard, 1949*d*.

collecting and geologic work on their land. Miss Elsa Hertz, Receptionist-Clerk of the University of Michigan Museums, sorted the large amount of washed matrix which yielded the mollusks of the Butler Spring local fauna.

This study was aided by permission to examine specimens under the care of W. H. Burt and Henry van der Schalie, of the University of Michigan Museum of Zoology; Theodore Downs, of the Los Angeles County Museum; R. G. Van Gelder, of the American Museum of Natural History; Donald F. Hoffmeister, of the University of Illinois; John A. Wilson, Department of Geology, University of Texas; Robert W. Wilson, of the Kansas University Museum of Natural History; and Harald A. Rehder, of the United States National Museum. Mrs. D. E. Beetle, Laramie, Wyoming, permitted examination of shells in her collection and provided ecological data.

Financial support to Hibbard for the field work in Meade County, Kansas, during the summer of 1956, for the services of Allen S. Hunt, Research Assistant, who helped in the supervision of work and the preparation and cataloguing, and for those of Michael O. Woodburne (M.O.W.), artist, was provided by the Board of Governors of the Horace H. Rackham School of Graduate Studies of the University of Michigan. Fifteen of the line drawings made by Woodburne in the fall of 1958 were paid for by the National Science Foundation (project G-5635). Other illustrations were by Mrs. Bonnie Hall (B.H.), Museums Artist, University of Michigan. Photographs of the mollusks were taken by Herbert W. Wienert, Preparator of the Museum of Paleontology.

COMPARISON OF LATE PLEISTOCENE AND RECENT FAUNAS

Comparative data between several late Pleistocene faunas (Fig. 1) and the Recent fauna in the southwestern Kansas-northwestern Oklahoma area reveal the sharp distinctions between them. Occurrence of species in these faunas is shown in Table I, and the number of species represented in each of the major groups is given in Table II. Uncritical examination of the tabular data, however, may be misleading, for the quality of the samples was uneven owing to the nature of the animals, the size of the samples, and the range of habitats. Sampling error which will affect representation in a single fossil fauna proves even more significant when dealing with several assemblages.

In every case, the simple numerical contrast between the fossil and Recent molluscan faunas showed a real and significant difference; each fossil assemblage is more diverse than its Recent counterpart. The difference is greater than allowance for sampling error suggests, because several species of Succineidae are not determinable by shell alone; and hence, that

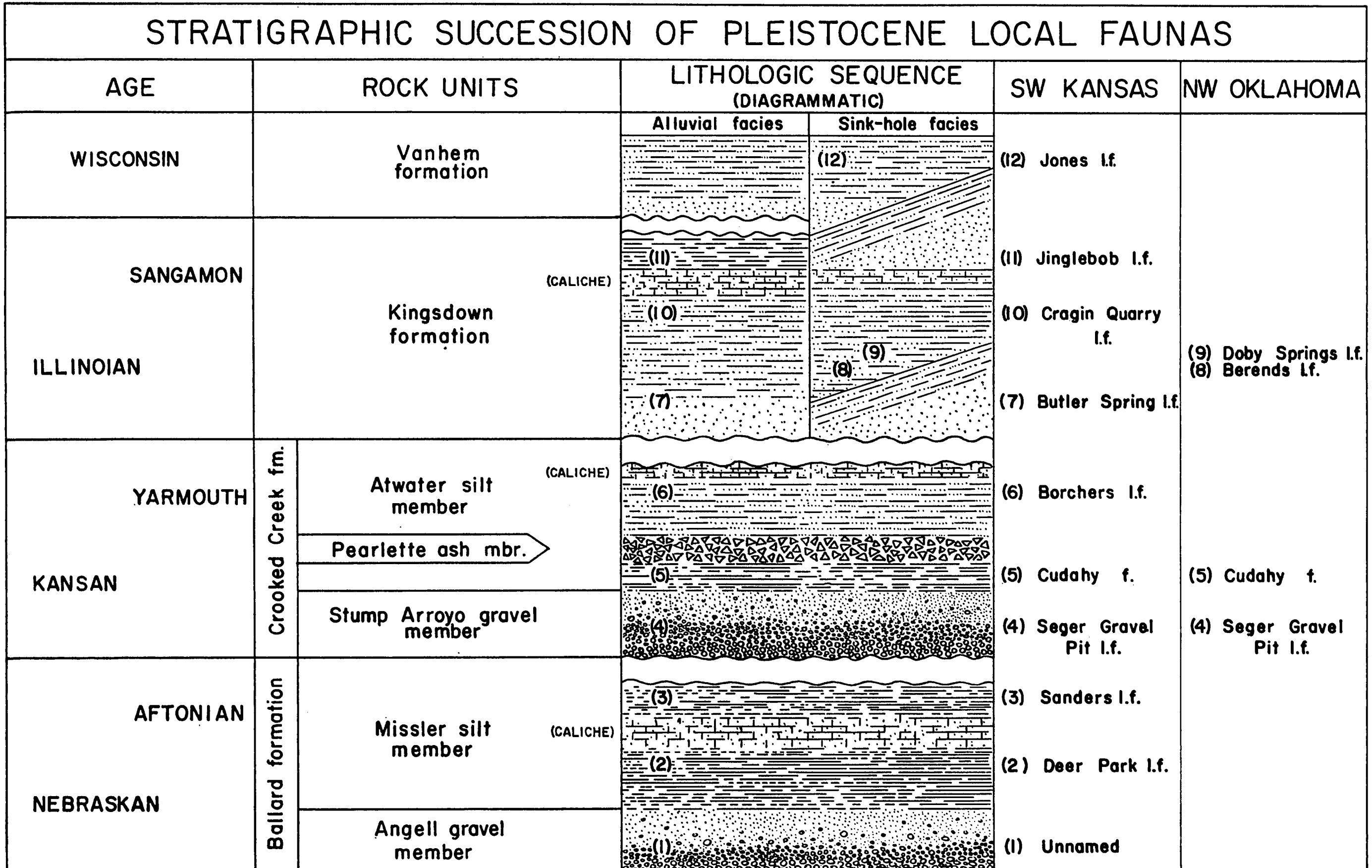
STRATIGRAPHIC SUCCESSION OF PLEISTOCENE LOCAL FAUNAS
AGE
ROCK UNITS
LITHOLOGIC SEQUENCE (DIAGRAMMATIC)
SW KANSAS
NW OKLAHOMA
Alluvial facies
Sink-hole facies
WISCONSIN
Vanhem formation
(12) Jones l.f.
SANGAMON
ILLINOIAN
Kingsdown formation
(CALICHE)
(11) Jinglebob l.f.
(10) Cragin Quarry l.f.
(7) Butler Spring l.f.
(9) Doby Springs l.f.
(8) Berends l.f.
YARMOUTH
KANSAN
Crooked Creek fm.
Atwater silt member
(CALICHE)
Pearlette ash mbr.
Stump Arroyo gravel member
(6) Borchers l.f.
(5) Cudahy f.
(4) Seger Gravel Pit l.f.
(5) Cudahy f.
(4) Seger Gravel Pit l.f.
AFTONIAN
NEBRASKAN
Ballard formation
Missler silt member
(CALICHE)
Angell gravel member
(3) Sanders l.f.
(2) Deer Park l.f.
(1) Unnamed

FIGURE 1

family is underrepresented by fossils. *Philomycus,* a genus of slugs which lack shells, naturally cannot be expected as a fossil in this area.

The many more Squamata in the Recent fauna are due to the small number of fossil snakes known. The record of lizard species in the Cragin Quarry local fauna is equal to that in the living one, and full count for that group may, therefore, have exceeded the modern total.

Fewer mammals are known from any one of the fossil faunas than now occur in the Recent fauna. Nevertheless, there were probably more in the Sangamon interval, at least, in Meade County, than now live there.

TABLE I

OCCURRENCE OF SPECIES IN LATE PLEISTOCENE AND RECENT FAUNAS OF SOUTHWESTERN KANSAS AND NORTHWESTERN OKLAHOMA[3]

Form	Fauna							
					Bar M			
	Berends	Butler Spring	Cragin Quarry	Jinglebob	Loc. 1	Loc. 2	Jones	Recent
Pelecypoda								
Order Prionodesmacea								
Unionidae								
Anodonta grandis	..	?	..	?	..	..	..	x
Quadrulidae								
Uniomerus tetralasmus	..	..	..	..	..	..	..	x
Quadrula quadrula	..	x	..	..	..	..	..	..
Order Teleodesmacea								
Sphaeriidae								
Sphaerium lacustre	x	..	..	..	..	..	..	..
Sphaerium occidentale	..	..	..	x	..	..	..	..
Sphaerium partumeium	..	..	x	x	..	..	..	..
Sphaerium striatinum	..	x	..	x	..	x	..	..
Sphaerium sulcatum	x	..	..	x	..	..	..	..
Sphaerium transversum	..	x	..	..	..	..	..	x
Pisidium casertanum	x	x	x	x	..	x	..	x
Pisidium compressum	x	x	..	x	..	x	x	..
Pisidium ferrugineum	..	..	..	..	..	..	x	..
Pisidium lilljeborgi	..	..	..	..	..	..	x	..
Pisidium nitidum	x	x	..	x	..	x	x	..
Pisidium obtusale	x	..	..	x	..	..	..	..
Pisidium walkeri	..	?	..	x	..	..	x	..

[3] Extinct species are marked by an asterisk (*); extinct genera and families, by a dagger (†).

TABLE I (*Continued*)

Form	Fauna							
	Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M Loc. 1	Bar M Loc. 2	Jones	Recent
Gastropoda								
Order Mesogastropoda								
Valvatidae								
Valvata tricarinata	x	x	..	x	..	..	x	..
Hydrobiidae								
Probythinella lacustris	..	x	..	..	..	..	..	..
Order Basommatophora								
Carychiidae								
Carychium exiguum	..	x	x	x	..	..	..	..
Lymnaeidae								
Fossaria dalli	x	x	x	x	..	x	x	x
Fossaria obrussa	x	x	..	x	..	x	..	x
Stagnicola bulimoides techella	..	..	..	..	..	..	..	x
Stagnicola caperata	x	x	x	x	x	x	x	..
Stagnicola cockerelli	..	..	..	..	..	x	x	x
Stagnicola exilis	x	..	x	..	..	..	..	..
Stagnicola palustris	..	..	..	..	x	x	x	..
Stagnicola palustris cf. *blatchleyi*	..	..	..	x	..	..	..	..
Stagnicola reflexa	..	x	..	..	..	..	..	..
Lymnaea stagnalis jugularis	..	x	..	..	x	x	x	..
Planorbidae								
**Anisus pattersoni*	..	x	..	..	..	..	..	..
Gyraulus circumstriatus	x	x	x	x	x	x	x	..
Gyraulus parvus	x	x	..	x	x	x	x	x
Armiger crista	x	..	x	..	x	x	x	..
Helisoma anceps	..	x	..	x	..	..	..	..
Helisoma trivolvis	x	x	x	x	x	x	x	x
Planorbula armigera	x	..	..	..	..	..	..	..
Promenetus exacuous	..	..	..	x	..	..	x	x
**Promenetus kansasensis*	x	x	x	..	..	..	..	..
Promenetus umbilicatellus	..	x	x	..	..	..	x	..
Ferrissiidae								
Ferrissia meekiana	..	x	x	x	..	x	..	..
Ferrissia parallela	..	..	..	..	..	x	..	..
Ferrissia rivularis	..	..	..	x	..	..	..	..
Laevapex fuscus	..	..	..	x	..	..	x	..
Laevapex kirklandi	..	x	..	x	..	..	..	..

TABLE I (*Continued*)

Form	Fauna							
	Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M Loc. 1	Bar M Loc. 2	Jones	Recent
Physidae								
Physa anatina	..	x	x	x	..	x	x	x
Physa gyrina	x	x	x	x	x	x	x	..
Physa skinneri	x	x	..	..	x	x	..	..
Aplexa hypnorum	x	x	..	x	x	x	x	..
Order Stylommatophora								
Strobilopsidae								
Strobilops labyrinthica	..	..	..	x	..	x	..	..
Pupillidae								
Gastrocopta armifera	x	x	x	x	..	x	x	x
Gastrocopta contracta	..	x	x	x	..	x	..	..
Gastrocopta cristata	..	x	x	x	x	..	x	x
Gastrocopta holzingeri	..	x	x	x	..	..	..	..
Gastrocopta pellucida hordeacella	..	..	x	..	..	..	..	x
Gastrocopta procera	x	x	..	x	..	..	x	x
Gastrocopta tappaniana	x	x	x	x	..	x	..	x
Pupoides albilabris	x	x	x	x	..	x	x	x
Pupoides inornatus	..	x	..	..	..	..	x	..
Pupilla blandi	..	x	x	x	..	x	x	..
Pupilla muscorum	..	x	..	..	..	x	..	..
Pupilla sinistra	..	x	..	..	..	..	..	..
Vertigo gouldi	..	x	..	..	..	..	..	..
Vertigo milium	..	x	x	x	..	..	..	..
Vertigo ovata	x	x	x	x	x	x	x	x
Valloniidae								
Vallonia cyclophorella	..	x	..	..	..	..	..	..
Vallonia gracilicosta	..	x	x	x	x	x	x	..
Vallonia parvula	..	x	x	x	..	..	..	x
Cionellidae								
Cionella lubrica	..	..	..	..	..	x	..	..
Succineidae								
Succinea concordialis	..	..	..	..	..	..	..	x
Succinea vaginacontorta	..	..	..	..	..	..	..	x
cf. *Succinea*	x	x	x	x	x	x	x	..
Oxyloma retusa	x	x	..	x	x	x	..	x
Quickella vagans	..	..	..	..	..	..	..	x
Philomycidae								
Philomycus carolinianus	..	..	..	..	..	..	..	x

TABLE I (*Continued*)

Form	Fauna							
					Bar M			
	Berends	Butler Spring	Cragin Quarry.	Jinglebob	Loc. 1	Loc. 2	Jones	Recent
Endodontidae								
Discus cronkhitei	..	x	..	..	x	x	..	..
Helicodiscus parallelus	x	..	x	x	..	x	..	x
Helicodiscus singleyanus	..	x	x	..	..	x	..	x
Punctum minutissimum	..	..	..	x	..	..	..	..
Limacidae								
**Deroceras aenigma*	..	..	x	x	..	..	..	..
Deroceras laeve	x	..	..	x	..	..	..	x
Zonitidae								
Euconulus fulvus	..	..	x	x	..	x	..	..
Nesovitrea electrina	..	..	x	x	x	x	..	..
Hawaiia minuscula	x	x	x	x	..	x	x	x
Zonitoides arboreus	..	x	x	x	..	x	..	..
Polygyridae								
Stenotrema leai	x	x	x	x	x	..	..	..
Amphibia								
Order Caudata								
Ambystomatidae								
Ambystoma tigrinum	..	x	x	cf	..	..	x	x
Order Salientia								
Scaphiopodidae								
Scaphiopus bombifrons	..	..	..	x	..	..	..	x
Bufonidae								
Bufo cognatus	..	..	..	..	..	..	..	x
Bufo woodhousii	..	..	..	x	..	..	..	x
Hylidae								
Acris crepitans	..	..	..	?	..	..	..	x
Pseudacris clarkii	..	..	..	..	..	..	..	x
Ranidae								
Rana catesbeiana	..	..	..	x	..	..	..	x
Rana pipiens	..	..	..	x	..	..	..	x
Microhylidae								
Gastrophryne olivacea	..	..	..	..	..	..	..	x
Reptilia								
Order Chelonia								
Chelydridae								
Chelydra serpentina	..	x	..	..	..	..	..	x
Kinosternon flavescens flavescens	..	..	..	..	..	..	..	x

TABLE I (*Continued*)

Form	Fauna							
	Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M Loc. 1	Bar M Loc. 2	Jones	Recent
Testudinidae								
*_Emydoidea twentei_	..	x	..	..	..	..	..	..
*_Terrapene llanensis_	..	..	x	x	..	..	..	..
Terrapene ornata	..	..	..	..	..	..	..	x
*_Geochelone_ sp.	..	..	x	..	..	..	..	..
Chrysemys picta belli	..	..	..	..	..	..	..	x
Pseudemys scripta elegans	..	..	..	..	..	..	..	x
Trionychidae								
Trionyx spinifer hartwegi	..	..	..	..	..	..	..	x
Order Squamata								
Iguanidae								
Crotaphytus collaris	..	..	x	..	..	..	..	x
Holbrookia maculata maculata	..	..	..	..	..	..	..	x
Holbrookia texana	..	..	x	..	..	..	..	..
Sceloporus undulatus garmani	..	..	..	..	..	..	..	x
Phrynosoma cornutum	..	..	x	..	..	..	..	x
Phrynosoma modestum	..	..	x	..	..	..	..	..
Teiidae								
Cnemidophorus sexlineatus	..	..	x	..	..	..	..	x
Scincidae								
Eumeces obsoletus	..	..	x	?	..	..	..	x
Mammalia								
Order Marsupialia								
Didelphiidae								
Didelphis marsupialis virginiana	..	..	..	..	..	..	..	x
Order Insectivora								
Soricidae								
Sorex cinereus	cf	..	..	cf	..	..	x	..
Blarina cf. _B. brevicauda_	x	..	..	x	..	..	..	..
Cryptotis parva parva	..	..	..	..	..	..	..	x
Notiosorex crawfordi	..	..	x	..	..	..	..	..
Talpidae								
Scalopus aquaticus intermedius	..	..	..	..	..	..	..	x
Order Chiroptera								
Vespertilionidae								
Lasiurus borealis borealis	..	..	..	..	..	..	..	x
Lasiurus cinereus	..	..	x	..	..	..	..	x
*_Dasypterus golliheri_, sp. nov.	..	..	x	..	..	..	..	..
Tadarida mexicana	..	..	..	..	..	..	..	x

TABLE I (*Continued*)

Form	Fauna							
	Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M Loc. 1	Bar M Loc. 2	Jones	Recent
Order Edentata								
†Megalonychidae								
†*Megalonyx* sp.	..	x	..	..	..	..	..	..
†Mylodontidae								
†*Paramylodon harlani*	..	..	x	x	..	..	..	..
Dasypodidae								
**Dasypus bellus*	..	..	..	..	x	..	..	..
Order Rodentia								
Sciuridae								
Cynomys ludovicianus	..	..	x	..	..	..	x	x
Citellus richardsoni	..	..	..	..	..	..	x	..
Citellus tridecemlineatus	..	..	x	..	..	..	x	x
Citellus spilosoma marginatus	..	..	..	..	..	..	..	x
Citellus sp.	..	x	..	x	..	..	..	..
Sciurus niger rufiventer	..	..	..	..	..	..	..	x
Geomyidae								
Geomys bursarius	..	..	x	..	..	..	..	x
Geomys sp.	x	cf	..	x	..	..	x	..
Cratogeomys castanops	..	..	..	..	..	..	..	x
Heteromyidae								
Perognathus hispidus	cf	..	x	x	..	..	..	x
Perognathus flavescens flavescens	..	..	..	..	..	..	..	x
Perognathus flavus bunkeri	..	..	..	..	..	..	..	x
Perognathus sp.	..	..	x	x	..	..	x	..
Dipodomys ordii richardsoni	..	..	cf	cf	..	..	..	x
Castoridae								
Castor canadensis	..	..	..	..	..	..	..	x
†*Paradipoides stovalli*	x	..	..	..	..	..	..	..
†*Castoroides* cf. *C. ohioensis*	..	x	..	..	..	..	..	..
†*Castoroides* sp.	x	..	..	..	..	..	..	..
Cricetidae								
**Onychomys jinglebobensis*	..	..	..	x	..	..	..	..
Onychomys leucogaster	..	..	cf	..	..	..	x	x
Reithrodontomys montanus	..	..	..	cf	..	..	..	x
Reithrodontomys megalotis	..	..	x	..	..	..	..	x
**Oryzomys fossilis*	..	..	..	x	..	..	..	..
Sigmodon hispidus texianus	..	..	..	..	..	..	..	x
Peromyscus maniculatus luteus	..	..	..	..	..	..	..	x
**Peromyscus progressus*, sp. nov.	..	..	x	..	..	..	..	..

TABLE I (*Continued*)

Form	Fauna: Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M: Loc. 1	Bar M: Loc. 2	Jones	Recent
**Peromyscus berendsensis*	x	..	..	..	..	..	..	..
Peromyscus leucopus	..	..	..	..	..	..	..	x
**Peromyscus cochrani*	..	..	cf	x	..	..	..	..
Peromyscus sp.	..	..	..	x	..	..	x	..
Neotoma micropus	..	..	x	..	..	..	..	x
Neotoma sp.	..	..	..	x	..	..	..	..
Ondatra zibethicus	..	..	..	x	..	..	..	x
**Ondatra triradicatus*	x	..	..	..	..	..	..	..
Pedomys ochrogaster	cf	..	?	x	..	..	x	x
Microtus pennsylvanicus	x	x	..	x	x	..	x	..
Synaptomys cooperi paludis	..	..	..	..	..	..	..	x
**Synaptomys australis*	..	..	..	x	..	..	..	..
Zapodidae								
**Zapus adamsi*	..	..	..	x	..	..	..	..
Order Carnivora								
Canidae								
Canis latrans	x	x	x	..	..	..	..	x
Canis lupus nubilus	..	..	..	..	..	..	..	x
†*Aenocyon dirus*	..	..	x	..	..	..	..	..
Vulpes velox	..	..	x	..	..	..	x	x
Urocyon cinereoargenteus	..	..	..	..	..	..	..	x
Ursidae								
†*Arctodus simus*	..	..	..	x	..	..	..	..
Ursus americanus	..	..	..	..	..	..	..	x
Procyonidae								
Procyon lotor hirtus	..	..	..	..	..	..	..	x
Mustelidae								
Mustela frenata neomexicana	..	..	..	..	..	..	..	x
Mustela vison	..	..	..	..	..	..	..	x
Mustela nigripes	..	..	..	..	..	..	..	x
Taxidea taxus	..	..	..	..	..	..	x	x
Spilogale interrupta	..	..	x	x	..	..	..	x
Mephitis mephitis	..	..	..	..	..	..	x	x
Felidae								
Felis concolor	..	..	cf	..	..	..	..	x
**Panthera atrox*	..	..	x	..	..	..	..	..
Lynx rufus baileyi	..	..	..	..	..	..	..	x

TABLE I (*Continued*)

Form	Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M Loc. 1	Bar M Loc. 2	Jones	Recent
Order Proboscidea								
Elephantidae								
†*Mammuthus columbi*	cf	?	x	x	..	..	..	..
Order Lagomorpha								
Leporidae								
Lepus townsendii campanius	..	..	..	..	..	..	..	x
Lepus californicus melanotis	..	..	..	..	..	..	..	x
Lepus sp.	..	..	x	..	..	..	..	..
Sylvilagus floridanus llanensis	..	..	..	..	..	..	..	x
Sylvilagus audubonii neomexicanus	..	..	..	..	..	..	..	x
Sylvilagus sp.	..	..	x	..	..	..	..	..
Order Artiodactyla								
Tayassuidae								
†*Platygonus* cf. *P. compressus*	..	..	x	..	..	..	?	..
Camelidae								
†*Camelops kansanus*	cf	?	x	..	..	..	?	..
†*Tanupolama* sp.	..	..	x	..	..	..	..	..
Cervidae								
Cervus canadensis	..	..	..	..	..	..	..	x
Odocoileus sp.	..	..	..	..	..	..	..	x
Antilocapridae								
†*Capromeryx furcifer*	..	..	x	..	..	..	..	..
Antilocapra americana americana	..	..	..	..	..	..	..	x
Bovidae								
**Bison latifrons*	..	..	..	x	..	..	..	..
Bison bison bison	..	..	..	..	..	..	..	x
Order Perissodactyla								
Equidae								
**Equus conversidens*	..	..	x	..	..	..	..	..
**Equus scotti*	..	x	x	..	..	..	..	..
**Equus* sp.	x	x	x	..	..	..	x	..

The carnivores, a diverse Recent group, are poorly represented as fossils, but most of them presumably occurred locally in the Sangamon, as well as some extinct foms, as the dire wolf, sabertooth cat, giant jaguar, and large short-faced bear. The remains of the sloth, mammoth, peccary, camels, pronghorn, *Bison,* and horses indicate a far richer herbivorous fauna then than now, which also suggests a rich carnivore fauna.

Environmental interpretation.—The variety of animals known from these Pleistocene faunas is much greater than that recorded from most other nonmarine Pleistocene assemblages in North America. All major groups of vertebrates are represented, usually several from each fauna, as well as numerous mollusks. This richness, although partly due to actual abundance of fossils preserved, is chiefly owing to the improved collecting technique of mass washing quantities of sediment through screens. The diversity of the fossil assemblages has considerably aided an environmental interpretation, for the broader inferences from each major animal group can be checked against one another. While the presence of certain types of animals sometimes added ecologic details, in no case so far has an harmonious interpretation from all lines of evidence been impossible.

The southwestern Kansas–northwestern Oklahoma area is so situated that it has recorded the marked climatic changes of the Pleistocene epoch. It is on the boundary between the dry subhumid and semiarid climatic types (Thornthwaite, 1948); and, fossil assemblages indicate former dryer as well as moister conditions. The Pleistocene faunas include many species which now live hundreds of miles to the north or at much higher elevations and others now restricted to the south and east. These significant changes in distribution suggest considerable north-south shifts of isotherms, and east-west changes of moisture belts. Probably, few other areas in the Great Plains could record these changes to the same extent, for the shifts in isohyets might be rather inconspicuous westward farther into the rain-shadow of the Rocky Mountains, or eastward, into what is now a moister climate. Although the exact amplitude of the north-south range shifts is not known, presumably both to the north and south at some place they would be less apparent.

The main reason why the shifts in distribution of species are so conspicuous here is that the area studied lies in the Great Plains—a tremendous expanse of relatively low relief that forms a broad pathway for ready dispersal. Furthermore, the Plains lie east of the Rocky Mountains and, as a result, are beyond the influence of westerly winds from the Pacific Ocean. They are a part of that great interior lowland of North America, between the Rocky Mountains and Appalachians, over which air masses from the Arctic or Gulf of Mexico can pass with little obstruction by mountains. These unimpeded air masses vitally affect all life on the Plains.

TABLE II

DIVERSITY OF ANIMAL GROUPS IN LATE PLEISTOCENE AND RECENT FAUNAS OF SOUTHWESTERN KANSAS AND NORTHWESTERN OKLAHOMA

Birds, sporadically represented and incompletely studied, are omitted. Figures represent the number of species in each order in each fauna; X, the forms present but unstudied or unidentified; and 0, no fossil record.

Group	Fauna						
	Berends	Butler Spring	Cragin Quarry	Jinglebob	Bar M	Jones	Recent
Pelecypoda	6	9	2	10	4	5	4
Prionodesmacea	0	2	0	1	0	0	2
Teleodesmacea	6	7	2	9	4	5	2
Gastropoda	25	45	33	42	37	26	25
Mesogastropoda	1	2	0	1	0	1	0
Basommatophora	13	19	12	17	16	15	8
Stylommatophora	11	24	21	24	21	10	17
Osteichthyes	12	5	2	2	0	x	x
Amphibia	x	1+	1+	6	0	1+	9
Caudata	0	1	1	1	0	1	1
Salientia	x	x	x	5	0	x	8
Reptilia	x	2+	8	4	0	x	34
Chelonia	x	2	2	1	0	0	6
Squamata	x	x	6	3	0	x	28
Mammalia	14	9	32	24	2	15	48
Marsupialia	0	0	0	0	0	0	1
Insectivora	2	0	1	2	0	1	2
Chiroptera	0	0	2	0	0	0	3
Edentata	0	1	1	1	1	0	0
Rodentia	8	3	12	16	1	9	21
Carnivora	1	1	6	2	0	3	14
Proboscidea	1	1	1	1	0	x	0
Lagomorpha	1	0	2	1	0	0	4
Artiodactyla	x	1	4	1	0	2	3
Perissodactyla	1	2	3	0	0	x	0

Thus, from the successive faunal differences in a local area, it is entirely possible to infer climatic changes over a large part of the continent.

Faunal differences.—After due allowance for sampling errors, the differences between the late Pleistocene and Recent faunas of southwestern Kansas and northwestern Oklahoma can be divided into two major categories: (1) progressive differences, caused by evolution of new forms and extinction of old ones, and (2) differences in faunal composition, owing to shifts in geographic range. While the two types are theoretically qualitatively distinct, in practice they sometimes cannot be discriminated between.

All species of fishes, amphibians, lizards, and birds recognized in these late Pleistocene faunas represent Recent forms. Genera that are extinct are known only among the mammals. Extinct species are most common in the mammals, but some of the turtles and a very few snails have, likewise, failed to survive. A few species are thought to have evolved during the late Pleistocene interval that is represented by the faunas studied; most of them are rodents, but one is a freshwater snail. Greatest contrast between Recent and fossil assemblages is shown by the mammals. It is due to the relatively high percentage of extinct mammal groups—a number of genera and two families (Mylodontidae and Megalonychidae). The difference is especially striking, because most of the nonsurviving species were large, whether herbivores or carnivores.

In the lower vertebrates and the mollusks, most of the faunal contrasts represent different combinations of living species. Extinctions and evolutionary novelties are rare. Most of the differences are explainable by changes in climate that affected the distribution patterns of the species. A possible exception is the salamander, *Ambystoma tigrinum,* which occurs in the Recent and Sangamon faunas as the normal metamorphosing form, but in the glacial Illinoian and Wisconsin faunas as the giant neotenic type. This phenomenon may or may not be caused by climatic differences. So far all the lizards have been found in the interglacial-age faunas. The fact that the number of them in the Cragin Quarry local fauna is equal to that living in Meade County today suggests that there may have been even more lizards in Sangamon time than now.

Despite the fact that the Recent fishes of Meade County are still unstudied, it is evident that the Illinoian fish fauna was very different and probably larger than that of the present. This may be accounted for by the lower summer temperatures and the greater abundance of water, which would furnish many habitats not now locally available. Sangamon and Wisconsin fishes are so poorly known that whether they too were more diverse than those of today is uncertain.

The number of mollusks known from each of the late Pleistocene faunas exceeds that in the better-sampled Recent one. Probably, if all of the former molluscan faunas were better known the discrepancy would be even more marked. As is true of the fishes, the contrast can be accounted for by former lower summer temperatures and greater precipitation. The larger number of species, including several nonpulmonate mollusks, is in conflict with that recorded by Leonard (1952, p. 10) and by Frye and Leonard (1957*a*, p. 10). Their conclusions about widespread extinction of mollusks in late Yarmouth or early Illinoian time are, therefore, open to question.

STRATIGRAPHY

The late Cenozoic stratigraphic sequence of southwestern Kansas was described in the form in which it is now understood by Hibbard (1949*a, b*). Subsequent changes in his scheme are nomenclatural, and are summarized in Figure 2. The chart also shows the relationship of the nomenclature of other reports on the area. In this section, because the paper is devoted primarily to late Pleistocene deposits in Meade County, the older rocks are treated cursorily. The earlier Pleistocene Ballard and Crooked Creek formations are rather widespread mantle deposits that are relatively easy to recognize and trace for considerable distances. In a number of localities the Crooked Creek overlies the Ballard. Younger beds were mostly laid down in valleys cut into these two older formations or in isolated sinkholes. The pronounced stratigraphic and physiographic break between these two modes of occurrence—sheet deposits and valley or sinkhole fillings—has led to distinguishing the older deposits as the Meade group and the younger as the Sanborn group.

The Sanborn group is recognized primarily by its age and topographic position, only secondarily by its physical characteristics. In the main it lacks gravel and is unindurated. Local features of sinkhole origin, such as thinly bedded sand and silt, gypsiferous beds, and red, thin-bedded silt and clay are peculiar to the Sanborn in this area. Of this group the Kingsdown and Vanhem formations were originally set apart by Hibbard (1944) as the upper and lower Kingsdown silt. In northwestern Clark County, Kansas, where he studied them, the two occur as alluvial valley fills differing slightly in color and texture, with the Vanhem locally channeled into the Kingsdown. Westward, in Meade County and beyond, however, the two units have not been found in contact. The Vanhem is widespread on the uplands, but near stream valleys it has been eroded away and the High Plains surface is underlain by the Crooked Creek formation. So far the Kingsdown formation is known in Meade County only in tributaries on the west side of Crooked Creek.

The sinkhole-filling sediments of the Sanborn group are of heterogeneous nature, they reflect the diverse histories of the basins in which they were deposited. In general they are fine-grained and massive to thin-bedded, without the coarser fractions or cross bedding of the older, stream-laid formations. Sorting and color are variable. The Odee formation of H. T. U. Smith (1940) included primarily basin-filling sediments, and that name, as Hibbard (1949*a*) proposed, could be applied to all such deposits.

Actually, the sinkhole deposits are so varied that referring them to the undifferentiated Sanborn group serves equally well.

Fossils from the Sanborn group, although more abundant than in the older rocks, have not been studied nearly as thoroughly. On available evidence the Kingsdown formation is of Illinoian and Sangamon age, and the Vanhem formation is of Wisconsin age. The oldest fossils so far collected from basin-filling deposits in Meade County are of Sangamon age.

LATE PLEISTOCENE HISTORY OF MEADE COUNTY, KANSAS

The Pliocene and Pleistocene history of the Meade County region in southwestern Kansas and northwestern Oklahoma has been reviewed by Hibbard (1949*a*, 1950, 1954, 1955*b*). New data together with new interpretations of older information have led to a revised interpretation of the late Pleistocene, which is summarized below in sections corresponding, so far as practicable, to the successive stages in this history as they are now recognized.

1. During the earlier part of the Yarmouth interglacial interval, a broad aggradational plain, essentially equivalent to the local High Plains surface of today, was being completed by deposition and distribution of sand and silt. Seasonal streams with indefinite channels, thunderstorms and flash floods, and wind were probably the principal agents in moving the sediment. The relatively fine-grained unit so deposited is the upper part of the Atwater member of the Crooked Creek formation. From this unit comes the Borchers local fauna, the composition of which implies a warm-temperate, dry subhumid climate.

2. Either owing to a slowing rate of deposition of sediment or to climatic change, or to both, caliche developed conspicuously in the soil. The extent to which it formed at this time is uncertain, but, probably, a concentration of calcium carbonate formed a resistant layer 6 to 18 inches thick close to the surface of the ground sometime during the Yarmouth interval. The inferred climate may have been warm and dry, with rainfall occurring in brief showers and evaporating relatively fast; summer temperatures may not have been much different from those of southwestern Kansas today, but winter temperatures are believed to have been higher.

3. A late Yarmouth-early Illinoian erosional interval is implied by the presence of Illinoian sediments in valleys below the top of the Crooked Creek formation. Three such occurrences are known: two in the local areas in Meade County, from which the Butler Spring and Cragin Quarry local faunas have been collected, and a third in the headwaters of Bluff Creek, in northwestern Clark County. Sometime during this late Yarmouth-early Illinoian time ancestral Crooked Creek came into being, as a consequence of renewed movement along the Crooked Creek fault. The essentially

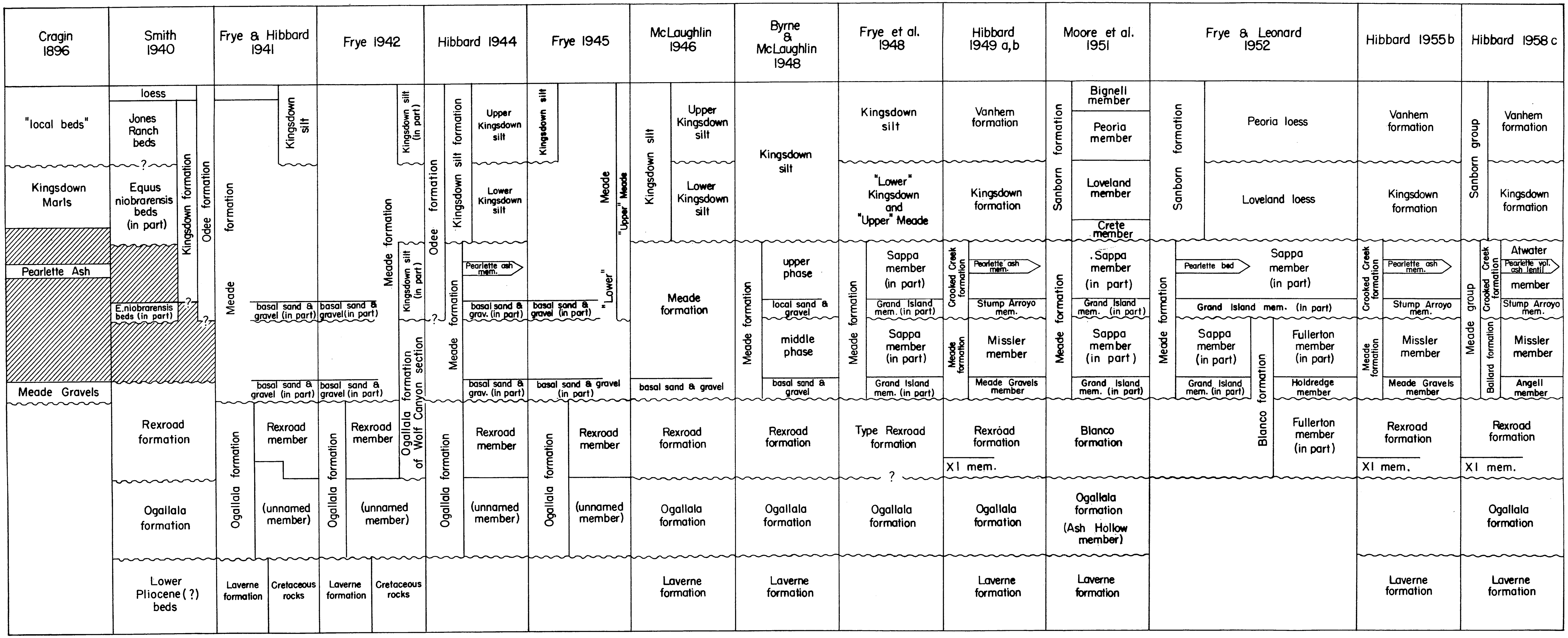

FIGURE 2. CORRELATION OF STRATIGRAPHIC NOMENCLATURE IN VARIOUS REPORTS ON MEADE COUNTY AREA.

unmodified surface of the Crooked Creek formation east of the fault, and the topographically low Illinoian sediments in the valleys west of it imply that the southwestward-flowing central part of Crooked Creek dates from this time. Crooked Creek flowed into the Cimarron River along the course of present Skunk Arroyo, following the southwestward trend of the fault. Subsequently (the date is uncertain), a southeastward-flowing tributary of the Cimarron River, a tributary which occupied approximately the present lower course of Crooked Creek, captured the greater part of ancestral Crooked Creek, probably aided by sinkhole collapse near the present right-angle bend of Crooked Creek. As a result the southwestward-flowing lower course of the former stream was reversed and became a minor tributary (Skunk Arroyo) of Crooked Creek.

Although deposits of ancestral Crooked Creek are to be expected in the area from which the Butler Spring local fauna is described, not enough field work has been done in this part of the Cimarron Valley to recognize them. The coarse, stream-laid sand from which this local fauna comes may be a deposit of ancestral Crooked Creek or of the former Cimarron River.

4. Late Illinoian and Sangamon deposits are known both from small valleys west of Crooked Creek and from the Cimarron River Valley. Sedimentation appears to have been regional, and the great thickness of the Kingsdown formation west of Crooked Creek Valley is due partly, but not entirely, to subsidence along the Crooked Creek fault.

5. Following the cooler-summer and the moist, late Illinoian climate inferred from the Butler Spring local fauna, there was again a change toward warmer and dryer conditions. The Cragin Quarry local fauna records a climate more nearly like the present, with summers nearly as warm as those of today and much warmer winters.

6. By the middle part of the Sangamon interval the climate was once more favorable for caliche formation. A massive, well-indurated bed 12 to 18 inches thick is preserved in the vicinity of both the Cragin Quarry and Butler Spring local faunas. Near Butler Spring the caliche was tilted during the collapse of a sinkhole and buried by younger sediments of late Sangamon and Wisconsin age. In the Cragin Quarry area the caliche occurs as remnants capping the bluffs of Kingsdown sediments, and is slightly tilted to the east. Evidently, Crooked Creek Valley subsided to some extent after the deposition of the Sangamon caliche. Caliche probably formed during Sangamon time under most of the exposed upland surfaces. The conspicuous caprock at the top of the Crooked Creek formation, underlying the High Plains surface, may represent a composite of both Yarmouth and Sangamon weathering.

7. The relatively warm, equable and semiarid climate that is implied by the Cragin Quarry local fauna changed to a humid climate later in

the Sangamon interval. Such a new environment is inferred from the Jinglebob local fauna, which was collected from near the base of alluvial sediments of the Kingsdown formation that fill a valley cut through the Crooked Creek and Ballard and into the Rexroad formation of Pliocene age. The fact that the basal part of the Kingsdown formation is of late Sangamon age here, whereas in the Cragin Quarry area it is Illinoian, suggests that movement on the Crooked Creek fault was responsible for the deposition of the sediments at the Jinglebob locality. These sediments may have been laid down when erosion was dominant in most parts of the Meade County area.

8. No late Sangamon-early Wisconsin erosional interval is directly recorded in Meade County, but the record from adjacent Clark County implies erosion at this time. The Vanhem formation of Wisconsin age is separated from the underlying Kingsdown formation by an erosional unconformity in the northwestern part of the county. This episode there seems to have been brief and probably in early Wisconsin time, for deposition replaced erosion regionally.

9. The Vanhem formation records widespread aggradation in southwestern Kansas. In Meade County and for some distance to the west, its distribution indicates that the former channels of the ancestral Cimarron River and ancestral Crooked Creek had been largely filled by this time. The relatively soft, fine-grained mantle has now been removed from the upland surface near the stream valleys.

What the environment was during part of the time when the Vanhem formation was being deposited is indicated by the Jones local fauna. Since this fauna is from a large sinkhole, the aquatic environment is probably not representative of upland conditions. The assemblage suggests a semi-arid climate with markedly cooler summers than those of today, and winters probably no warmer than the present ones.

10. Two geologic events recorded in Meade County may have been partly contemporaneous: (*a*) deposition of loess, which may have taken place on the uplands while stream valleys were deepening, and (*b*) entrenchment of the Cimarron River to more than 250 feet below the upland surface on which the Vanhem formation was deposited. That the valley cutting, which is still going on, was discontinuous, is evidenced by thin terrace deposits of late Wisconsin age in minor valleys on the north side of the Cimarron River.

11. At least two important events in the late Pleistocene history of Meade County are recorded by terrace gravel deposits along the Cimarron River. They cannot be related to the rest of the geologic history because of the uncertain ages of the gravels, but the two deposits are younger than the Crooked Creek formation.

ILLINOIAN AND SANGAMON CLIMATIC CHANGES

In addition to furnishing new stratigraphic information, study of the Butler Spring and Cragin Quarry local faunas has yielded new inferences about the climate at the times when the faunas lived. The new ideas gained permit a revised and more detailed account of the climatic changes from late Illinoian throughout much of Sangamon time. The former climates are described chiefly in terms of the present climate of Meade County, because the different climates are inferred primarily from the contrasts between the fossil faunas and the Recent one. For clarification the climate of Meade County is summarized here.

Meade County now has a continental, temperate, generally moisture-deficient climate. Precipitation and temperatures are variable, both from year to year and within a given year. Mean annual rainfall is 19.66 inches for a period of 45 years. The lowest recorded annual rainfall is 9.35 inches, for 1910; the highest, 31.62 inches, for 1915. The climate is dry, with no seasonal water surplus; Meade County is on the boundary between semiarid and dry subhumid climatic types. Summer is the wettest season, and nearly three-quarters of the annual precipitation comes during the warmer half year. Mean annual temperature is about 56° F. January, the coldest month, has a mean temperature of about 32° F.; July, the hottest month, has a mean temperature of about 80° F. Recorded temperature extremes are –20° F. and 110° F. Normal annual evaporation from pans is slightly over 90 inches; from May to October, 65 inches. (Sources: U. S. Weather Bureau records, examined directly and as summarized by Frye, 1942; Thornthwaite, 1948; Visher, 1954).

The late Illinoian climate in Meade County, inferred from the Butler Spring local fauna, differed from that of today in being generally cooler, with the difference mostly or entirely in the summers. The summer concentration of thermal efficiency and potential evapotranspiration was reduced, that is, the climate was less continental than the existing one. Unless winters were warmer, the mean annual temperature of the area in late Illinoian time was lower than the present. Amount and distribution of rainfall need not have differed from those of today; the greater effectiveness of rainfall in cooler summers can account for observed faunal differences. Meade County may have been on the semiarid–dry subhumid border as it is now.

The early Sangamon climate was less continental than that of the late Illinoian, and much less continental than the present one. This phase of climatic change is inferred from the Cragin Quarry local fauna. Summers, and especially winters, had become warmer. If temperatures ever fell as low as freezing, they did not stay there long. Summers were somewhat warmer than those in late Illinoian time, but lacked the present-day extremes of heat. The climate was semiarid; mean annual precipitation probably differed little from that of the area today or in Illinoian time.

Climatically, the massive caliche layer which is preserved above the horizon of the Cragin Quarry local fauna in both the Cragin Quarry and Butler Spring areas is equivocal. Its formation in both places can be explained by slowing or cessation of deposition rather than by climatic change.

A later stage in Sangamon climatic change is recorded by the Jinglebob local fauna. Rainfall was much greater, about 40 to 45 inches yearly if well distributed. There was no seasonal deficiency of moisture. Winters were much milder than those of Meade County today. They were perhaps not quite as strikingly frost-free as in earlier Sangamon time, but about as warm as those of coastal Virginia. Summers differed both from those of the present and those of the earlier Sangamon primarily in humidity, but also by the slightly lesser extremes of temperature. The climates inferred from the Cragin Quarry and Jinglebob local faunas may not have differed in degree of continentality (summer concentration of thermal efficiency), but the mean annual temperature of the late Sangamon climate was probably slightly lower.

The presence of continental glaciers or of a polar icecap can only be inferred in a general way from these hypothetical climates. At the time of the Butler Spring local fauna there may have been widespread, but generally retreating, continental ice sheets. If the circulation of air masses in the Sangamon was generally like that today, in that there were winter incursions of air from Canada and the Arctic southward over the Plains, the Jinglebob and Cragin Quarry assemblages imply that there were no continental glaciers and no ice on the Arctic Ocean. Aside from the matter of much milder winters, the considerably greater precipitation suggested by the pine pollen and vertebrate fauna from the Jinglebob site can be explained most simply by the postulation that the moisture was derived from an ice-free Arctic Ocean. The Rocky Mountains, which now cast a great rain shadow, were presumably at about their present height in the late Sangamon.

The Illinoian-Sangamon climatic sequence outlined above naturally stimulates speculation concerning earlier glacial–interglacial changes. Here, the evidence is inconclusive but it suggests they were generally similar. Massive caliche layers formed in all three interglacial intervals. The Aftonian post-caliche Sanders local fauna is analogous to the Jinglebob local fauna; the Yarmouth pre-caliche Borchers local fauna to the Cragin Quarry local fauna; and the late Kansan Cudahy fauna to the Butler Spring local fauna.

The present-day relatively continental climate of Meade County is similar to no known ancient climate that is to be inferred from fossils in the area. If a climate like that of today was part of the Illinoian-Sangamon sequence, its most probable position is between the phases represented by the Cragin Quarry and Butler Spring local faunas.

CRAGIN QUARRY LOCAL FAUNA

Previous work.—Orestes St. John (1887, p. 149) recorded the first fossils known to have been collected in Meade County. They were taken on the Big Springs Ranch, but the present whereabouts of these specimens, or the stratigraphic position or exact location where they were found, is unknown. The second collection was made by F. W. Cragin in 1891, and these fossils have been described by Hay (1917; 1924, p. 270). Thanks to a local resident who was present at the time of Cragin's visit, this locality is precisely identifiable (Hibbard, 1939, pp. 463–64; 1955*b*, p. 189) and is described in this paper as Cragin Quarry locality 1. A later, small collection made by Sternberg (Hibbard, 1939, p. 463) has never been located. Additional fossils collected in 1935, 1937 and 1938, were reported by Hibbard (1937; 1939) and H. T. U. Smith (1940, p. 109); these are all from locality 1 (University of Kansas, Meade County locality 6).

A University of Kansas field party quarried at "locality 1" for two weeks in 1945, but no matrix was washed. The study of the Cragin Quarry fauna lapsed for a number of years, until 1953. In the summer of that year the authors collected mollusks and small vertebrates by hand-picking at localities 1 and 3 (see Fig. 3). Intensive sampling of the fauna was carried on by University of Michigan Museum of Paleontology field parties from 1954 to 1956. About 15 tons of matrix from locality 1 have been washed (see Pl. XVI, Fig. 1), but only small samples from localities 2 and 3. Etheridge (1958) described the lizards of the Cragin Quarry local fauna, and his were the first results of the bulk sampling to be published.

The name "Cragin Quarry" was given by Hibbard (1939) to the site of Cragin's early collection, when its location was definitely established. The term "Cragin Quarry fauna," as subsequently used (Hibbard, 1949*a*, p. 83), has consistently referred to the fossils from this particular locality. In this report, however, invertebrate and vertebrate fossils from the same stratigraphic unit but from nearby localities have been included under the "Cragin Quarry local fauna."

FAUNAL LIST[4]

Class Pelecypoda

Order Teleodesmacea

Sphaerium partumeium (Say)

Pisidium casertanum (Poli)

[4] See note 3, p. 8.

Class Gastropoda
- Order Basommatophora
  - *Carychium exiguum* (Say)
  - *Stagnicola exilis* (Lea)
  - *Stagnicola caperata* (Say)
  - *Fossaria dalli* (Baker)
  - *Gyraulus circumstriatus* (Tryon)
  - *Armiger crista* (Linnaeus)
  - *Helisoma trivolvis* (Say)
  - **Promenetus kansasensis* (Baker)
  - *Promenetus umbilicatellus* (Cockerell)
  - *Ferrissia meekiana* (Stimpson)
  - *Physa anatina* Lea
  - *Physa gyrina* Say
- Order Stylommatophora
  - *Gastrocopta armifera* (Say)
  - *Gastrocopta contracta* (Say)
  - *Gastrocopta holzingeri* (Sterki)
  - *Gastrocopta tappaniana* (Adams)
  - *Gastrocopta cristata* (Pilsbry and Ferriss)
  - *Gastrocopta pellucida hordeacella* (Pilsbry)
  - *Pupoides albilabris* (Adams)
  - *Pupilla blandi* Morse
  - *Vertigo ovata* Say
  - *Vertigo milium* (Gould)
  - *Vallonia gracilicosta* (Reinhardt)
  - *Vallonia parvula* Sterki
  - cf. *Succinea*
  - **Deroceras aenigma* Leonard
  - *Helicodiscus parallelus* (Say)
  - *Helicodiscus singleyanus* (Pilsbry)
  - *Euconulus fulvus* (Müller)
  - *Hawaiia minuscula* (Binney)
  - *Nesovitrea electrina* (Gould)
  - *Zonitoides arboreus* (Say)
  - *Stenotrema leai* (Binney)

Class Osteichthyes
  - Cyprinid indet., minnow
  - *Ictalurus* sp., bullhead

Class Amphibia
- Order Caudata
  - *Ambystoma tigrinum* (Green), tiger salamander
- Order Salientia
  - Frogs and toads

Class Reptilia
- Order Chelonia
  - **Terrapene llanensis* (Oelrich), Plains box turtle
  - **Geochelone* sp.
- Order Squamata
  - *Crotaphytus collaris* (Say), Eastern collared lizard

Phrynosoma cornutum (Harlan), Texas horned lizard
Phrynosoma modestum Girard, round-tailed horned lizard
Holbrookia texana (Troschel), greater earless lizard
Cnemidophorus sexlineatus (Linnaeus), six-lined racerunner
Eumeces obsoletus (Baird and Girard), Great Plains skink

Class Mammalia
Order Insectivora
Notiosorex crawfordi (Coues), desert shrew
Order Chiroptera
Lasiurus cinereus (Beauvois), hoary bat
**Dasypterus golliheri* Hibbard, sp. nov., Plains yellow bat
Order Edentata
†*Paramylodon harlani* (Owen), Harlan's ground sloth
Order Rodentia
Cynomys ludovicianus (Ord), blacktail prairie dog
Citellus tridecemlineatus (Mitchill), thirteen-lined ground squirrel
Geomys bursarius (Shaw), eastern pocket gopher
Perognathus hispidus Baird, hispid pocket mouse
Perognathus, pocket mouse
Dipodomys cf. *D. ordii* Woodhouse, kangaroo rat
Onychomys cf. *O. leucogaster* (Wied-Neuwied), grasshopper mouse
Reithrodontomys cf. *R. megalotis* Baird, western harvest mouse
**Peromyscus progressus* Hibbard, sp. nov., Plains deer mouse
**Peromyscus* cf. *P. cochrani* Hibbard, Cochran's white-footed mouse
Neotoma micropus Baird, southern plains woodrat
Pedomys, prairie vole
Order Carnivora
†*Aenocyon dirus* (Leidy), terrible wolf
Canis cf. *C. latrans* Say, coyote
Vulpes velox (Say), kit fox
Spilogale cf. *S. interrupta* (Rafinesque), southern spotted skunk
**Panthera atrox* (Leidy), fierce jaguar
Felis concolor Linnaeus, mountain lion
Order Proboscidea
†*Mammuthus columbi* (Falconer), Columbian mammoth
Order Lagomorpha
Lepus, jackrabbit
Sylvilagus, cottontail rabbit
Order Artiodactyla
†*Platygonus* cf. *P. compressus* Le Conte, Le Conte's peccary
†*Tanupolama,* extinct llama
†*Camelops kansanus* Leidy, Kansas camel
†*Capromeryx furcifer* Matthew, Plains pronghorn
Order Perissodactyla
**Equus conversidens* Owen, Mexican ass
**Equus scotti* Gidley, Scott's horse
**Equus* sp., horse

Rejected records.—Earlier publications give a number of names which we did not include in the faunal list for several reasons. Either the change

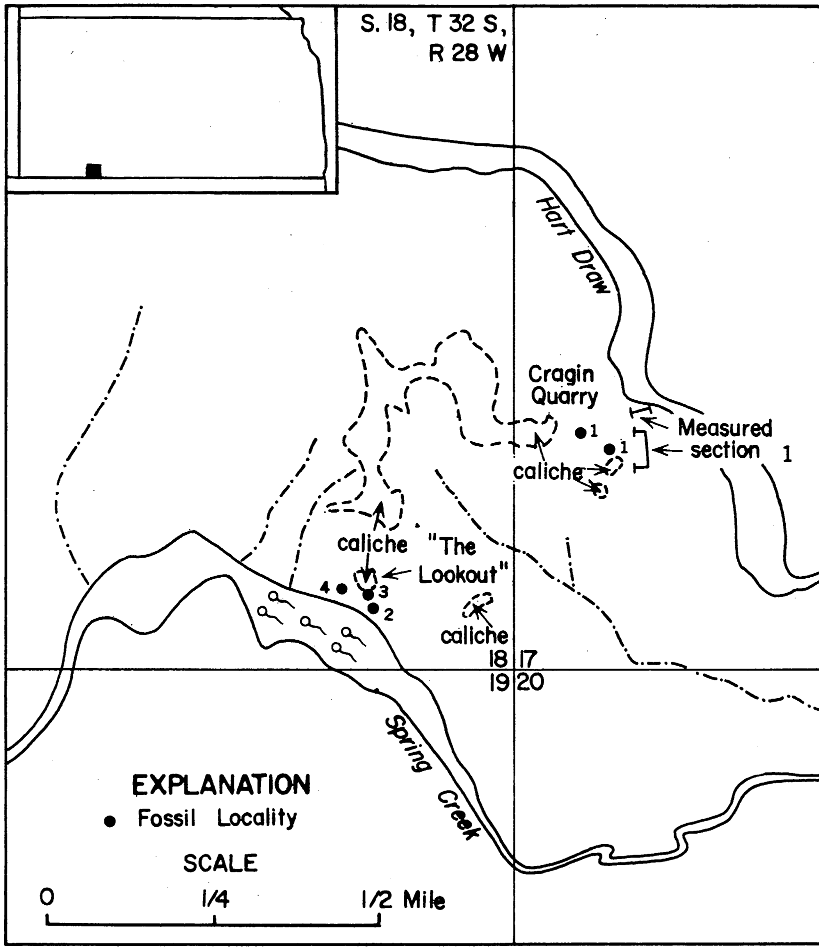

FIG. 3. Index map of Cragin Quarry fossil localities, Meade County, Kansas. Base traced from U. S. Department of Agriculture Production Marketing Administration aerial photograph CDE 104 09. Insert map shows location of Meade County in Kansas.

is purely nomenclatural, specific names once believed valid are now considered synonyms, or previous identifications were erroneous. In the lists of rejected records to follow, the older rejected name is given first and followed by its present disposition; the reasons for each change are noted, under the appropriate species heading, in the section on "Systematic Discussion."

MOLLUSCA: *Helisoma trivolvis lentum* = *Helisoma trivolvis; Gyraulus altissimus* = *Gyraulus circumstriatus; Physa hawnii* = *Physa gyrina; Polygyra monodon* = *Stenotrema leai; Succinea grosvenori* = cf. *Succinea; Gastrocopta armifera similis* = *Gastrocopta armifera.*

MAMMALIA: *Equus francisci* = *Equus conversidens; Equus littoralis* = *Equus conversidens.*

Occurrence.—The Cragin Quarry local fauna is known only from a few sites in the SW¼ sec. 17 and SE¼ sec. 18, T. 32 S., R. 28 W., Meade County, Kansas (see Fig. 3). The fossils are from silt and fine sand deposited by an aggrading tributary of Crooked Creek, and from the fine, very well-sorted and well-rounded white sand ("flour sand") and associated silt and clay that represent the deposits of a former artesian spring.

Local stratigraphy.—The fossiliferous strata yielding the Cragin Quarry local fauna are part of the Kingsdown formation. Frye and Hibbard (1941, p. 418) thought a disconformity was present in the unit at Cragin Quarry locality 1, but careful study by Taylor and Hibbard in 1957 revealed no evidence of this. The exposures are nearly continuous along the south side of Hart Draw, where a section was measured. To the southwest, around "The Lookout" (see Fig. 3), outcrops are scarcer, especially on the lower slopes, but from what is visible at the surface there seems to be no difference in sedimentary sequence between the two areas. An exposure at the base of the bluff indicates that the Kingsdown formation extends within 18± feet of the bed of Spring Creek.

Measured Section 1

Geologic section in NW¼SW¼ sec. 17, T. 32 S., R. 28 W., Meade County, Kansas. Measured from bed of Hart Draw southwestward to top of bluff. The stratigraphic column is about 20 feet greater than the topographic thickness of the essentially flat-lying beds because of erosional unconformity at the base of the Kingsdown formation. D. W. Taylor, July 1957.

Unit	*Description*	*Thickness (feet)*	*Total (feet)*
Kingsdown formation			
9.	Sandstone, very calcareous, massive, moderately well indurated, with numerous small tubular and irregular cavities. Forms caprock. Lower boundary irregular. Interpreted as caliche. ..	1.0	1.0
8.	Sand, fine to very fine, silt, and clay, brown to pale brown, weathering pale brown (10YR 6/3 dry); thinly interbedded toward base, medium to thick bedded toward top; lime streaks and nodules in upper 10′–15′; numerous shells locally. Lower contact sharp.	35.0	36.0
7.	Clay, silt, and very fine sand, light gray, interbedded in thin to medium thick beds, limonite stains in small streaks. Numerous shells. Near base lenses of dark gray clay and medium to coarse sand, poorly sorted, with lenses of small caliche pebbles (probably derived from Crooked Creek formation).	14.0	49.0

Base not exposed, but probably no lower than 1 or 2 feet.

Unit	*Description*	*Thickness (feet)*	*Total (feet)*
	Top of bluff. Top of underlying formation truncated by erosional unconformity at base of Kingsdown formation.		
	Crooked Creek formation, Stump Arroyo member		
6.	Sand, pebbly, well sorted, with clay lenses; pebbles more numerous at base.	7.0	56.0
	Erosional unconformity		
	Ballard formation, Missler member		
5.	Clay, dark gray-brown (10YR 4/2 moist) and brown (10YR 5/3 moist) to light olive gray (5Y 6/2 moist), massive, limey, with streaks and nodules of lime. Lower contact sharp.	3.0	59.0
4.	Sand, medium, brown (7.5YR 5/4 dry), poorly sorted, massive, limey, with scattered lime nodules; limier at base. Lower contact sharp.	3.25	62.25
3.	Clay, silty and sandy, olive to pale olive, limey, with streaks and nodules of lime; very limey at top. Lower contact sharp.	1.0	63.25
2.	Sand, fine to medium, reddish yellow, well sorted, subrounded. Lower contact sharp.	1.5	64.75
1.	Silt and very fine sand, brown (7.5YR 5.5/4 dry), interbedded, massive, limey, with streaks and nodules of lime, limier toward top.	9.25	74.0
	Bed of Hart Draw. Base not exposed.		

Cragin Quarry local fauna locality 1 (see Pl. XVI, Fig. 1) lies about 10 feet below the caliche, 100′–200′ west of Measured Section 1, in light-gray and light-brown clay and silt, with (at Cragin Quarry proper) veins and pockets of flour sand. The texture, fineness, and veinlike occurrence of the sand, and the type of preservation of the fossils and their mechanical sorting indicate that they were deposited in a former artesian spring. The local gray rather than uniformly pale-brown color of the beds has probably been caused by reducing conditions associated with the permanently high water table in the immediate vicinity of the spring. No such evidence of a spring was at "The Lookout," localities 2, 3, and 4.

To facilitate collection of fossils at locality 1 and study of their stratigraphic position, J. T. Sanders generously bulldozed a long exposure between the two quarries at locality 1. In this exposure and in the two quarries themselves the stratigraphic details are readily observable. The veins and tubules of flour sand at Cragin Quarry proper occur only in the upper 10 feet of the bluff; the sediments visible immediately below this level are light-gray and light-brown clay and silt like those in the southeastern quarry.

At locality 1, "The Lookout," and at several intermediate places caliche occurs as rubble, a thin, much-weathered limey sandstone, or rarely as a well-exposed, well-indurated thick layer of limey sandstone and sandy limestone (see map, Fig. 3). The thickest, best-preserved exposure is at the south edge of "The Lookout," where the caliche caps a high bluff of Kingsdown formation (see Pl. XVI, Fig. 2). H. E. Malde and G. R. Scott, U. S. Geological Survey, Denver, examined this outcrop in company with the authors and concluded that it does represent a caliche. Hibbard (1955*b*, p. 190) regarded this layer as local lime-enrichment derived from the older caliches of the Ballard and Crooked Creek formations. No such local source was available for the similar bed in the Butler Spring area, however, and, hence, an independent pedogenic origin is probable there.

Localities (see Fig. 3).—Locality 1 (Kansas University locality 6 and USGS Cenozoic locality 21274): SW¼ sec. 17, T. 32 S., R. 28 W., Meade County, Kansas (see Pl. XVI, Fig. 1). Fossils are from two nearby quarries just below the top of the bluff on the south side of a tributary to Spring Creek, 450′ E., 1800′ N. and 700′ E., 1650′ N. of the southwest section corner. The northwestern site is Cragin Quarry proper; the southeastern quarry has been worked by University of Michigan parties from 1954 to 1956. Vertebrates were collected on the surface and by quarrying at Cragin Quarry proper. This is the site of a former artesian spring and yielded almost exclusively large bones. The southeastern quarry is in light-gray and light-brown clay and silt, which contains numerous fossils. Two hundred and seventy sacks (about 15 tons) of matrix from it were washed. The vertebrates included in this study are from University of Kansas and University of Michigan collections (1935, 1937, 1945, 1953–1956). Less than 5 per cent of the washed matrix has been sorted for mollusks. The shells submitted to F. C. Baker (H. T. U. Smith, 1940, p. 109) were not available for study, but the species reported have been duplicated.

Locality 2 (USGS Cenozoic locality 21277): SE¼ sec. 18, T. 32 S., R. 28 W., Meade County, Kansas, 1100′ W., 500′ N. of southeast section corner. Southeast slope of "The Lookout," about 25′ below the caliche. Fifteen sacks of matrix were washed in 1954; less than 5 per cent of the concentrate has been sorted.

Locality 3 (USGS Cenozoic locality 21276): SE¼ sec. 18, T. 32 S., R. 28 W., Meade County, Kansas, 1150′ W., 600′ N. of southeast section corner. Fossils are from light red-brown silt immediately beneath the caliche on the south side of "The Lookout." A surface collection was made in 1953 and three sacks were collected in 1954. All of them have been sorted.

Locality 4 (USGS Cenozoic locality 21275): SE¼ sec. 18, T. 32 S., R. 28 W., Meade County, Kansas, 1350′ W., 650′ N. of southeast section corner. Fossils are from north side of Spring Creek Valley, about 10′ below caliche. Collecting (1954) was done by surface picking only. The only vertebrate from this locality is represented by a single specimen of *Phrynosoma cornutum*. This lizard was recorded by Etheridge (1958), who inadvertently omitted the locality information in his publication.

Age and correlation.—On the basis of inferences drawn from the environment (see below), the Cragin Quarry local fauna is of interglacial age. Numerous species of southern and southwestern distribution and the absence of markedly northern forms give the assemblage an aspect quite unlike that of Butler Spring fauna and others of glacial age. Independent stratigraphic as well as paleontologic evidence establish this interglacial age to be Sangamon. The Kingsdown formation, from which the fossils come, is an alluvial deposit filling a valley cut through the Crooked Creek formation into the underlying Ballard. Stratigraphically below the Cragin Quarry local fauna, in the basal part of the Kingsdown, undescribed fossils of Illinoian age have been collected.

The mammals of the Cragin Quarry local fauna indicate a late Pleistocene age, but restricted to Sangamon by their interglacial implications. The rodents in particular are significant, for they are mainly referable to living species; even the few extinct forms are closely related to the Recent ones. The low percentage of extinct species in this fauna is in contrast to that in the Yarmouth Borchers local fauna, in which all of the rodents belong to species that failed to survive.

The relative ages of the Cragin Quarry and Jinglebob faunas, both Sangamon, are now reasonably certain on the basis of new stratigraphic and paleontologic evidence. The Cragin Quarry local fauna is the older; evidence corroborating this, partly new discoveries and partly from new interpretations of already known facts, is as follows:

1. In the valley of Spring Creek, on the Big Springs Ranch, undescribed fossils of glacial age occur in the base of the Kingsdown formation, stratigraphically below the Cragin Quarry local fauna with no indication of an intervening gap in sedimentation. There is no paleontologic record from this interval of a humid mesothermal climate such as that implied by the Jinglebob local fauna.

2. In the Butler Spring area sediments stratigraphically above the horizon of the Butler Spring local fauna include fossils of mild climate, interglacial type of the nature of the Cragin Quarry local fauna. Above these fossils is a buried and deformed caliche layer and, still higher, are faunal forms that suggest a mesothermal and relatively humid climate like that under which the Jinglebob local fauna lived.

3. Occurrence of an old caliche layer unrelated to present topography or drainage and in similar stratigraphic position, as determined by fossils, in both the Butler Spring and Cragin Quarry regions (see Measured Sections 1, 3, 4) suggests that this caliche represents the same interval. Earlier, Hibbard (1955*b*, p. 190) noted the similarities of this bed in the two areas but did not consider it caliche.

Known fossil faunas correlative with the Cragin Quarry local fauna are few. In part, this is certainly due to lack of study, but in part it no doubt reflects a real scarcity of interglacial fossils compared to the number from glacial deposits. At most places in the Great Plains interglacial deposits are thin or nonexistent; and even where thin ones were laid down, later weathering has often removed whatever fossils were present. The two assemblages from the Great Plains that are probably correlative with the Cragin Quarry local fauna are the Slaton local fauna, Lubbock County, Texas (Herrington and Taylor, 1958; Meade, 1942, 1952), and a small group of mollusks from the Kassler quadrangle near Denver, Colorado (G. R. Scott, ms., in preparation). The Slaton local fauna includes a few described mammals and many mollusks, mostly undescribed. Although the mollusks suggest an age and environment similar to that of the Cragin Quarry local fauna, because of their location so much farther south they may be slightly older, perhaps latest Illinoian. The assemblage from the Kassler quadrangle is from the Slocum alluvium of Scott (in ms.), which overlies the youngest pediment in the Kassler area and has a soil developed on it that is apparently the same as that of Sangamon soil in Nebraska.

Environment.—Inferences about the conditions under which the Cragin Quarry local fauna lived can be drawn from (1) the physical features of the fossil-bearing deposit, (2) the nature of the fossils, and (3) the present-day habitat of the species represented or their close, living relatives. From this inferred local habitat and from the distribution pattern of the living species one is led to broader generalizations about climate.

Local habitat: The sediments which yielded the Cragin Quarry local fauna are part of the Kingsdown formation and fill a valley, trending generally eastward toward Crooked Creek, in which the stream exposed both the Crooked Creek formation and part of the underlying Ballard. On the southwest side of Hart Draw (see Measured Section 1) the base of the Kingsdown formation rises toward the north or northeast. Half a mile to the southwest, on the northeast side of Spring Creek, all sediments exposed from the top of the bluff at "The Lookout" to near the bed of the stream are also Kingsdown. Here the base of the formation probably descends toward the southwest, because although topographic control is lacking, Hart Draw and Spring Creek join less than a mile below these exposures and there is no obvious difference in their gradients. On the south side of Spring Creek Valley opposite "The Lookout" no Kingsdown formation has been found, nor anywhere on the south side of this valley. Near the Cragin Quarry fossil localities the ancient valley was almost as deep as the present one of Spring Creek and, although it may have been wider, was probably not much wider than the modern valley.

Known exposures of the Kingsdown formation along the north side of Spring Creek upstream from the Cragin Quarry fossil localities and the southward dip of the Crooked Creek and Ballard formations in that area indicate that the former stream valley did not uncover the Angell member of the Ballard formation. Only one aquifer, the Stump Arroyo member of the Crooked Creek formation, could have supplied water to this valley from outcrops, and the fine-grained texture of the Kingsdown suggests that this source produced only little water. The body of the formation, from which the fossils come, consists of very fine sand, silt, and clay, with no coarse sand or gravel. Such texture is significant, because it implies that even though coarse clastics (the Stump Arroyo gravel) were exposed nearby along the valley walls, these larger particles were not transported in appreciable amounts; hence, the stream had low carrying power. Some vegetation probably covered the outcropping gravel, for rainwash on barren exposures of this material would, otherwise, have carried it downslope and added it to the valley-filling sediments. Significantly, too, the larger mammal bones were not concentrated by stream action.

Presence of a former artesian spring at Cragin Quarry locality 1 is clear from the physical evidence. Tubes and pockets of flour sand cut through silt and clay to form an irregular dendritic pattern, and imply a spring like those nearby which give the Big Springs Ranch its name. The old spring may have been almost the only local source of perennial water and, directly or indirectly, it must have provided habitats for numerous animals and attracted many of the larger forms seeking water or food. Moreover, trapping of larger mammals in the quicksand of the spring boils has probably augmented the record of the local biota.

The fossils from Cragin Quarry locality 1 suggest that the old artesian spring formed a restricted oasis in a semiarid region. The kinds of vertebrates imply two distinct habitats: aquatic (in the immediate vicinity of the spring) and semiarid upland. Mammals of aquatic habit or those of marsh and bog are strikingly absent: there are no beavers, muskrats, water rats, rice rats, or cotton rats. The single shrew is the desert shrew, *Notiosorex,* and voles are represented only by a single tooth of *Pedomys.* Lack of all these animals cannot be explained simply by sampling error; a whole group of habitats is unaccounted for.

The life about the former spring is recorded by existence of mollusks, fishes, salamanders, frogs, toads, and snakes. Even though the spring implies perennial water, the limited variety of aquatic mollusks, absence of prosobranch snails, and presence of only small fish indicates that the perennial water was shallow and limited in area (see Table III). Abundance of certain land snails indicates for those mollusks that require the shelter of humus and downed logs a growth of trees and shrubs around the spring and its outflow. The large tree bats, *Dasypterus* and *Lasiurus,* further support such an implication, as do the harvest mouse, *Reithrodontomys* cf. *R. megalotis,* and deermouse, *Peromyscus progressus,* if that species is related to the *leucopus* group as Hibbard considers. The lizards and most of the other small mammals bespeak a drier, upland habitat, but their occurrence can be readily explained as due to the hawks and owls which preyed upon them and dropped their remains in pellets from nests or perches in trees around the site of deposition.

Mammals of lowland or marshy habitats, as *Cryptotis, Sigmodon, Ondatra,* and *Pedomys,* are rare or absent in the Cragin Quarry local fauna. This suggests that the local habitat was an upland, moderately dry tributary valley. The ancient artesian spring was, perhaps, the farthest occurrence of permanent water and trees from the Crooked Creek Valley on the east toward the semiarid Plains on the west. Part of the reason for the lack of lowland animals was a lesser topographic relief in Sangamon time. Cragin Quarry locality 1 is about 45 feet above the bed of Hart Draw; hence the old valley, about as wide as that of Spring Creek, was shallower and did not offer a canyon-type shelter for such animal life.

A few large herbivores are characteristic of more heavily vegetated areas than the rest of the Cragin Quarry local fauna. Of these, the large ground sloth, mammoth, and *Equus scotti* are of rare occurrence, and their association with a generally different ecologic group of animals suggests that they browsed into the small valley along a narrow belt of scattered trees, shrubs, and tall grasses upstream from the larger regional water courses, Crooked Creek and the Cimarron River. *Camelops* probably ranged along the drier parts of tributary valleys in the Meade County area and on the upland. The other herbivores indicate an upland habitat.

The ecological implications of the fossil lizards are discussed by Etheridge (1958, p. 99). He postulated "that the Cragin Quarry local habitat was one of extensive areas of bare, rocky ground with occasional rocky outcrops, perhaps small, scattered patches of sand, and vegetation consisting of scattered clumps of short grass and low xerophilous shrubs." The fence lizard, *Sceloporus undulatus,* is now common in the vicinity of Cragin Quarry locality 1. But, as Etheridge remarked, "since it is the only arboreal lizard expected but not found in the fauna, the absence of trees or bushes is implied."

The generally xeric character of the lizard fauna is in agreement with the dominantly upland nature of the mammals. Like the small mammals, the lizards no doubt served as food for hawks and owls which dropped the bones in pellets from nests or perches in trees around the artesian spring. So much positive evidence argues for trees in the vicinity, that lack of the fence lizard cannot be explained by postulating a lack of its arboreal habitat. Its absence from the Cragin Quarry local fauna may partly be due to competition by *Holbrookia texana,* but the fact that its natural habitat makes it a less ready target for the predatory birds which concentrated the lizard remains, is a more likely explanation.

TABLE III

Habitat Indications of Mollusks of Cragin Quarry Local Fauna

The uncertainly identified Succineidae have been omitted from a specific habitat, but the total number of specimens from which the percentage abundance of each species has been calculated includes them.

Habitat	Species	Percentage of Specimens at Each Locality			
		25 feet below caliche	10 feet below caliche		0–2 feet below caliche
		2	1	4	3
Shallow, quiet water bodies, fluctuating seasonally: pools or marginal situations with slight current at the edge of a stream.	*Sphaerium partumeium*	. .	0.1	. .	. .
	Pisidium casertanum	. .	2.2	0.9	<0.1
	Stagnicola caperata	0.8	1.8	1.9	0.4
	Stagnicola exilis	. .	2.2	. .	. .
	Gyraulus circumstriatus	0.5	7.2	0.9	0.8
	Armiger crista	. .	. .	. .	<0.1
	Helisoma trivolvis	. .	<0.1	. .	. .
	Promenetus kansasensis	. .	11.5	. .	0.1
	Promenetus umbilicatellus	. .	7.2	. .	. .
	Ferrissia meekiana	. .	<0.1	. .	. .
	Physa anatina	0.1	0.5	. .	<0.1
	Physa gyrina	. .	0.2	. .	. .
Marginal situation: wet mud; debris edge of water; shallow pools, protected spots.	*Fossaria dalli*	0.2	0.4	. .	. .
Moist leaf mold and plant debris: under logs and bark, or among leaves, moss, or grass in moist situations not far from water.	*Carychium exiguum*	26.5	16.2	. .	<0.1
	Gastrocopta tappaniana	16.6	10.0	3.7	1.0
	Vertigo milium	<0.1	<0.1	. .	<0.1
	Vertigo ovata	0.4	1.8	2.8	<0.1
	Deroceras aenigma	0.3	11.5	0.9	0.1
Wooded area: in leaf litter or under logs and bark in wooded spots.	*Euconulus fulvus*	0.4	0.7	. .	<0.1
	Nesovitrea electrina	<0.1	0.1	. .	<0.1
	Zonitoides arboreus	0.1	0.1	0.9	<0.1
	Stenotrema leai	1.8	2.1	27.0	<0.1
Protected situations among vegetation: grass, shrubs, or wooded area.	*Gastrocopta armifera*	3.3	<0.1	21.5	0.9
	Gastrocopta contracta	2.1	0.8	0.9	<0.1
	Gastrocopta holzingeri	8.3	0.3	. .	1.5
Damp to dry habitat: damp, protected places or relatively dry, exposed habitats. These species are more tolerant of drouth than others, and require little cover.	*Gastrocopta cristata*	8.3	0.3	3.7	21.1
	Gastrocopta pellucida hordeacella	<0.1	<0.1	. .	12.7
	Pupoides albilabris	<0.1	<0.1	1.9	3.4
	Pupilla blandi	. .	. .	. .	0.2
	Vallonia gracilicosta	. .	<0.1	. .	12.7
	Vallonia parvula	12.4	4.3	2.8	3.8
	Helicodiscus parallelus	<0.1	<0.1	1.9	12.7
	Helicodiscus singleyanus	. .	<0.1	0.9	19.1
	Hawaiia minuscula	16.6	17.4	23.4	8.5

Spring Creek Valley is generally similar, except for its greater depth, to the Sangamon tributary valley. In particular, the bedrock units, the Ballard and Crooked Creek formations, are common to both the present and former. These two formations must have supplied the local habitats approaching "rocky ground" or "occasional rocky outcrops" that are inferred by Etheridge (1958). Probably, the Stump Arroyo gravel and the caliche in the Crooked Creek formation outcropped in bare patches of rubble, sand, and gravel. Such conditions go far to account for the habitats of the upland Cragin Quarry lizards, habitats that were suitable even if not optimum.

Climate: In any fossil fauna the most interesting and significant species are those no longer living locally. If they, or their close relatives, are still living elsewhere, it suggests a changed environment. Sometimes the species associated as fossils remain associated in life and, if so, the ancient fauna can be explained by a comparatively simple environmental shift. But for the Cragin Quarry local fauna, and also for some others not included in this paper, the situation is more complex. Its fossils record the former joint occurrence of numerous species still living but with distribution patterns separated by hundreds of miles. The most conservative and reasonable interpretation of this phenomenon is to consider these now allochthonous forms marginal in the Cragin Quarry local fauna; that is, the fossils are assumed to show the peripheral occurrence of such southern and southwestern forms as *Geochelone, Holbrookia,* and *Dasypterus* and such northern and eastern species as *Stagnicola caperata, Armiger crista,* and *Stenotrema leai.*

**Geochelone, *Terrapene llanensis, Phrynosoma modestum, Holbrookia texana, *Dasypterus golliheri*[5], and *Notiosorex crawfordi* constitute a conspicuous southern element in the Cragin Quarry local fauna. Presence of these forms, especially of the cold-blooded reptiles, points to former winter extremes much milder than those experienced in southwestern Kansas today. *Geochelone* is now strictly subtropical to tropical in its distribution. Smaller, Temperate Zone land turtles of the related genus *Testudo* are all circum-Mediterranean and hibernate after crawling into holes, but this habit is not known in *Geochelone*. The evidence from this genus indicates a radical reduction of winter extremes. If temperatures ever dropped as low as freezing in Sangamon time, when this turtle lived in Meade County, they must not have remained so long. This is in obvious contrast to Meade County today, where there are annually about 20 days with temperature *continuously* below freezing, and annually about 115 nights with frost (Visher, 1954, Maps 294, 298).

Several mollusks in the fauna have a northern or eastern distribution which does not now extend as far as Meade County, much less to the

[5] See note 3, p. 8.

ranges of the southwestern and southern vertebrates. They are *Stagnicola caperata, S. exilis, Gyraulus circumstriatus, Armiger crista, Promenetus umbilicatellus, Physa gyrina,* and *Stenotrema leai. Pupilla blandi* and *Vallonia gracilicosta* probably represent a southern Rocky Mountain element.

What the significance of these northeastern snails in the Cragin Quarry local fauna is, is uncertain because of the complex relationship between the former regional climate and the microclimate of the local habitat.

The northeastern group of mollusks is composed almost entirely of aquatic species; *Stenotrema* is the only land snail. Occurrence of these species might have been made possible by the ameliorating effect of the spring water on their habitat. If an artesian spring can have such important ecologic value, then the fact that there is only one relict population of freshwater snails (*Promenetus exacuous*) now in Meade County is strange. Possibly, alluviation and erosion in the Wisconsin was sufficiently severe to eliminate species which might otherwise have persisted locally. The former occurrence in Meade County of *Pupilla blandi, Vallonia gracilicosta,* and the various northern and eastern species mentioned above can probably be explained by a slight reduction of summer extremes of heat and by the local effects of the artesian spring. Rainfall may have been no different in annual mean total, but perhaps was better distributed and more effective.

The percentage differences in the mollusks from the four Cragin Quarry localities, on the basis of local habitat changes, are given in Table IV. The only evidence for a possible climatic change lies in the marked dominance of snails tolerant of a relatively dry habitat at locality 3, as

TABLE IV

RELATIVE SIGNIFICANCE OF HABITATS (INFERRED FROM MOLLUSKS) AT LOCALITIES OF CRAGIN QUARRY LOCAL FAUNA

Species are grouped as in Table III, except that all aquatic species are considered as a unit here.

Habitat	Percentage at Each Locality			
	25 feet below caliche	10 feet below caliche		0–2 feet below caliche
	2	1	4	3
All aquatic habitats	1.5	33.2	3.7	1.4
Moist leaf mold	43.1	39.6	7.5	1.1
Wooded area	2.4	0.3	28.0	0.1
Protected situations	13.7	0.1	22.4	2.5
Damp to dry habitats	37.4	22.0	34.6	94.5

opposed to their lesser abundance at the stratigraphically lower localities. All species of the fauna occur at locality 1 except *Pupilla blandi,* which is rare at locality 3.

Summary.—The Cragin Quarry local fauna lived in and near a former valley tributary to Crooked Creek. This valley was about as wide as the present valley of Spring Creek, but shallower. Two markedly different environments met here. The uplands were semiarid. An artesian spring, and perhaps groundwater seepage from outcropping gravel, formed an oasis, where perennial water, trees and shrubs provided suitable habitats for many animals which could not live on the dry uplands. The small size of the stream, however, and the narrowness of the riparian belt of vegetation barred many typically lowland mammals from the area. The former climate differed radically from that of the present by being much less continental: winter temperatures may never have reached freezing and summers were slightly less hot than those of today. Mean annual rainfall may have been the same.

BUTLER SPRING LOCAL FAUNA

Previous work.—The local stratigraphy in the Butler Spring area has been recognized as complex for some time. Fossils had been recorded previously from a number of scattered localities (Hibbard, 1949*a*), but only a few of them are referable to the stratigraphically restricted Butler Spring local fauna. These include a turtle (E. H. Taylor, 1943), a salamander (Tihen, 1955, p. 240), a vole (Hibbard, 1943, p. 190) and other mammals (Hibbard, 1949*a,* p. 83), clams (Herrington and Taylor, 1958), and fishes (C. L. Smith, 1958). Mollusks reported by Franzen and Leonard (1947) are from an uncertain horizon, but they may represent the Butler Spring local fauna. The vertebrate fossils have been collected at various times since the early 1940's, but the numerous mollusks are principally the result of bulk collections made in 1953 and 1957.

FAUNAL LIST[6]

Class Pelecypoda
- Order Prionodesmacea
  - *Anodonta grandis* Say?
  - *Quadrula quadrula* (Rafinesque)
- Order Teleodesmacea
  - *Sphaerium striatinum* (Lamarck)
  - *Sphaerium transversum* Say
  - *Sphaerium* indet.
  - *Pisidium casertanum* (Poli)
  - *Pisidium compressum* Prime
  - *Pisidium nitidum* Jenyns
  - *Pisidium walkeri* Sterki?

[6] See note 3, p. 8.

Class Gastropoda

Order Mesogastropoda

Valvata tricarinata (Say)
Probythinella lacustris (Baker)

Order Basommatophora

Carychium exiguum (Say)
Stagnicola reflexa (Say)
Stagnicola caperata (Say)
Fossaria obrussa (Say)
Fossaria dalli (Baker)
Lymnaea stagnalis jugularis Say
**Anisus pattersoni* (Baker)
Gyraulus circumstriatus (Tryon)
Gyraulus parvus (Say)
Helisoma anceps (Menke)
Helisoma trivolvis (Say)
**Promenetus kansasensis* (Baker)
Promenetus umbilicatellus (Cockerell)
Ferrissia meekiana (Stimpson)
Laevapex kirklandi (Walker)
Physa anatina Lea
Physa gyrina Say
Physa skinneri Taylor
Aplexa hypnorum (Linnaeus)

Order Stylommatophora

Gastrocopta armifera (Say)
Gastrocopta contracta (Say)
Gastrocopta holzingeri (Sterki)
Gastrocopta tappaniana (Adams)
Gastrocopta cristata (Pilsbry and Vanatta)
Gastrocopta procera (Gould)
Pupoides albilabris (Adams)
Pupoides inornatus Vanatta
Pupilla muscorum (Linnaeus)
Pupilla blandi Morse
Pupilla sinistra Franzen
Vertigo ovata Say
Vertigo milium (Gould)
Vertigo gouldi (Binney)
Vallonia cyclophorella Sterki
Vallonia gracilicosta Reinhardt
Vallonia parvula Sterki
cf. *Succinea*
Oxyloma retusa (Lea)
Discus cronkhitei (Newcomb)
Helicodiscus singleyanus (Pilsbry)
Hawaiia minuscula (Binney)
Zonitoides arboreus (Say)
Stenotrema leai (Binney)

Class Osteichthyes
- *Lepisosteus,* gar
- *Catostomus commersoni* (Lacépède), white sucker
- *Ictalurus melas* (Rafinesque), black bullhead
- *Ictalurus* cf. *I. punctatus* (Rafinesque), channel catfish
- *Perca flavescens* (Mitchill), yellow perch

Class Amphibia
- Order Caudata
  - *Ambystoma tigrinum* (Green), tiger salamander

Class Reptilia
- Order Chelonia
  - *Chelydra serpentina* (Linnaeus), snapping turtle
  - **Emydoidea twentei* (Taylor), Plains semibox turtle

Class Mammalia
- Order Edentata
  - †*Megalonyx,* ground sloth
- Order Rodentia
  - *Citellus,* ground squirrel
  - cf. *Geomys,* eastern pocket gopher
  - †*Castoroides ohioensis* Foster, Ohio giant beaver
  - *Microtus pennsylvanicus* (Ord), meadow vole
- Order Carnivora
  - *Canis latrans* Say, coyote
- Order Proboscidea
  - †*Mammuthus,* mammoth
- Order Artiodactyla
  - †*Camelops,* camel
- Order Perissodactyla
  - **Equus scotti* Gidley, Scott's horse
  - **Equus* sp., horse

Occurrence.—The Butler Spring local fauna is known only from a few sites in the E½ sec. 32 and W½ sec. 33, T. 34 S., R. 29 W., Meade County, Kansas (see Fig. 4). The fossils are from coarse limonitic sand, conspicuously cross-bedded, which may have been deposited by the ancestral Cimarron River or Crooked Creek.

Local stratigraphy.—The fossiliferous strata which yielded the Butler Spring local fauna are now referred to the undifferentiated Sanborn group, which is primarily defined by topographic position and age and only secondarily by rock type. The following reasons for including them in the Sanborn group are, therefore, largely inferences drawn from the fossils and topographic situation. They are: (1) The deposits in the Butler Spring area are well below the regional High Plains surface but clearly do not represent the known Pliocene or early Pleistocene units. Instead, nearly all of them were laid down in a sinkhole, as revealed by the lenticular nature of some gypsiferous silt and clay beds, the lack of cross bedding, the fine grain size, and thin to medium interbedded relationship of many silt, clay, and fine sand beds. (2) The contrast in composition between the Butler Spring local fauna and that of assemblages from underlying sediments shows that this series of deposits is younger than the Crooked Creek formation. This is in agreement with observations elsewhere that the sinkhole deposits of the Meade County area are younger than that unit.

The Butler Spring area (Fig. 4) includes a series of sinkhole deposits with discordant dips, lenticular beds, and unconformities which record

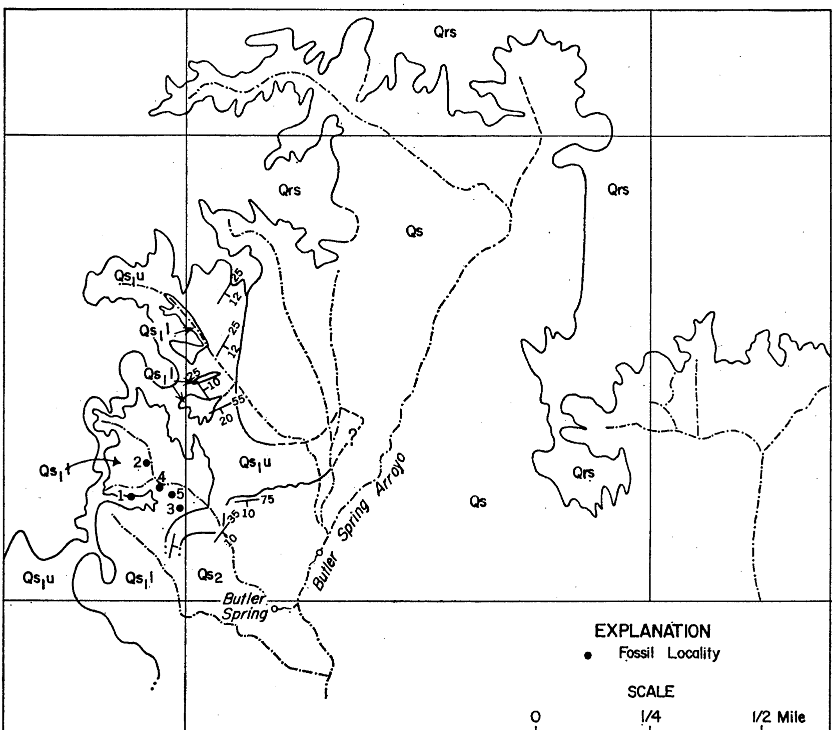

FIG. 4. Index map of Butler Spring fossil localities, Meade County, Kansas. Base traced from U. S. Department of Agriculture Production Marketing Administration aerial photograph CDE 45 143; central square represents sec. 32, T. 34 S., R. 29 W. Geology by D. W. Taylor; plotted on the photograph in the field. For location of Meade County in Kansas, see Figure 3. Qs_1 lower unit of Sanborn group (divided into lower member (Qs_1l) and upper member (Qs_1u), Qs_2 middle unit of Sanborn group. Qs undifferentiated middle and upper units of Sanborn group. Qrs Recent soil or surficial material.

two major periods of basin filling. Because detailed study is incomplete with regard to the younger units, the buried soils, and so on, just information specifically pertinent to the Butler Spring local fauna can be given.

The outcrop of the oldest (Qs_1) of the three divisions in the Sanborn group, as developed in this very local area, is mapped in Figure 4. This oldest division is flat-lying at the edge of the drainage basin of Butler Spring Arroyo, is concealed to the south, and dips beneath younger beds to the east and southeast. Two members of it are distinguishable on the basis of lithology and inferred origin: (1) a lower, coarse-grained, limonitic, cross-bedded sand (Qs_1l) and (2) an upper series (Qs_1u) of reddish brown clay, silt, and sand which is transitional to the lower, coarse sand by the intertonguing of individual beds rather than graduation in grain size. For example, a tongue of clay from the upper member may separate a tongue of sand from the lower, but both are relatively well-sorted and pinch out, rather than grade laterally into one another. The lithology and relationship of individual beds are given in Measured Sections 2, 3, and 4.

H. T. U. Smith (1940, p. 102) described the Butler Spring area, which he called "locality B," briefly. Smith's "75 to 100 feet of sand" is identifiable with the "basal sand" (Qs_1l) of this paper, but he overestimated the thickness. The name "Butler Spring local fauna" (Herrington and Taylor, 1958, p. 4) is used to designate only the assemblage from the basal sand (Qs_1l) in the Butler Spring area. Fossils from even slightly higher in the section were laid down under different conditions of deposition which may or may not have been of significantly lesser age.

Measured Section 2

Geologic section in SE¼SE¼ sec. 32, T. 34 S., R. 29 W., Meade County, Kansas. Measured on south side of east-trending draw. D. W. Taylor, August 1957.

Unit	*Description*	*Thickness (feet)*	*Total (feet)*
	Sanborn group. Oldest Unit, upper member, Qs_1u.		
	Top eroded away.		
3.	Clay, light reddish brown (5YR 5.5/4 dry) below grading to reddish brown (2.5YR 5/4 dry) above, massive. Lower contact gradational.	3	3
2.	Clay, silt, and sand in interbedded lenses from a few inches to over one foot thick. Specific lithologies follow: Sand, fine, well sorted, subrounded to subangular. Sand, coarse, limonitic, moderately well-sorted, subangular to subrounded, with subrounded to well rounded pebbles up to 3″ in maximum diameter. Silty sand, fine to medium, brown (7.5YR 5/4 dry), massive. Clay, reddish brown (2.5YR 4/4 moist). Lower contact irregular.	10	13
	Lower member, Qs_1l.		
1.	Sand, medium to coarse, cross-bedded, limonitic, with lenses of clay, grit, and indurated sandstone. Fossil shells and bone (Butler Spring locality 1) common, mostly at top. Specific lithologies follow: Sand, fine to medium, cross-bedded, white, well sorted, subrounded. Coarse sand and grit, cross-bedded, black-stained, moderately well sorted, subangular to subrounded.		

Unit	*Description*	*Thickness (feet)*	*Total (feet)*
	Sand, medium, limonitic, cross-bedded, moderately well sorted, subrounded to subangular, with scattered small subrounded pebbles. Sand, clayey, light-gray, moderately well sorted except for clay, medium to coarse grained, with abundant shells; the fine sand and silt fractions are scarcer than the coarser and finer ones.	18	31
	Bed of draw; base not exposed.		

Measured Section 3

Geologic section in NW¼SW¼ sec. 33, T. 34 S., R. 29 W., Meade County, Kansas, Measured on southeast side of northeast-trending draw. D. W. Taylor, August 1957.

Unit	*Description*	*Thickness (feet)*	*Total (feet)*
	Sanborn group.		
	Oldest Unit, upper member, Qs_1u.		
4.	Sandstone, fine to medium, limey, moderately well indurated, moderately well sorted, subangular to subrounded. Forms ledge locally at top of bluff where not eroded away. Lower contact gradational. Interpreted as caliche.	1	1
3.	Sand, silty and clayey, fine to medium, reddish brown (5YR 5.5/4 dry), compact, massive, with coarse columnar jointing. Lime streaked, especially at base. Very limey with abundant caliche nodules and less silt and clay toward top. Lower contact gradational.	15	16
2.	Clay, silt, and sand in interbedded lenses from streaks to 2′ thick. Clay reddish brown (5YR 3.5/3 moist). Silt light-brown (7.5YR 6/4 dry). Sand fine to medium, cross-bedded, moderately well sorted, subangular to subrounded, with scattered small pebbles and clay pellets. Lower contact irregular.	4	20
	Lower member, Qs_1l.		
1.	Sand, medium to coarse, cross-bedded, with lenses of clay and grit, limonite streaked. Scattered fossils, mostly bones (Butler Spring local fauna). Specific lithologies follow: Sand, fine to medium, white, cross-bedded, very well sorted, well rounded. Sand, medium to coarse, limonitic, cross-bedded, moderately well sorted, subrounded, with many thin lenses of grit and clay pellets. Sandy gravel, poorly sorted, with lithic pebbles up to 3″ maximum diameter and many reddish-brown clay balls.	16	36
	Bed of draw; base not exposed.		

Measured Section 4

Geologic section in SW¼SW¼ sec. 33, T. 34 S., R. 29 W., Meade County, Kansas. Measured along southeast-trending draw. D. W. Taylor, August 1957.

Unit	*Description*	*Thickness (feet)*	*Total (feet)*
	Sanborn group. Middle unit, Qs_2.		
	Top not exposed.		
9.	Sand and clay, interbedded in lenses up to 1′ thick. Sand fine to medium, moderately well sorted, subangular to subrounded, limonite streaked. Lower contact fairly sharp	30	30
8.	Marl, argillaceous, yellowish brown (10YR 5/4 dry) to marl, white (10YR 8/2 dry), with very abundant ostracod and snail shells. Lower contact sharp	1	31
7.	Clay, gray (10YR 6/1 dry) to light gray (7.5YR 7.5/0 dry) with dark limonitic streaks. Nodules and fissure fillings of gypsum crystals and limonite common. Scattered bone fragments. Lower contact sharp	26	57
6.	Marl, light gray (10YR 7.5/1 dry), limonite streaked, firm to slightly indurated, with scattered calcite crystals and silt and sand grains. Probably partly the lateral equivalent of unit 5, which nowhere underlies unit 6. Lower contact on unit 4 sharp	12	69
	Oldest unit, Qs_1; upper member, Qs_1u.		
5.	Sandstone, moderately well indurated, fine to medium, limey, moderately well sorted. Exposed on higher slopes where it probably has weathered for some time, it contains many small cavities and weathers in an irregular nodular pattern. Interpreted as caliche	1	70
4.	Silt to fine sand, light brown (7.5YR 6/4 dry) to light gray (5Y 7/2 dry), massive, in intergrading medium beds locally persistent, streaked with lime and limonite. Gypsum rosettes common; shells common at base but scarce higher up. Lower contact fairly sharp. Fossils from the lower third of this bed include *Aenocyon dirus, Equus,* and *Camelops* (Hibbard, 1949*a,* p. 79) and mollusks (H.T.U. Smith, 1940, p. 102)	18	88
3.	Silt, brown (7.5YR 5.5/4 dry), massive. Lime streaks or nodules rare, in contrast to unit 2. Shells locally common. Lower contact fairly sharp	14	102
2.	Clay, silt, and sand, in interbedded lenses 6″–4′ thick. Lime streaks and caliche nodules conspicuous in upper part, especially in silt. Clay reddish brown to gray. Silt brown, massive, with lime streaks and caliche nodules. Sand medium to coarse, limonitic, well sorted, subangular, with scattered small pebbles. Lower contact irregular. Locally a minor erosional bench at top.	10	112
	Lower member, Qs_1l.		
1.	Sand, medium to coarse, limonitic, well sorted, subrounded, with lenses of grit and fine pebble gravel. Scattered fossil shells and bone (Butler Spring locality 3). Poorly exposed	10	122
	Base not exposed.		

Localities.—Most, but not all, the fossils included in the Butler Spring local fauna are from the precise localities listed below (see Fig. 4). A number of the vertebrates come from the basal sand in the NW¼ SW¼ sec. 33 and the NE¼ SE¼ sec. 32, T. 34 S., R. 29 W., but we have no more exact data for them.

Several earlier papers list fossils from Kansas University Meade County locality 7. This included a considerable area and stratigraphic thickness in the Butler Spring region. Only a few of the fossils reported under this designation represent the Butler Spring local fauna, however, which was originally assigned to the particular locality and deposits in the Butler Spring area where *Aenocyon dirus* was found (Hibbard, 1939, p. 464; see Measured Section 4). We therefore propose that locality 7 be restricted to the deposits described as unit 4 of Measured Section 4. Franzen and Leonard (1947) reported mollusks which may possibly be referable to the Butler Spring assemblage. The locality data are inadequate for certainty, but the species listed were duplicated by University of Michigan collections.

LOCALITY 1 (USGS Cenozoic locality 21042). SE¼ sec. 32, T. 34 S., R. 29 W., Meade County, Kansas, 600′–900′ W., 1100′ N. of southeast section corner. Fossils from flat-lying medium to coarse, cross-bedded, limonitic sand on the south side of an east-flowing second-order tributary to Butler Spring Arroyo, see Measured Section 2. Mollusks from this locality were collected by handpicking on the surface in 1952; a bulk sample of 12 sacks was taken in 1953. Data in this paper are based on all of the 1952 material; only about 60 per cent of the 1953 material has been sorted and studied. The fishes described by C. L. Smith (1958) are from bulk collections made in 1953 and 1957 and from earlier surface collecting.

Hibbard (1943, p. 190; 1949*a*, p. 79) recorded a specimen of *Microtus pennsylvanicus* from this locality.

LOCALITY 2 (USGS Cenozoic locality 21043). SE¼ sec. 32, T. 34 S., R. 29 W., Meade County, Kansas. 400′ W., 1500′ N. of southeast section corner. Fossils from SE-dipping, medium to coarse, cross-bedded, limonitic sand in a cut bank on the west side of a first-order tributary to Butler Spring Arroyo. The exposure is the northernmost of two such conspicuous cut banks. The only fossils recorded from this locality previously are *Ambystoma tigrinum* (Tihen, 1955, p. 240–41). Two sacks of matrix were collected in 1957, of which about 5 per cent of the shell-bearing concentrate was sorted and available for this study.

LOCALITY 3. SE¼ sec. 32 and SW¼ sec. 33, T. 34 S., R. 29 W., Meade County, Kansas. On section line, 900′ N. of southern common section corner. Fossils from east-dipping, medium to coarse, limonitic sand in a minor, NE-trending gulch running into a first-order tributary to Butler Spring Arroyo. See Measured Section 4. The only fossil recorded from this site is an isolated mussel, *Quadrula*. Fragmentary mussel shells are more abundant at this locality than elsewhere, however.

Locality 4. SE¼ sec. 32, T. 34 S., R. 29 W., Meade County, Kansas. 300′ W., 1200′ N. of southeast section corner. Medium to coarse, limonitic, cross-bedded sand exposed on the south side of a first-order tributary to Butler Spring Arroyo. This is the type locality of *Emydoidea twentei* (Taylor) (E. H. Taylor, 1943; Hibbard, 1949*a,* p. 83).

Locality 5. SE¼ sec. 32, T. 34 S., R. 29 W., Meade County, Kansas. 175′ W., 1100′ N. of southeast section corner. Medium to coarse, limonitic, cross-bedded sand exposed on the south side of a first-order tributary to Butler Spring Arroyo. The only fossil collected here is *Castoroides.*

Age and correlation.—The Butler Spring local fauna is assigned to late Illinoian age on the basis of the following evidence from stratigraphic position and environmental interpretation of the local stratigraphic and faunal sequence:

1. The Butler Spring local fauna is stratigraphically, although not topographically, above the Crooked Creek formation of Kansan and Yarmouth age. It is from a medium to coarse, locally pebbly, cross-bedded, limonitic sand inferred to be of fluviatile origin. Occurrence of this deposit below the topographic level of the Crooked Creek formation records an early stage in late Pleistocene stream entrenchment.
2. Ecological inferences from the fauna (see below) suggest that this local fauna lived in a climate considerably different from that of southwestern Kansas today. Winters were perhaps not significantly unlike, but the summers were markedly cooler and moister. Hence, it follows that the Butler Spring local fauna is of glacial rather than interglacial age.
3. The sequence of deposits overlying the Butler Spring local fauna at several stratigraphic horizons includes assemblages of mild-climate type, as opposed to the Butler Spring local fauna, as well as a massive caliche bed, features that are ascribed to a post-Yarmouth interglacial, hence Sangamon interval.
4. After the period when the Butler Spring fauna lived, there took place an interval of weathering during which a massive caliche bed formed, two intervals of basin collapse and filling separated by erosion, and a discontinuous entrenchment of the Cimarron River to a depth of about 100 feet.

Probably many of the Illinoian faunas of the Great Plains are equivalent to the Butler Spring local fauna. Only in the Meade County area, however, can correlative faunas be recognized with reasonable certainty. They are the Berends and Doby Springs local faunas and perhaps the Bar M (these are summarized elsewhere in this paper). Undescribed fossils from the lower part of the Kingsdown formation in the vicinity of the Cragin Quarry localities are probably also of late Illinoian age.

Environment.—Inferences about the conditions under which the Butler Spring local fauna lived can be derived (1) from the physical features of the fossil-bearing deposit and the fossils, and (2) from the present-day habitats of species represented as fossils or of their close living relatives.

LOCAL HABITAT. Presence of an ancient stream in and about which these animals lived is evidenced by several features: (1) The coarse sand from which the fossils were collected is conspicuously cross-bedded and generally well sorted. The well-sorted sand lenses include very few of the smaller, relatively fragile fossils; they are from lenses of finer-grained sediment. Coarser lenses of gravel occur that have pebbles up to 3 inches in diameter. (2) None of the vertebrate fossils has been found in articulation. The larger bones, from coarse sand, are abraded and apparently have been carried for some distance. (3) Most of the fossils represent aquatic species. These imply several types of habitat, but some of the animals are characteristic of perennially flowing rivers: the gar, *Lepisosteus;* the channel catfish, *Ictalurus punctatus;* and the freshwater mussel *Quadrula.*

The size of this former stream is debatable, but the kinds of fishes indicate that it was large enough to be called a small river rather than a creek. It was definitely larger than either present-day Crooked Creek or the Cimarron River. This indirect evidence suggests that the fossils are from deposits of the ancestral Cimarron River, rather than from those of the former Crooked Creek.

The most detailed information about the local site of deposition is furnished by the aquatic mollusks, partly because they are abundant and represent several types of habitats and partly because they are more sedentary than the vertebrates. Habitats and relative abundance of these species are summarized in Table V. The three localities from which the mollusks came are nearby and at the same horizon in a single lithologic unit which was probably deposited fairly rapidly. Consideration of all of the mollusks as a unit is, therefore, justified.

The habitat groups into which the species are divided are to some extent arbitrary. Certainly, many species of one group lived in association with those of another. Assignment of a few of poorly known habitat, such as *Laevapex kirklandi* and *Physa skinneri,* to a given category is little more than guesswork. Even with all these inadequacies, however, the table shows a relative scarcity of forms usually found in shallow, seasonal bodies of water.

The most conspicuous feature of the molluscan assemblage is the overwhelming abundance of *Valvata tricarinata* and *Gyraulus parvus.* Dominance of these two species indicates that the immediate environment of deposition was a habitat favorable primarily or exclusively for them. The other species were only living there in small numbers or occurred in

TABLE V

HABITAT INDICATIONS OF AQUATIC MOLLUSKS OF BUTLER SPRING LOCAL FAUNA

Some uncertainly identified species have been omitted. Number of specimens are combined totals for three localities; they are individual counts except for multiples of ten above 250. Fractions indicate the number of separate valves.

Habitat	Species	Number of Specimens
Marginal situations: wet mud; debris at edge of water; shallow pools and protected spots	*Fossaria dalli*	24
	Fossaria obrussa	140
Shallow, quiet water: sloughs and backwaters, probably subject to seasonal drying: water depth perhaps less than 1 foot	*Pisidium casertanum*	29/2
	Stagnicola caperata	300
	Stagnicola reflexa	243
	Anisus pattersoni	36
	Gyraulus circumstriatus	600
	Promenetus umbilicatellus	57
	Physa gyrina	325
	Aplexa hypnorum	3
	Ferrissia meekiana	6
Shallow, quiet water: backwaters with no current, or protected places exposed to only a slight current; not subject to significant seasonal drying; water depth perhaps 1 to 3 feet	*Sphaerium transversum*	5/2
	Lymnaea stagnalis jugularis	1
	Gyraulus parvus	49,500
	Helisoma trivolvis	46
	Promenetus kansasensis	1200
	Physa anatina	7500
	Physa skinneri	19
	Laevapex kirklandi	221
Perennial stream: slow current, or moderate current in protection of vegetation; not affected by seasonal drying; water depth probably more than 1 foot	*Anodonta grandis?*	2/2
	Sphaerium striatinum	47/2
	Pisidium compressum	1 + 731/2
	Pisidium nitidum	221/2
	Valvata tricarinata	74,000
	Helisoma anceps	2
Perennial, medium-sized stream: slow to moderate current; water depth several feet	*Quadrula quadrula*	1/2
	Probythinella lacustris	2

other habitats at varying distances away. This immediate habitat was probably dense beds of submergent aquatic plants, such as *Potamogeton, Myriophyllum,* and *Ceratophyllum.* The vegetation was probably in a protected area with less current than in the main stream, such as an embayment, or the downstream and inner side of a bend. The high concentration of fossils and finer-grained sediment at the top of the coarse sand unit (Qs_1l in Measured Section 2) suggests a local shift in the ancient river channel, from the fossil locality to a short distance away.

The terrestrial environment near the fossil locality is inferred from the mammals and land snails. The fossil sample of these animals is poorer than that of the aquatic species and, hence, less detail in habitat reconstruction is possible. Table VI shows the habitat indications and relative abundance of the terrestrial mollusks. Although, clearly, there was some

TABLE VI

HABITAT INDICATIONS OF LAND SNAILS OF BUTLER SPRING LOCAL FAUNA

Uncertainly identified Succineidae have been omitted. Numbers of specimens are combined totals for localities 1 and 2; they are individual counts except for multiples of ten above 200.

Habitat	Species	Number of Specimens
Semiaquatic, riparian: among sedges, watercress, and other plants at the waters edge, or in debris and vegetation in marshy places	*Oxyloma retusa*	17
Moist leaf mold and plant debris: under logs and bark, or among leaves, moss, or in grass in moist situations not far from water	*Carychium exiguum*	81
	Gastrocopta tappaniana	300
	Vertigo gouldi	1
	Vertigo milium	118
	Vertigo ovata	300
Woodland habitat: in moist, protected spots among plant debris in wooded area, or associated with dead wood on the flood plain	*Discus cronkhitei*	6
	Zonitoides arboreus	51
	Stenotrema leai	68
Protected places in vegetation: grass, shrubs, or woodland. These species vary as to habitat, but do not require woods	*Gastrocopta armifera*	200
	Gastrocopta contracta	19
	Gastrocopta holzingeri	49
	Gastrocopta cristata	800
	Gastrocopta procera	24
	Pupoides albilabris	200
	Pupoides inornatus	44
	Pupilla muscorum	82
	Pupilla blandi	36
	Pupilla sinistra	5
	Vallonia cyclophorella	400
	Vallonia gracilicosta	189
	Vallonia parvula	200
	Helicodiscus singleyanus	75
	Hawaiia minuscula	400

woodland along the river, species which can live in grass or among shrubs are so much more common than the woodland species that it suggests the trees probably were in scattered groups rather than in a thick belt beside the stream.

Further inferences from this local habitat and from the distributions of the living species lead to broader generalizations about climate.

CLIMATE. Inferences about the climate in which the Butler Spring local fauna lived are derived partly from the nature of the local habitat, as interpreted, and partly from the present distribution of living species represented in the fauna.

A rainfall considerably greater, or else much more effective, than that of today is implied by the large size of the ancient stream. Occurrence of the fossil gar and channel catfish show this river was of medium size, and evidently much larger than the modern Cimarron River (see McLaughlin, 1947). This discrepancy in size alone would suggest the rainfall supplying the former stream was somewhat greater than now, but other considerations also point to an increase in rainfall. The stream in and near which the Butler Spring fauna lived was incised only half as deeply as the present Cimarron River. Since the modern stream can receive ground-water contributions from strata not available to the older one, a greater rainfall must be postulated to compensate for this fact.

Markedly cooler summers when the fossil fauna lived are indicated by a number of species. Summer-cool streams fed by springs or ground-water seepage might explain the occurrence of some aquatic species or of small land snails living close to such water, but other conspicuously northern forms (*Pupilla*) do not live in habitats which could be so influenced.

Although the Butler Spring local fauna has a large northern element, the fauna does not entirely resemble that of some region in higher latitudes, such as part of North Dakota or Manitoba. There is no local area in which all of the living species in this fauna can now be found. Generally speaking, however, the fauna is characteristic of the Great Plains; only a few of the extant species are not found in the Plains, and these occur in the more humid region to the east. But even in the group of living Great Plains animals represented in the Butler Spring assemblage are several kinds not now associated. Any adequate paleoecological interpretation should at least take these distributional data into account; indeed, we believe they are among the most significant clues to the past environment in which the fauna lived.

The living species of the Butler Spring assemblage which have present-day restricted distribution in the Great Plains, or the ones which do not now live in the Great Plains at all, are grouped in Table VII according to the patterns of their ranges. While these patterns are not similar in detail,

TABLE VII

Distribution Patterns (Relative to the Great Plains) of Living Species of Butler Spring Local Fauna

Species	Distribution
Far northern:	
Valvata tricarinata *Lymnaea stagnalis jugularis* *Physa skinneri* *Pupilla blandi* *Pupilla muscorum* *Pupilla sinistra* *Vallonia cyclophorella*	Great Plains only in the northernmost states; in the Rocky Mountains and in the more humid Central Lowland may range farther south, but are still of obviously northern distribution.
Mid-northern:	
Stagnicola caperata *Gyraulus circumstriatus* *Promenetus umbilicatellus* *Vallonia gracilicosta* *Discus cronkhitei* *Stenotrema leai* *Microtus pennsylvanicus*	Great Plains only as far south as Nebraska; not known in Kansas even from more humid northeastern region.
Mid-southern:	
Physa anatina *Gastrocopta cristata* *Vallonia parvula* *Helicodiscus singleyanus*	Great Plains as far north as South Dakota or Nebraska, but more common farther south, in the central Plains region.
Eastern:	
Quadrula quadrula *Probythinella lacustris* *Ferrissia kirklandi* *Ferrissia meekiana* *Perca flavescens*	Not known from Great Plains or westward; inhabit more humid eastern areas, mostly in larger streams or lakes.

they are generally alike and suggest similar reactions to seasonal extremes of temperature and humidity.

The largest number of Butler Spring species now live in the Central Lowland of the eastern Dakotas. *Gastrocopta cristata, Pupoides inornatus* and *Pupilla blandi* are not known from this region and probably do not occur there. *Ferrissia kirklandi, Ferrissia meekiana, Physa anatina,* and *Pupilla sinistra* may not either, but their distributions are too poorly known to be certain. Within this region, however, not all of the species will be found in a local area. *Gastrocopta tappaniana, Gastrocopta procera, Vallonia parvula, Helicodiscus singleyanus,* and *Stenotrema leai* reach their northern limits in South Dakota, but they are not found in association with the more northern species *Physa skinneri, Pupilla muscorum,* and *Vallonia cyclophorella.*

The mollusks of North Dakota have not been thoroughly studied. The only reasonably careful collecting has been in parts of northeastern North Dakota (Winslow, 1921). Records of mollusks from other parts of the state are largely based on random collections or the work of transient collectors. A significant feature of the molluscan assemblage reported by Winslow from the Devils Lake area, which shows similarity to the Butler Spring local fauna, is the occurrence, near the southern or western limits of their ranges, of *Probythinella lacustris, Valvata tricarinata, Lymnaea stagnalis jugularis, Pupilla muscorum,* and *Vallonia cyclophorella.*[7]

The simplest explanation for the former association, in a single small area, of a number of species that now live hundreds of miles apart is that the climatic extremes separating them today were once absent. If the climate in which the Butler Spring local fauna flourished combined winters no more severe than those of Nebraska with the shorter, cooler summers of North Dakota, then the association of most of the species can be accounted for. But the factors affecting the distribution of the western snails *Pupoides inornatus, Pupilla blandi,* and *Pupilla sinistra* are not apparent; one might gain comfort from the fact that there seems to be a relatively simple explanation for the occurrence of so much of the fauna.

Attempts to quantify the climatic elements involved are necessarily tentative. Neither the Recent distribution of the mollusks nor the precise factors controlling the various ranges of the species are well known. The line of reasoning employed here is that seasonal extremes of temperature are the simplest factors to account for the distribution of some species in the Great Plains. On the basis of their habitats and general ranges, the known distribution of the species is then compared with an appropriate group of the climatic maps (Visher, 1954) in search of a reasonable fit. This is found on Maps 250 and 294 which indicate a highest normal daily mean temperature of less than 70 degrees Fahrenheit, and a normal annual number of days with temperature continuously below freezing less than 45.

The present rainfall of Meade County would be more effective in a climate with cooler summers, such as is thought to have prevailed when the Butler Spring assemblage lived there. Comparison of the climates of Meade County and eastern North Dakota with respect to precipitation and potential evapotranspiration shows this difference. Average precipitation recorded at Plains, Meade County, is 18.43 inches per year (Frye, 1942); the county lies on the dividing line between the dry subhumid and semiarid regions of Thornthwaite (1948). The part of North Dakota with similar rainfall, but a highest normal daily mean temperature of less than

[7] The specimens of *Vallonia cyclophorella* from North Dakota recorded in this paper were collected by Winslow but recorded by her as *V. gracilicosta.*

70 degrees, is the northeastern part (Visher, 1954, Maps 250, 492). It is in the eastern, more humid, part of Thornthwaite's dry subhumid region, where potential evapotranspiration is less and more nearly balanced by precipitation. The general region of the eastern Dakotas where the fauna is most similar to the Butler Spring local fauna has a mean annual precipitation in most places greater than that of Meade County, and the warmer summers and higher potential evapotranspiration to the south are offset by the greater precipitation toward the east. Thus, the mean precipitation in the hypothetical climate postulated for Meade County may have been over 20 inches per year, depending on the amount of potential evapotranspiration. Comparison is simplified, however, if the mean annual precipitation is considered to have been essentially the same in Meade County in late Illinoian time as it is now.

The contrast between the three climates, that of part of northeastern North Dakota, modern Meade County, and the hypothetical one inferred from the Butler Spring local fauna can be summarized by using the climatic classification and symbols of Thornthwaite (1948). Such a summary follows, together with figures for annual precipitation and evaporation from Visher (1954).

Northeastern North Dakota: $C_1C'_2db'_1$. Climate dry subhumid, microthermal (near the first mesothermal boundary), generally moisture-deficient, with a thermal efficiency regime normal for first mesothermal climates. Mean annual precipitation is 18″–20″, 80 per cent of which falls in the warmer half-year; annual evaporation from pans 40″–45″.

Meade County, Kansas: $DB'_2db'_2$. Climate semiarid (actually on the line between semiarid and dry subhumid), second mesothermal, generally moisture-deficient, with a temperature-efficiency regime normal to second mesothermal, but not far from the third mesothermal line. Mean annual precipitation 18″–19″, 75 per cent of which falls in the warmer half-year; annual exaporation from pans over 90″.

Meade County, Kansas, in late Illinoian time, climate inferred from Butler Spring local fauna: $C_1B'_1db'_3$. Climate dry subhumid, first mesothermal, generally moisture-deficient, with the summer concentration of thermal efficiency normal for a third mesothermal climate. Mean annual precipitation 18″–20″, 75–80 per cent falling in the warmer half-year; annual evaporation from pans about 40″.

The climate suggested by the Butler Spring local fauna, then, differed from that of present-day Meade County in having a lower annual potential evapotranspiration. The difference is mostly in the summer concentration of this potential, however. The rainfall may have been about the same, but its greater effectiveness then changed the climatic type from the present borderline semiarid to well within the dry subhumid type. This hypothetical climate differs from that of the area in northeastern North Dakota, where the fauna is generally similar to the Butler Spring assemblage, by being slightly warmer (first mesothermal as opposed to borderline microthermal), but most conspicuously by having much less of the annual potential evapotranspiration concentrated in the summer. The climate is thus much less continental than that in northeastern North Dakota.

Summary.—The Butler Spring assemblage lived in and near a medium-sized river, one considerably larger than the present Cimarron River or Crooked Creek. Immediate site of deposition of the fossil-bearing sediments was a somewhat protected area out of the main current, where there were dense beds of submergent aquatic plants. The river bank had some trees, as scattered groups or isolated individuals, but vegetation consisted mostly of grasses and shrubs. The late Pleistocene climate differed from that of Meade County today in being generally cooler, with the difference mostly or entirely in the summers. Eastern North Dakota has these cooler summers, and a similar amount but more effective rainfall than this former climate. Winters were not as severe as those of North Dakota, however; no longer and colder than those of north-central Nebraska and perhaps little more so than those of Meade County.

OTHER LATE PLEISTOCENE FAUNAS FROM SOUTHWESTERN KANSAS AND NORTHWESTERN OKLAHOMA

The significant features of the Butler Spring and Cragin Quarry local faunas are only evident, or are most readily apparent, by comparison with other late Pleistocene assemblages from southwestern Kansas and northwestern Oklahoma. A summary of these is, therefore, included in this paper; the data are in part from previous publications and in part from new revisions. The faunas are Berends local fauna, Illinoian, Beaver County, Oklahoma; Doby Springs local fauna, Illinoian, Harper County, Oklahoma; Jinglebob local fauna, Sangamon, Meade County, Kansas; Bar M local fauna, Wisconsin or Illinoian, Harper County, Oklahoma; and Jones local fauna, Wisconsin, Meade County, Kansas.

Berends Local Fauna

Previous work.—The sediments which yielded the Berends local fauna were discovered by C. W. Hibbard and a University of Michigan Museum of Paleontology field party in 1950. They have been studied by Michigan parties in most subsequent years, and a varied fauna of mammals, birds, reptiles, fishes, and mollusks has been collected from them (Herrington and Taylor, 1958; Hibbard, 1956; Mengel, 1952; Rinker and Hibbard, 1952; Smith, 1954, 1958; Starrett, 1956; D. W. Taylor, 1954*a;* Taylor and Hibbard, 1955).

FAUNAL LIST[8]

Class Pelecypoda

Order Teleodesmacea

Sphaerium lacustre (Müller)
Sphaerium sulcatum (Lamarck)
Pisidium casertanum (Poli)
Pisidium compressum Prime
Pisidium nitidum Jenyns
Pisidium obtusale Pfeiffer

Class Gastropoda

Order Mesogastropoda

Valvata tricarinata (Say)

Order Basommatophora

Stagnicola exilis (Lea)
Stagnicola caperata (Say)
Fossaria dalli (Baker)
Fossaria obrussa (Say)
Gyraulus circumstriatus (Tryon)
Gyraulus parvus (Say)
Armiger crista (Linnaeus)
Helisoma trivolvis (Say)
Planorbula armigera (Say)
**Promenetus kansasensis* (Baker)
Physa gyrina Say
Physa skinneri Taylor
Aplexa hypnorum (Linnaeus)

Order Stylommatophora

Gastrocopta armifera (Say)
Gastrocopta procera (Gould)
Gastrocopta tappaniana (Adams)
Pupoides albilabris (Adams)
Vertigo ovata Say
cf. *Succinea*
Oxyloma retusa (Lea)
Helicodiscus parallelus (Say)
Deroceras laeve (Müller)
Hawaiia minuscula (Binney)
Stenotrema leai (Binney)

Class Osteichthyes

Lepisosteus, gar
Esox masquinongy Mitchill, muskellunge
Catostomus commersoni (Lacépède), white sucker
Notemigonus crysoleucas (Mitchill), golden shiner
Semotilus cf. *S. atromaculatus* (Mitchill), creek chub
Semotilus, minnow
Cyprinidae, indeterminate, minnow
Ictalurus melas (Rafinesque), black bullhead
Ictalurus punctatus (Rafinesque), channel catfish

[8] See note 3, p. 8.

Lepomis cf. *L. cyanellus* Rafinesque, green sunfish
Perca flavescens (Mitchill), yellow perch
Aplodinotus grunniens Rafinesque, drum

Class Reptilia
Order Chelonia
Unidentifiable turtle remains

Class Aves
Order Pelecaniformes
Pelecanus erythrorhynchos Gmelin, white pelican

Class Mammalia
Order Insectivora
Sorex cf. *S. cinereus* Kerr, masked shrew
Blarina cf. *B. brevicauda* (Say), short-tailed shrew
Order Rodentia
†*Castoroides,* giant beaver
†*Paradipoides stovalli* Rinker and Hibbard, Stovall's beaver
Geomys, eastern pocket gopher
Perognathus cf. *P. hispidus* Baird, hispid pocket mouse
**Peromyscus berendsensis* Starrett, deer mouse
**Ondatra triradicatus* Starrett, muskrat
Microtus pennsylvanicus (Ord), meadow vole
Pedomys cf. *P. ochrogaster* (Wagner), prairie vole
Order Carnivora
Canis latrans Say, coyote
Order Proboscidea
†*Mammuthus* cf. *M. columbi* (Falconer), Columbian mammoth
Order Lagomorpha
Leporidae indeterminate, rabbit
Order Perissodactyla
Equus, horse

Rejected records.—
Sphaerium cf. *lacustre* = *S. lacustre; Lymnaea turritella* = *Fossaria dalli; Lymnaea palustris* = *Stagnicola exilis; Planorbula vulcanata* = *P. armigera; Promenetus pearlettei* = *P. kansasensis; Physa elliptica* = *P. gyrina; Succinea* cf. *grosvenori* = cf. *Succinea; Oxyloma haydeni* = *O. retusa; Deroceras* cf. *laeve* = *D. laeve. Sphaerium striatinum* and *S. transversum* were recorded by Taylor and Hibbard (1955, p. 12) in error.

Locality.—The Berends local fauna is known only from secs. 5 and 6, T. 5 N., R. 28 E. C. M., Beaver County, Oklahoma. The fossils are from deposits laid down in a sinkhole whose collapse involved the Pearlette ash.

Age and environment.—A late Pleistocene age for the Berends local fauna is presumed, because the fossiliferous deposits were laid down after collapse of Pleistocene beds including the Pearlette ash of late Kansan age. Presence of spruce, fir, and pine pollen, and of species of mammals, fishes, and mollusks having present-day distributions markedly more northern than the fossil occurrence suggests that former summers were definitely cooler and moister and, hence, that the fauna is of glacial age. The several extinct rodents indicate that this was Illinoian rather than Wisconsin.

Doby Springs Local Fauna

Previous work.—In the course of geologic mapping in Harper County, Oklahoma, Arthur J. Myers of the Oklahoma Geological Survey and University of Oklahoma, discovered some fossiliferous sediments evidently of Pleistocene age (see Myers 1959). In order to determine the age of the beds Claude W. Hibbard and field parties from the University of Michigan Museum of Paleontology washed about 14 tons of matrix for fossils. The local geology and the mammalian fauna are being studied by John J. Stephens (1959, p. 1680); C. L. Smith (1958) has recorded the fishes. Only one of the many mollusks awaiting study is listed here.

FAUNAL LIST

Class Gastropoda
- Order Mesogastropoda
  - *Probythinella lacustris* (Baker)

Class Osteichthyes
- *Catostomus commersoni* (Lacépède), white sucker
- *Semotilus atromaculatus* (Mitchill), creek chub
- cf. *Hybopsis gracilis* (Richardson), flathead chub
- *Pimephales promelas* Rafinesque, fathead minnow
- Cyprinidae, 6 additional species, minnows
- *Ictalurus melas* (Rafinesque), black bullhead
- *Lepomis* cf. *L. cyanellus* Rafinesque, green sunfish
- *Perca flavescens* (Mitchill), yellow perch

Locality.—The Doby Springs local fauna is known from several nearby sites in the N½SW¼ sec. 10, T. 27 N., R. 24 W., Harper County, Oklahoma. The fossil-bearing deposit was laid down in a sinkhole formed by collapse in an area of Permian rocks.

Age and environment.—Inasmuch as few of the fossils have been studied, the age of the Doby Springs fauna is uncertain, but occurrence of the now northern yellow perch, *Perca flavescens,* points to a glacial age. Indeed, the general similarity of the fishes of the Berends, Butler Spring, and Doby Springs local faunas suggests all three are of the same age, and that Illinoian.

Jinglebob Local Fauna

Previous work.—In 1947, on the basis of local information, C. W. Hibbard visited a locality where some large fossil bones had been found in association with abundant shells. Later surface collecting and the washing of a small sample of matrix led to an unusually interesting fauna, and stimulated intensive study. The Jinglebob local fauna is significant not only because of the large number of species represented, but also because striking environmental inferences may be derived from the assemblage. Mollusks, fishes, amphibians, reptiles and mammals have been recorded

(Herrington and Taylor, 1958; Hibbard, 1955*b*, 1956; Oelrich, 1953; Rinker, 1949; Taylor and Hibbard, 1955; Tihen, 1954, 1955; van der Schalie, 1953).

FAUNAL LIST[9]

Class Pelecypoda
- Order Prionodesmacea
  - *Anodonta grandis* Say?
- Order Teleodesmacea
  - *Sphaerium occidentale* Prime
  - *Sphaerium partumeium* (Say)
  - *Sphaerium striatinum* (Lamarck)
  - *Sphaerium sulcatum* (Lamarck)
  - *Pisidium casertanum* (Poli)
  - *Pisidium compressum* Prime
  - *Pisidium nitidum* Jenyns
  - *Pisidium obtusale* Pfeiffer
  - *Pisidium walkeri* Sterki

Class Gastropoda
- Order Mesogastropoda
  - *Valvata tricarinata* (Say)
- Order Basommatophora
  - *Carychium exiguum* (Say)
  - *Stagnicola palustris* cf. *S. palustris blatchleyi* (Baker)
  - *Stagnicola caperata* (Say)
  - *Fossaria dalli* (Baker)
  - *Fossaria obrussa* (Say)
  - *Gyraulus circumstriatus* (Tryon)
  - *Gyraulus parvus* (Say)
  - *Helisoma anceps* (Menke)
  - *Helisoma trivolvis* (Say)
  - *Promenetus exacuous* (Say)
  - *Ferrissia meekiana* (Stimpson)
  - *Ferrissia rivularis* (Say)
  - *Laevapex fuscus* (Adams)
  - *Laevapex kirklandi* (Walker)
  - *Physa anatina* Lea
  - *Physa gyrina* Say
  - *Aplexa hypnorum* (Linnaeus)
- Order Stylommatophora
  - *Strobilops labyrinthica* (Say)
  - *Gastrocopta armifera* (Say)
  - *Gastrocopta contracta* (Say)
  - *Gastrocopta cristata* (Pilsbry and Vanatta)
  - *Gastrocopta holzingeri* (Sterki)
  - *Gastrocopta procera* (Gould)
  - *Gastrocopta tappaniana* (Adams)
  - *Pupoides albilabris* (Adams)
  - *Pupilla blandi* Morse

[9] See note 3, p. 8.

Vertigo milium (Gould)
Vertigo ovata Say
Vallonia gracilicosta Reinhardt
Vallonia parvula Sterki
cf. *Succinea*
Oxyloma retusa (Lea)
Helicodiscus parallelus (Say)
Punctum minutissimum (Lea)
**Deroceras aenigma* Leonard
Deroceras laeve (Müller)
Euconulus fulvus (Müller)
Nesovitrea electrina (Gould)
Hawaiia minuscula (Binney)
Zonitoides arboreus (Say)
Stenotrema leai (Binney)

Class Osteichthyes
Family Cyprinidae
Semotilus atromaculatus? (Mitchill), creek chub
Family Ictaluridae
Ictalurus, bullhead

Class Amphibia
Order Caudata
Ambystoma cf. *A. tigrinum* (Green), tiger salamander
Order Salientia
Scaphiopus bombifrons (Cope), Plains spadefoot toad
Bufo woodhousii Girard, Rocky Mountain toad
Acris?
Rana catesbeiana Shaw, bullfrog
Rana pipiens Schreber, leopard frog

Class Reptilia
Order Chelonia
**Terrapene llanensis* Oelrich, Plains box turtle
Order Squamata
Holbrookia?, lizard
Sceloporus?, lizard
Eumeces, skink

Class Mammalia
Order Insectivora
Sorex cf. *S. cinereus* Kerr, masked shrew
Blarina cf. B. brevicauda (Say), short-tailed shrew
Order Edentata
†*Paramylodon harlani* (Owen), Harlan's ground sloth
Order Rodentia
Citellus, ground squirrel
Geomys, eastern pocket gopher
Perognathus hispidus Baird, hispid pocket mouse
Perognathus, pocket mouse
Dipodomys cf. *D. ordii* Woodhouse, Ord's kangaroo rat
**Onychomys jinglebobensis* Hibbard, jinglebob grasshopper mouse
Reithrodontomys cf. *R. montanus* (Baird), Plains harvest mouse

**Peromyscus cochrani* Hibbard, Cochran's white-footed mouse
Peromyscus, deer mouse
Neotoma, packrat
**Oryzomys fossilis* Hibbard, fossil rice rat
**Synaptomys australis* Simpson, Simpson's bog lemming
Pedomys ochrogaster (Wagner), prairie vole
Microtus pennsylvanicus (Ord), meadow vole
Ondatra zibethicus (Linnaeus), muskrat
**Zapus adamsi* Hibbard, Adams' jumping mouse

Order Carnivora
†*Arctodus simus* (Cope), short-faced bear
Spilogale interrupta (Rafinesque), southern spotted skunk

Order Proboscidea
†*Mammuthus columbi* (Falconer), Columbian mammoth

Order Lagomorpha
Leporidae indeterminate, rabbit

Order Artiodactyla
**Bison latifrons* (Harlan), giant bison

Rejected records.—

Musculium transversum = *Sphaerium partumeium* and *S. sulcatum; Sphaerium* cf. *truncatum* = *S. partumeium; Pisidium noveboracense* = *P. casertanum; Pisidium abditum* = *P. casertanum, P. nitidum, P. compressum, P. obtusale, Sphaerium occidentale,* and *S. sulcatum; Pisidium contortum* = *P. nitidum; Carychium* cf. *exiguum* = *C. exiguum; Lymnaea parva* = *Fossaria dalli; Lymnaea humulus rustica* = *Fossaria obrussa; Lymnaea bulimoides* = *Stagnicola caperata; Lymnaea* cf. *galbana* = *Fossaria dalli; Lymnaea humilis modicella* = *Fossaria dalli; Lymnaea* cf. *palustris* = *Stagnicola palustris* cf. *S. palustris blatchleyi* and *Fossaria obrussa; Lymnaea turritella* = *Fossaria dalli; Gyraulus similaris* = *G. circumstriatus* and *G. parvus; Helisoma lentum* = *H. trivolvis; Helisoma* cf. *lentum* = *H. trivolvis; Ferrissia parallela* = *Ferrissia meekiana* and *Laevapex kirklandi; Ferrissia* cf. *pumila* = *F. meekiana; Physa hawni* = *P. gyrina; Physa* cf. *anatina* = *P. anatina; Physa* cf. *elliptica* = *P. gyrina; Strobilops texasiana* = *S. labyrinthica; Gastrocopta armifera abbreviata* = *G. armifera; Gastrocopta pentodon* = *G. tappaniana; Gastrocopta* cf. *tappaniana* = *G. tappaniana?; Gastrocopta* sp. = *G. contracta?; Pupoides marginatus* = *P. albilabris; Succinia concordalis* = cf. *Succinea; Succinia haydeni* = *Oxyloma retusa; Succinea ovalis* = *Oxyloma retusa; Succinea grosvenori* = cf. *Succinea; Succinea* cf. *avara* = cf. *Succinea; Succinea* cf. *concordialis* = cf. *Succinea; Succinea* cf. *grosvenori* = cf. *Succinea; Deroceras* cf. *laeve* = *D. laeve; Retinella* cf. *rhoadsi* = *Nesovitrea electrina; Stenotrema monodon* = *S. leai.*

Locality.—The Jinglebob local fauna is known from only one locality, SW¼ sec. 32, T. 33 S., R. 29 W., Meade County, Kansas. The fossils are from near the base of an alluvial fill deposited in a small valley cut through the Crooked Creek and Ballard formations into the upper part of the Rexroad formation. These valley-filling sediments are included in the Kingsdown formation.

Age and environment.—The Jinglebob local fauna includes a number of animals of present-day southern distribution in North America and lacks conspicuous northern elements. It is in strong contrast to the glacial-age faunas of the area and clearly of interglacial age. It is the youngest of the three recognized interglacial faunas in southwestern Kansas, and, hence, of Sangamon age. The Jinglebob local fauna is markedly different in composition from the Borchers local fauna of Yarmouth age and the Sanders and Deer Park local faunas of Aftonian.

Stratigraphic and paleontologic evidence indicates, moreover, that the Jinglebob local fauna is of late Sangamon age. The Jinglebob local fauna is from sediments deposited after dissection of the High Plains surface. Because the upper part of the Crooked Creek formation which forms this surface is of Yarmouth age, this dissection can be dated no older than late Yarmouth. The oldest fossils found in sediments younger than this dissection are Illinoian (Butler Spring local fauna and undescribed forms).

The chief significance of the Jinglebob local fauna lies in its environmental implications. The assemblage not only suggests a climate unlike any of those of the Great Plains today, but unlike any climate implied by other Pleistocene faunas of the Great Plains. The joint occurrence of species with ranges which either do not overlap today or only overlap in local areas leads to the conclusion that the climate of southwestern Kansas was formerly much less continental than at present. Summers were cooler, without the present-day extremes of heat and drouth; winters milder, as warm as those of coastal Virginia. Precipitation must have been greater than that now falling locally, for the presence of pine pollen suggests an annual rainfall of 40 to 45 inches.

Bar M Local Fauna

Previous work.—The deposits which yielded the Bar M local fauna were first encountered by Arthur J. Myers, of the University of Oklahoma, in the course of geologic mapping in Harper County, Oklahoma (see Myers, 1959). Small collections made by Hibbard and a University of Michigan field party in 1954 have been described by Taylor and Hibbard (1955), and by Herrington and Taylor (1958). A later collection added the *Microtus*.

Faunal List[10]	Locality 1	Locality 2
Class Pelecypoda		
Order Teleodesmacea		
Sphaerium striatinum (Lamarck)	..	x
Pisidium casertanum (Poli)	..	x
Pisidium compressum Prime	..	x
Pisidium nitidum Jenyns	..	x
Class Gastropoda		
Order Basommatophora		
Lymnaea stagnalis jugularis Say	x	x

[10] See note 3, p. 8.

Stagnicola palustris (Müller)	x	x
Stagnicola cockerelli (Pilsbry and Ferriss)	..	x
Stagnicola caperata (Say)	x	x
Fossaria dalli (Baker)	..	x
Fossaria obrussa (Say)	..	x
Gyraulus circumstriatus (Tryon)	x	x
Gyraulus parvus (Say)	x	x
Armiger crista (Linnaeus)	x	x
Helisoma trivolvis (Say)	x	x
Ferrissia meekiana (Stimpson)	..	x
Ferrissia parallela (Haldeman)	..	x
Physa anatina Lea	..	x
Physa gyrina Say	x	x
Physa skinneri Taylor	x	x
Aplexa hypnorum (Linnaeus)	x	x
Order Stylommatophora		
Strobilops labyrinthica (Say)	..	x
Gastrocopta armifera (Say)	..	x
Gastrocopta contracta (Say)	..	x
Gastrocopta cristata (Pilsbry and Vanatta)	x	..
Gastrocopta tappaniana (Adams)	..	x
Pupoides albilabris (Adams)	..	x
Pupilla blandi Morse	..	x
Pupilla muscorum (Linnaeus)	..	x
Vertigo ovata Say	x	x
Vallonia gracilicosta Reinhardt	x	x
Cionella lubrica (Müller)	..	x
cf. *Succinea*	x	x
Oxyloma retusa (Lea)	x	x
Discus cronkhitei (Newcomb)	x	x
Helicodiscus parallelus (Say)	..	x
Helicodiscus singleyanus (Pilsbry)	..	x
Euconulus fulvus (Müller)	..	x
Nesovitrea electrina (Gould)	x	x
Hawaiia minuscula (Binney)	..	x
Zonitoides arboreus (Say)	..	x
Stenotrema leai (Binney)	x	..
Class Mammalia		
Order Edentata		
Dasypus bellus (Simpson), beautiful armadillo	x	..
Order Rodentia		
Microtus pennsylvanicus (Ord), meadow vole	x	..

Rejected records.—

Lymnaea stagnalis = *Lymnaea stagnalis jugularis; Lymnaea parva* = *Fossaria dalli; Physa elliptica* = *Physa gyrina; Ferrissia* cf. *pumila* = *Ferrissia meekiana; Succinea* cf. *avara* = cf. *Succinea; Succinea* cf. *grosvenori* = cf. *Succinea; Oxyloma* cf. *haydeni* = *Oxyloma retusa.*

Localities.—Two separate sinkholes in Harper County, Oklahoma, recorded by isolated Pleistocene deposits in Permian rocks, have yielded similar assemblages of mollusks and, hence, are grouped as one (Bar M) local fauna. Locality 1, which yielded both mammals and mollusks, is in the NW¼ sec. 13, T. 28 N., R. 22 W. Locality 2, represented by more species of mollusks than Locality 1 but no mammals, is in the SE corner sec. 14, T. 26 N., R. 23 W.

Age and environment.—The Bar M local fauna is of either Illinoian or Wisconsin age. Occurrence of the supposedly extinct snail *Physa skinneri* was thought formerly (Taylor and Hibbard, 1955) to favor an Illinoian interpretation, but the matter is still uncertain for this species is now known to be still living. Its presence and that of several other species, particularly *Lymnaea stagnalis jugularis* and *Pupilla muscorum*, in the Great Plains today, but only far to the north and east, suggest that the summers were formerly much cooler and moister in northwestern Oklahoma, and imply a glacial age.

Jones Local Fauna

Previous work.—In 1940, a University of Kansas Museum of Natural History field party under the direction of C. W. Hibbard was guided by a local resident to a fossil site on the Jones Ranch, Meade County. Subsequent collecting by Hibbard and by later parties from the University of Kansas and University of Michigan has yielded a variety of mollusks and vertebrates, which constitute the youngest fauna studied in the Meade County area. See Downs, 1954; Franzen and Leonard, 1947; Frye and Hibbard, 1941, p. 419; Goodrich, 1940; Herrington and Taylor, 1958; Hibbard, 1940, 1942, 1943, 1949*a*, p. 86, 1949*c*, p. 1425; H. T. U. Smith, 1940, p. 110; Taylor and Hibbard, 1955; Tihen, 1942, 1955.

FAUNAL LIST[11]

Class Pelecypoda
- Order Teleodesmacea
  - *Pisidium compressum* Prime
  - *Pisidium ferrungineum* Prime
  - *Pisidium lilljeborgi* Clessin
  - *Pisidium nitidum* Jenyns
  - *Pisidium walkeri* Sterki

Class Gastropoda
- Order Mesogastropoda
  - *Valvata tricarinata* (Say)
- Order Basommatophora
  - *Stagnicola palustris* (Müller)
  - *Stagnicola caperata* (Say)
  - *Stagnicola cockerelli* (Pilsbry and Ferriss)
  - *Fossaria dalli* (Baker)
  - *Lymnaea stagnalis jugularis* Say

[11] See note 3, p. 8.

Gyraulus circumstriatus (Tryon)
Gyraulus parvus (Say)
Armiger crista (Linnaeus)
Helisoma trivolvis (Say)
Promenetus exacuous (Say)
Promenetus umbilicatellus (Cockerell)
Laevapex fuscus (Adams)
Physa anatina Lea
Physa gyrina Say
Aplexa hypnorum (Linnaeus)
Order Stylommatophora
Gastrocopta armifera (Say)
Gastrocopta cristata (Pilsbry and Vanatta)
Gastrocopta procera (Gould)
Pupoides albilabris (Adams)
Pupoides inornatus Vanatta
Pupilla blandi Morse
Vertigo ovata Say
Vallonia gracilicosta Reinhardt
cf. *Succinea*
Hawaiia minuscula (Binney)
Class Osteichthyes
Unstudied material
Class Amphibia
Order Caudata
Ambystoma tigrinum (Green), tiger salamander
Class Aves
Order Podicipediformes
Podiceps caspicus (Hablizl), eared grebe
Order Anseriformes
Anas acuta Linnaeus, pintail duck
Anas clypeata (Linnaeus), shoveller duck
Anas, duck
Aythya, scaup duck
Order Charadriiformes
Bartramia longicauda (Bechstein), upland plover
Erolia, sandpiper
Order Columbiformes
Zenaidura macroura (Linnaeus), mourning dove
Order Passeriformes
Agelaius?
Molothrus?
Calamospiza melanocorys Stejneger, lark bunting..
Calcarius, longspur
Class Mammalia
Order Insectivora
Sorex cinereus Kerr, masked shrew
Order Rodentia
Citellus richardsonii (Sabine), Richardson's ground squirrel
Citellus tridecemlineatus (Mitchill), thirteen-lined ground squirrel

Cynomys ludovicianus (Ord), blacktail prairie dog
Geomys, eastern pocket gopher
Perognathus, pocket mouse
Onychomys leucogaster (Wied-Neuwied), northern grasshopper mouse
Peromyscus, deer mouse
Pedomys ochrogaster (Wagner), prairie vole
Microtus pennsylvanicus (Ord), meadow vole

Order Carnivora
Mephitis mephitis (Schreber), skunk
Taxidea taxus (Schreber), badger

Order Artiodactyla
†*Camelops,* camel
†*Platygonus,* peccary

Rejected records.—

Pisidium abditum = *P. ferrugineum; Pisidium noveboracense* = *P. nitidum* and *P. walkeri; Pisidium lilljeborgi?* = *P. lilljeborgi; Lymnaea stagnalis* subsp.? = *L. stagnalis jugularis; Lymnaea stagnalis* = *L. stagnalis jugularis; Lymnaea parva* = *Fossaria dalli; Helisoma lentum* = *H. trivolvis; Gastrocopta armifera abbreviata* = *G. armifera; Pupoides marginatus* = *P. albilabris; Pupoides hordaceus* = *P. inornatus; Pupilla muscorum* = *P. blandi; Vallonia costata* = *V. gracilicosta; Succinea grosvernori* = cf. *Succinea; Succinea* cf. *avara* = cf. *Succinea; Succinea* cf. *grosvenori* = cf. *Succinea; Mephitis mesomelas* = *M. mephitis.*

Musculium partumeium was recorded by Goodrich (1940) as from the Jones local fauna, but the specimens are actually from a lower stratigraphic horizon.

Locality.—The Jones local fauna is known from a single locality, in sec. 8, T. 33 S., R. 27 W., Meade County, Kansas. The fossils occur in the Vanhem formation, in beds 5 and 6 of the section described by Hibbard (1940). The sediments filled a sinkhole during the late Pleistocene.

Age and environment.—The local nature of the sinkhole deposit from which the fossils come reduces the amount of stratigraphic information obtainable. The upper part of the sedimentary fill is referred to the Vanhem formation only because of its lithologic similarity to the type Vanhem formation in Clark County. Environmental inferences from the Jones local fauna indicate a glacial age and the low percentage of extinct species, in contrast to Illinoian and Sangamon assemblages, suggests that it is Wisconsin.

Certain of the species are extant but now live considerably north of the fossil site. This environmental shift of such forms as *Sorex, Microtus,* and *Citellus richardsonii* and especially of the mollusks *Pisidium ferrugineum, Pisidium lilljeborgi* and *Valvata tricarinata* suggests that the summer temperatures were much lower than those in southwestern Kansas today. The presence of these now northern species, together with the absence of southern elements, in the fauna, is further evidence for its glacial age.

RECENT FAUNA OF MEADE COUNTY

Since the simplest and most obvious method of ecologic interpretation of faunas is to analyze the habitat requirements of component species, this approach is the principal source of our paleoecologic inferences. Sampling error, both in connection with the preservation as well as the collection of the fossils, inevitably affects such interpretations, however; hence, another source of ecologic information, the comparison of each extinct fauna with the one now living near the fossil locality was employed. While the Recent fauna can become much better known than the ancient, sampling error still affects it. The absence of some Recent species in the fossil fauna may be uncertain, but the former presence of species now locally extinct can be established to a much higher degree of probability.

To provide a basis for comparison between the Recent and late Pleistocene faunas of the Meade County area we summarized, so far as possible, in the lists below the living representatives of two of the major fossil groups which have been collected—the vertebrates and the mollusks. The Recent fishes and birds remain unstudied.

Mollusca

The first records of living mollusks from the Meade County area were published by Call (1885*a,* p. 52; 1885*b,* p. 118). They referred to shells from "marshy draws near Belle Meade, Ford Co." that were collected by F. W. Cragin. (Belle Meade, later changed to Meade Center, is now simply Meade.) No more mollusks were noted from this region until the appearance of A. E. Leonard's report (1943). Her paper, which included both Meade and Clark counties, remains the only comprehensive study of mollusks for southwestern Kansas or western Oklahoma. Subsequent publications have revised the nomenclature or identification of a few species and added some others to her list (see Franzen and Leonard, 1947; Lee, 1951; A. B. Leonard, 1950, p. 45, and 1959; Miles, 1958; Webb, 1953). Such revision and addition is continued in this paper; it is based on collections made in 1950 and 1957 and on taxonomic changes made in the course of the paleontologic studies.

FAUNAL LIST OF RECENT SPECIES

Class Pelecypoda
- Order Prionodesmacea
  - *Anodonta grandis* Say
  - *Uniomerus tetralasmus* (Say)
- Order Teleodesmacea
  - *Sphaerium transversum* (Say)
  - *Pisidium casertanum* (Poli)

Class Gastropoda
- Order Basommatophora
  - *Stagnicola bulimoides techella* (Haldeman)

Stagnicola cockerelli (Pilsbry and Ferriss)
Fossaria dalli (Baker)
Fossaria obrussa (Say)
Gyraulus parvus (Say)
Helisoma trivolvis (Say)
Promenetus exacuous (Say)
Physa anatina Lea

Order Stylommatophora
Gastrocopta armifera (Say)
Gastrocopta cristata (Pilsbry and Vanatta)
Gastrocopta pellucida hordeacella (Pilsbry)
Gastrocopta procera (Gould)
Gastrocopta tappaniana (Adams)
Pupoides albilabris (Adams)
Vertigo ovata Say
Vallonia parvula Sterki
Succinea concordialis Gould
Succinea vaginacontorta Lee
Oxyloma retusa (Lea)
Quickella vagans (Pilsbry)
Philomycus carolinianus (Bosc)
Helicodiscus parallelus (Say)
Helicodiscus singleyanus (Pilsbry)
Deroceras laeve (Müller)
Hawaiia minuscula (Binney)

Rejected records.—The following modifications of earlier records come either from the papers mentioned above or are noted in the section "Systematic Discussion."

Sphaerium solidulum? = *Sphaerium transversum; Pisidium fabale* and *P. compressum* = *Pisidium casertanum; Limnophysa catascopium* = *Stagnicola bulimoides techella; Limnophysa bulimoides* = *Stagnicola cockerelli; Lymnaea parva* = *Fossaria dalli; Lymnaea humilis rustica* = *Fossaria obrussa; Gyraulus circumstriatus* = *Gyraulus parvus; Physa hawni* = *Physa anatina; Gastrocopta armifera abbreviata* = *Gastrocopta armifera; Gastrocopta procera mcclungi* = *Gastrocopta procera; Gastrocopta tappaniana curta* = *Gastrocopta tappaniana; Pupoides marginatus* = *Pupoides albilabris; Deroceras gracilis?* = *Deroceras laeve.*

A. B. Leonard (1950, p. 45) recorded *Succinea grosvenori* also, but Miles (1958) believed that Kansas records for this species are based on other members of the family.

Vertebrata

Lists are based on collections by Hibbard and paleontologic field parties since 1937; specimens are in the University of Kansas Museum of Natural History and the University of Michigan Museum of Zoology. Mammal records were supplemented by reports by early settlers. *Bison,* elk, mule deer and whitetail deer have been reintroduced at Meade County State Park. The deer have free range of the park and some stray away.

Subspecific identifications of the amphibians and reptiles are from Conant (1958). Nomenclature of the mammals except that of the bears, which is from Erdbrink (1953), is that of Miller and Kellogg (1955).

FAUNAL LIST OF RECENT SPECIES[12]

Class Amphibia
- Order Caudata
  - *Ambystoma tigrinum* (Green), tiger salamander
- Order Salientia
  - *Scaphiopus bombifrons* Cope, Plains spadefoot toad
  - *Bufo cognatus* Say, Plains toad
  - *Bufo woodhousii woodhousii* Girard, Rocky Mountain toad
  - *Acris crepitans blanchardi* Harper, northern cricket frog
  - *Pseudacris clarkii* (Baird), spotted chorus frog
  - *Rana catesbeiana* Shaw, bullfrog
  - *Rana pipiens* Schreber, leopard frog
  - *Gastrophryne olivacea* (Hallowell), western narrow-mouthed frog

Class Reptilia
- Order Chelonia
  - *Chelydra serpentina* (Linnaeus), snapping turtle
  - *Kinosternon flavescens flavescens* (Agassiz), yellow mud turtle
  - *Terrapene ornata* (Agassiz), ornate box turtle
  - *Chrysemys picta belli* (Gray), western painted turtle
  - *Pseudemys scripta elegans* (Wied), red-eared turtle
  - *Trionyx spinifer hartwegi* Conant & Goin, western spiny softshell turtle
- Order Squamata
  - *Crotaphytus collaris collaris* (Say), eastern collared lizard
  - *Holbrookia maculata maculata* Girard, northern earless lizard
  - *Sceloporus undulatus garmani* (Boulenger), northern prairie lizard
  - *Phrynosoma cornutum* (Harlan), Texas horned toad
  - *Cnemidophorus sexlineatus* (Linnaeus), six-lined racerunner
  - *Eumeces obsoletus* (Baird and Girard), Great Plains skink
  - *Leptotyphlops dulcis dissectus* (Cope), New Mexico blind snake
  - *Natrix erythrogaster transversa* (Hallowell), blotched water snake
  - *Natrix rhombifera rhombifera* (Hallowell), diamond-backed water snake
  - *Natrix sipedon sipedon* (Linnaeus), northern water snake
  - *Thamnophis sirtalis parietalis* (Say), red-sided garter snake
  - *Thamnophis radix haydeni* (Kennicott), western Plains garter snake
  - *Thamnophis sauritus proximus* (Say), western ribbon snake
  - *Heterodon platyrhinos* Latreille, eastern hognose snake
  - *Heterodon nasicus nasicus* Baird and Girard, Plains hognose snake
  - *Diadophis punctatus arnyi* (Kennicott), prairie ringneck snake
  - *Coluber constrictor flaviventris* (Say), eastern yellow-bellied racer
  - *Masticophis flagellum testaceus* (Say), western coachwhip
  - *Elaphe guttata emoryi* (Baird and Girard), Great Plains rat snake
  - *Arizona elegans blanchardi* Klauber, Kansas glossy snake
  - *Pituophis melanoleucus sayi* (Schlegel), bullsnake
  - *Lampropeltis calligaster calligaster* (Harlan), prairie kingsnake
  - *Lampropeltis getulus holbrooki* Stejneger, speckled kingsnake

[12] Species locally extinct are marked by a double dagger (‡).

Lampropeltis doliata gentilis (Baird and Girard), western milk snake
Rhinocheilus lecontei tessellatus Garman, Texas long-nosed snake
Tantilla nigriceps nigriceps Kennicott, Plains black-headed snake
Sistrurus catenatus tergeminus (Say), western massasauga
Crotalus viridis viridis (Rafinesque), prairie rattlesnake

Class Mammalia

Order Marsupialia

Didelphis marsupialis virginiana Kerr, Virginia opossum

Order Insectivora

Cryptotis parva parva (Say), least shrew
Scalopus aquaticus intermedius (Elliott), eastern mole

Order Chiroptera

Lasiurus borealis borealis (Müller), red bat
Lasiurus cinereus cinereus (Beauvois), hoary bat
Tadarida mexicana (Saussure), Mexican free-tailed bat

Order Rodentia

Cynomys ludovicianus ludovicianus (Ord), blacktail prairie dog
Citellus tridecemlineatus arenicola A. H. Howell, thirteen-lined ground squirrel
Citellus spilosoma marginatus (V. Bailey), spotted ground squirrel
Sciurus niger rufiventer E. Geoffroy-Saint-Hilaire, fox squirrel
Geomys bursarius industrius Villa and Hall, Plains pocket gopher
‡*Cratogeomys castanops castanops* (Baird), Mexican pocket gopher
Perognathus flavescens flavescens Merriam, Plains pocket mouse
Perognathus flavus bunkeri Cockrum, silky pocket mouse
Perognathus hispidus paradoxus Merriam, hispid pocket mouse
Dipodomys ordii richardsoni (J. A. Allen), Ord's kangaroo rat
Castor canadensis Kuhl, beaver
Reithrodontomys montanus albescens Cary, Plains harvest mouse
Reithrodontomys megalotis aztecus J. A. Allen, western harvest mouse
Peromyscus maniculatus luteus Osgood, deer mouse
Peromyscus leucopus tornillo Mearns, white-footed mouse
Onychomys leucogaster arcticeps Rhoades, northern grasshopper mouse
Sigmodon hispidus texianus (Audubon and Bachman), hispid cotton rat
Neotoma micropus canescens J. A. Allen, southern Plains woodrat
Synaptomys cooperi paludis Hibbard and Rinker, southern bog lemming
Pedomys ochrogaster taylori (Hibbard and Rinker), prairie vole
Ondatra zibethicus cinnamominus (Hollister), muskrat

Order Carnivora

Canis latrans latrans Say, coyote
‡*Canis lupus nubilus* Say, gray wolf
Vulpes velox velox (Say), kit fox
Urocyon cinereoargenteus (Schreber), gray fox
‡*Ursus americanus* Pallas, black bear
Procyon lotor hirtus Nelson and Goldman, raccoon
Mustela frenata neomexicana (Barber and Cockerell), long-tailed weasel
Mustela vison Schreber, mink
‡*Mustela nigripes* (Audubon and Bachman), black-footed ferret
Taxidea taxus merriami Schantz, badger
Spilogale interrupta (Rafinesque), spotted skunk
Mephitis mephitis varians Gray, long-tailed skunk

‡*Felis concolor hippolestes* Merriam, mountain lion
Lynx rufus baileyi Merriam, bobcat
Order Lagomorpha
‡*Lepus townsendii campanius* Hollister, white-tailed jackrabbit
Lepus californicus melanotis Mearns, black-tailed jackrabbit
Sylvilagus floridanus llanensis Blair, eastern cottontail
Sylvilagus audubonii neomexicanus Nelson, New Mexico cottontail
Order Artiodactyla
‡*Cervus canadensis* (Erxleben), elk
‡*Odocoileus* sp., deer
‡*Antilocapra americana americana* (Ord), pronghorn
‡*Bison bison bison* (Linnaeus), bison

SYSTEMATIC DISCUSSION

The systematic section of this paper is devoted primarily to the collation of the taxonomic information necessary for identification of the species in the Butler Spring and Cragin Quarry local faunas, but it also furnishes stratigraphic and ecologic information about these species. References include (*a*) all previous records for the Cragin Quarry and Butler Spring local faunas, (*b*) all previous records of Recent mollusks in Meade County, (*c*) records in other late Pleistocene faunas of southwestern Kansas and northwestern Oklahoma which are revised herein, and (*d*) principal sources for taxonomic, geographic, and ecologic information.

The mollusks have been studied by Taylor. The systematic treatment is uneven, because some species have received more careful study than others. In summarizing data about Recent distributions, it was realized that in many cases (e.g., Pilsbry, 1948) those on range are misleading, since they are based on a mixture of Recent, fossil, and uncertain material, the result of uncritical inclusion of river-drift specimens. In compiling the distribution maps (Figs. 5–9) and the lists of peripheral occurrences special care has been taken to eliminate this source of error. The location of the shells examined has been indicated by citing institutions and catalogue numbers; sources not otherwise identified are cited under the species heading. Leonard's "Handbook of Gastropods in Kansas" (Leonard, 1959) is an important source for geographic and ecologic information, but appeared too late for most of the pertinent data to be included.

With regard to taxonomic matters concerning particular groups, friends at the University of Michigan Museum of Zoology have been most helpful. J. B. Burch and H. J. Walters assisted us with the Lymnaeidae and P. F. Basch with the Ferrissiidae; Henry van der Schalie identified the *Quadrula*. H. B. Herrington, Keene, Ontario, is responsible for most of the section on the Sphaeriidae; he identified the majority of the specimens and all of the species and the text of that part is based largely on Herrington and Taylor (1958). J. P. E. Morrison, U. S. National Museum, aided in the discussion of several taxonomic questions.

References given in the synonymies for the mollusks do not usually include original descriptions, type designations for genera, or other nomenclatural information. These data may, however, be found through the citations that are listed. The conventional arrangement (chronological order under each synonymic heading) has only been followed in the instances of more thorough systematic study. Ordinarily, the more general and significant references precede the minor and less significant. Consistency has been sacrificed in the hope of greater usefulness.

The number of shells listed is the minimum of individuals required to account for the total of whole and fragmentary specimens studied. Up to 200, these numbers are counts of individual specimens, beyond that they are usually estimates. Separated clam shells are shown as fractions; for example, 29/2 signifies 29 isolated valves. Integers represent whole shells.

The mammals were studied by Hibbard, who also summarized, from published and unpublished sources, the data on the lower vertebrates.

Catalogue numbers not otherwise identified are those of the University of Michigan Museum of Paleontology. Names of other collections are abbreviated as follows: AMNH, American Museum of Natural History; ANSP, Academy of Natural Sciences of Philadelphia; DEB, Mrs. D. E. Beetle, Laramie, Wyoming; UIMNH, University of Illinois Museum of Natural History; KU, Kansas University Museum of Natural History; UCMNH, University of Colorado Museum of Natural History; UMMZ, University of Michigan Museum of Zoology; USGS, United States Geological Survey; USNM, United States National Museum.

Taxonomic Changes and Additions

Two new species are described:

Dasypterus golliheri Hibbard, sp. nov.
Peromyscus progressus Hibbard, sp. nov.

Certain previously described forms are placed in synonymy:

Cincinnatia emarginata canadensis Baker = *Probythinella lacustris* (Baker)
Probythinella lacustris limafodens Morrison = *Probythinella lacustris* (Baker)
Carychium perexiguum Baker = *Carychium exiguum* (Say)
Lymnaea macella Leonard = *Stagnicola exilis* (Lea)
Lymnaea parexilis Leonard = *Stagnicola exilis* (Lea)
Galba bulimoides cassi Baker = *Stagnicola bulimoides techella* (Haldeman)
Lymnaea diminuta Leonard = *Stagnicola bulimoides techella* (Haldeman)
Lymnaea hendersoni Baker = *Stagnicola cockerelli* (Pilsbry and Ferriss)
Lymnaea turritella Leonard = *Fossaria dalli* (Baker)
Planorbis parvus walkeri Vanatta = *Gyraulus circumstriatus* (Tryon)
Planorbis vermicularis hendersoni Walker = *Gyraulus circumstriatus* (Tryon)
Gyraulus labiatus Leonard = *Gyraulus parvus* (Say)

Gyraulus enaulus Leonard = *Gyraulus parvus* (Say)
Menetus pearlettei Leonard = *Promenetus kansasensis* (Baker)
Planorbis Harni Pilsbry = *Promenetus exacuous* (Say)
Planorbis exacutus var. *rubellus* Sterki = *Promenetus exacuous* (Say)
Planorbis exacuous megas Dall = *Promenetus exacuous* (Say)
Planorbis imus Vanatta = *Promenetus exacuous* (Say)
Menetus hudsonicus Pilsbry = *Promenetus exacuous* (Say)
Menetus coloradoensis Baker = *Promenetus exacuous* (Say)
Promenetus blancoensis Leonard = *Promenetus umbilicatellus* (Cockerell)
Ancylus pumilus Sterki = *Ferrissia meekiana* (Stimpson)
Physa parva Lea = *Physa anatina* Lea
Physa grosvenorii Lea = *Physa anatina* Lea
Physa hawnii Lea = *Physa gyrina* Say
Sphyradium hasta Hanna = *Pupilla muscorum* (Linnaeus)
Columella tridentata Leonard = *Gastrocopta armifera* (Say)
Gastrocopta proarmifera Leonard = *Gastrocopta armifera* (Say)
Succinea haydeni Binney = *Oxyloma retusa* (Lea)
Oxyloma navarrei Leonard = *Oxyloma retusa* (Lea)
Capromeryx minimus Meade = *Capromeryx furcifer* Matthew
Breameryx Furlong, 1946 = *Capromeryx* Matthew, 1902

The following forms, previously considered as varieties or subspecies, are raised to specific rank:

Lymnaea bulimoides cockerelli Pilsbry and Ferriss = *Stagnicola cockerelli* (Pilsbry and Ferriss)
Pupilla muscorum sinistra Franzen = *Pupilla sinistra* Franzen

Phylum MOLLUSCA
Class PELECYPODA
Order PRIONODESMACEA
Family Unionidae
Subfamily Anodontinae
Genus *Anodonta* Lamarck, 1799
Subgenus *Pyganodon* Crosse and Fischer, 1894
Anodonta (Pyganodon) grandis Say, 1829

Anodonta grandis Say, Baker, 1928*b*, p. 152, Pl. 62, Fig. 5. Frierson, 1927, p. 14. A. E. Leonard, 1943, p. 231, Pl. 2, Figs. 22–23. Franzen and Leonard, 1943, p. 391, Pl. 28, Fig. 2.
Anodonta gigantea Lea, Baker, 1928*b*, p. 161, Pl. 62, Fig. 4; Pl. 65, Fig. 3.
?*Anodonta* sp., Taylor and Hibbard, 1955, p. 12.

Geologic range.—Late Pleistocene to Recent. There are no certain fossil occurrences of this species in the southern Great Plains.

Distribution.—Throughout the Mississippi River system, and in adjacent parts of the St. Lawrence and Red River of the north drainages; northwest to Lake Winnipeg, Manitoba, and southwest to Texas.

Habitat.—This widespread species lives in relatively quiet, shallow perennial bodies of water, such as creeks, ponds, lakes, and marginal areas of larger streams. In Meade County, Kansas, A. E. Leonard (1943) found that "Throughout the upper reaches of Crooked Creek, *Anodonta grandis* occurs in beds including many individuals, but in the stream below the town of Meade, where the bottom becomes sandy, this mussel is absent. The dry beaches left when Lake Larrabee was drained were covered with the shells of *A. grandis.*"

Occurrence.—Recent in Meade County, Kansas; ? Butler Spring and ? Jinglebob local faunas.

Material.—Butler Spring loc. 1, UMMZ 177365 (1/2), 177366 (1/2); Jinglebob, UMMZ 177628 (2/2).

Remarks.—Fragmentary material from the Butler Spring local fauna may represent *A. grandis*. The fossils show the double-looped beak sculpture and lack of hinge teeth which characterize *Anodonta* and are relatively thick-shelled.

Family Quadrulidae
Subfamily Quadrulinae
Genus *Uniomerus* Conrad, 1853
Uniomerus tetralasmus (Say), 1830

Uniomerus tetralasmus (Say), Ortmann, 1912, p. 272. A. E. Leonard, 1943, p. 231, Pl. 2, Figs. 26–27. Franzen and Leonard, 1943, p. 394, Pl. 29, Fig. 11.
Elliptio tetralasmus Say, Frierson, 1927, p. 34.
Unio tetralasmus Say, Scammon, 1906, p. 336, Pl. 78, Fig. 1. Isely, 1925, p. 100.

Geologic range.—Unknown.

Distribution.—"Throughout the Mississippi valley as far north as forty degrees latitude and southwest to Mexico. It is also found in the Ohio and Alabama river systems." (Scammon, 1906, p. 337).

Habitat.—"This is an exceedingly interesting species. It thrives in temporary ponds, 'tanks,' sloughs, and intermittent creeks. In small sluggish streams where no other mussels are likely to be found *U. tetralasmus* will probably appear. This species has unusual power to withstand drying . . . I have found animals alive and in perfectly good condition buried deeply in old pond bottoms, so dry on the surface that the ground was being plowed." (Isley, 1925, p. 100). "In Kansas this species is found in all the drainage areas, but perhaps most frequently in the small, muddy tributaries and the large ponds and lakes of the southern drainage basin. There is hardly another species which has an equal range over the state . . ." (Scammon, 1906, p. 337).

In Meade County this mussel lives in the deep pools of the upper part of Crooked Creek, along with *Anodonta grandis.*

Occurrence.—Recent in Meade County, Kansas.

Remarks.—The most striking account of the resistance to desiccation shown by *Uniomerus tetralasmus* is that of Witter (1888). After collecting *Unio camptodon* (= *Uniomerus tetralasmus*) and *Unio subrostratus*

(= *Ligumia subrostrata*) in Allen Creek, seven miles northwest of Emporia, Lyon County, Kansas, he reported:

I procured a box of about three pecks capacity, in which I placed my larger specimens first, and filled the interstices along with the smaller, including some fossils and pebbles from the vicinity. The soft parts of *camptodon* and *subrostratus* were not removed. Alive as they were, they were thrust in among the other material, all of which was very dry. I then shook into the box all the dry oats it would hold and put on a lid. The box was scarcely tight enough to hold the oats. They were packed July 22d, 1886.

On arrival at Muscatine, I put the box in my study, a dry room on the second floor. Here it remained unopened till August 29th. When I opened the box on this date everything seemed thoroughly dry. On removing the specimens, I found *subrostratus* all open and completely desicated. *Camptodon* were all tightly closed. I tried to open them with my knife, but found this impossible without breaking the shell. I determined to soak them in water a little while, as I supposed the valves adhered through some animal matter that had dried in them. I put the whole twelve in a bucket of water, when, in a few minutes I could scarcely believe my eyes. They were all alive and well as far as I could judge, although they had been packed in a dry box in dry oats, in a dry room from July 22d to August 29th, a period of thirty eight days, in the hottest and driest part of the year,—and the summer of 1886 was characterized by a drouth in the west.

Other observations of resistance to desiccation by this species have been summarized by van der Schalie (1940).

Genus *Quadrula* Rafinesque, 1820

Quadrula quadrula (Rafinesque), 1820

(Pl. IV, Figs. 4, 7)

Quadrula quadrula (Rafinesque), Neel, 1941, p. 3, Pl. 1, Figs.1–4. Franzen and Leonard, 1943, p. 397, Pl. 28, Fig. 8.

Quadrula quadrula Rafinesque, Frierson, 1927, p. 47.

Quadrula quadrula, Raf., Baker, 1928*b,* p. 84, Pl. 46, Fig. 4; Pl. 48, Figs. 2–4.

Quadrula quadrula bullocki Nov. Var., Baker, 1928*b,* p. 87, Pl. 46, Figs. 1–3.

Quadrula quadrula-fragosa Conrad, Frierson, 1927, p. 47.

Quadrula fragosa (Conrad), Baker, 1928*b,* p. 88, Pl. 46, Figs. 5–6; Pl. 47, Fig. 1; Pl. 48, Fig. 1.

Quadrula fragosa Conrad, Scammon, 1906, p. 353, Pl. 82, Fig. 1.

Quadrula lachrymosa Lea, Scammon, 1906, p. 351, Pl. 82, Fig. 2.

Geologic range.—Late Pleistocene to Recent. The earliest record in the southern Great Plains is in the Illinoian Butler Spring local fauna.

Distribution.—Throughout most of the Mississippi River drainage and adjacent parts of the basins of the Red River of the North and Great Lakes; Alabama River system; westward to central Texas.

Habitat.—"This species is not at all choice as to habitat. It often rivals *Obovaria ellipsis* as a habitant of sand-bars, and is also found in mud or shingle in water of variable depth." (Scammon, 1906, p. 352).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 3, UMMZ 197592 (1/2).

Order TELEODESMACEA

Family Sphaeriidae

Genus *Sphaerium* Scopoli, 1777

Sphaerium partumeium (Say), 1822

Sphaerium partumeium (Say), Herrington and Taylor, 1958, p. 7.
Musculium partumeium (Say) Baker, 1928*b*, p. 354, Pl. 99, Figs. 24–26.
Musculium truncatum (Linsley), Baker, 1928*b*, p. 356, Pl. 99, Figs. 21–23.

Geologic range.—Early Pleistocene (Nebraskan age) to Recent. In the southern Great Plains the earliest known occurrence is in the Nebraskan or Aftonian Dixon local fauna.

Distribution.—Most of the United States; less common in mountainous areas; southern Canada from Saskatchewan to Quebec.

Habitat.—This species is found in ponds and eddies in streams where there is considerable vegetation and a soft bottom.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, UMMZ 184454 (33/2), USGS 21274-1 (30/2).

Sphaerium striatinum (Lamarck), 1818

(Pl. IV, Figs. 10, 12–16)

Sphaerium striatinum (Lamarck), Herrington and Taylor, 1958, p. 9. D. W. Taylor, 1957, p. 656. Baker, 1928*b*, p. 334, Pl. 98, Figs. 1–5.

Geologic range.—Middle Pliocene to Recent. In the southern High Plains, the species is first known from the late Pliocene Saw Rock Canyon local fauna.

Distribution.—Almost all of North America, from Great Slave Lake, Northwest Territories, to Panama.

Habitat.—Perennial water bodies with some current action are suitable habitats. The species lives in large lakes or small ones, in rivers or small streams, in a bottom of gravel, sand, or mud. Ponds, lagoons, and swamps are not favorable places, probably because there is insufficient current to thoroughly oxygenate the water.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 177367 (24/2), 197545 (3/2), USGS 21042-1 (14/2), 21042-2 (9/2).

Remarks.—The synonymy of this species will probably prove to be long, on account of its variability in different habitats. There are certainly other names in Baker's work (1928*b*) which refer to this species, but a comprehensive list cannot be yet given.

Sphaerium transversum (Say), 1829

(Pl. IV, Figs. 8–9, 11)

Sphaerium transversum (Say), Herrington and Taylor, 1958, p. 8.
Musculium transversum (Say), Baker, 1928*b*, p. 351, Pl. 98, Figs. 22–25 (not 22–28).

Sphaerium solidulum (Prime)?, A. E. Leonard, 1943, p. 231, Pl. 2, Figs 24–25 (not of Prime).

Geologic range.—Early Pleistocene (Nebraskan age) to Recent. In the southern Great Plains, the earliest known record is in the Dixon local fauna (Nebraskan or Aftonian).

Distribution.—North America east of the Rocky Mountains from Mexico to the Northwest Territories.

Habitat.—Information on labels of specimens in the collection of H. B. Herrington suggests still water and a muddy bottom as the usual habitat for this clam. In Meade County, Kansas, it occurs commonly in Crooked Creek, and lives in both sand and mud in slow current or quiet water. Empty shells were abundant in a dry metal stock tank, usually kept full by a windmill pump. Before the water had dried up, the habitat there was a soft mud bottom, with thin cover of submerged aquatic vegetation.

Occurrence.—Butler Spring local fauna; Recent in Meade County, Kansas.

Material.—Butler Spring loc. 1, UMMZ 177368 (1/2), 197546 (4/2).

Sphaerium indeterminate

Sphaerium indet., Herrington and Taylor, 1958, p. 13; in part.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 186410 (1/2).

Remarks.—An indeterminate valve may represent a third species of *Sphaerium* in the Butler Spring local fauna.

Genus *Pisidium* Pfeiffer, 1821

Pisidium casertanum (Poli), 1791

(Pl. I, Figs. 3–4; Pl. II, Fig. 2; Pl. III, Figs. 2, 6, 8)

Pisidium casertanum (Poli), Herrington, 1954, p. 131. Herrington and Taylor, 1958, p. 14.

Pisidium abditum Haldeman, A. B. Leonard, 1950, p. 42, Pl. 1, Fig. I.

Pisidium fabale Sterki, A. E. Leonard, 1943, p. 234, Pl. 2, Figs. 28–29.

Pisidium compressum Prime, A. E. Leonard, 1943, p. 234; not of Prime.

Geologic range.—Early Pliocene to Recent. The Laverne local fauna (early Pliocene) of Beaver County, Oklahoma, yields the earliest known record of this species.

Distribution.—Almost cosmopolitan; in the Western Hemisphere from Patagonia to Alaska.

Habitat.—The wide distribution of *Pisidium casertanum* reflects a corresponding adaptability, greater than any other American sphaeriid. It thrives wherever any other species of *Pisidium* can live, except for deep water. The typical form, with relatively heavy shells, frequents rivers or fairly large creeks. Those with thinner shells with smoother outline are found in ponds, swamps, lagoons, bog ponds, and similar quiet water bodies. Because *P. casertanum* is one of the few species of *Pisidium* which can tolerate seasonal desiccation, it sometimes may be the only aquatic mollusk present in a small, temporary stream or seepage.

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197547 (17/2), USGS 21042–3 (12/2). Cragin Quarry: loc. 1, UMMZ 184468 (600/2), USGS 21274–2 (600/2); loc. 3, UMMZ 197519 (7/2); loc. 4, UMMZ 197528 (1/2).

Pisidium compressum Prime, 1851

(Pl. I, Figs. 1–2, 5; Pl. II, Figs. 1, 5–6; Pl. III, Figs. 1, 5, 7)

Pisidium compressum Prime, Herrington, 1954, p. 135. Herrington and Taylor, 1958, p. 15. A. B. Leonard, 1950, p. 40, Pl. 1, Figs. *G–H*. Frye and Leonard, 1952, p. 159, Pl. 15, Fig. *k*. D. W. Taylor, 1957, p. 657.

Geologic range.—Middle Pliocene to Recent. In the southern Great Plains the earliest known occurrence is in the Dixon local fauna (Nebraskan or Aftonian).

Distribution.—North America, from Great Slave Lake, Northwest Territories, to Mexico.

Habitat.—This species inhabits only perennial water bodies with some current action, such as lakes, rivers, and creeks; it is never found in ponds, swamps, lagoons, or bogs.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 186409 (3/2), 197548 (1+348/2), USGS 21042–4 (380/2).

Pisidium nitidum Jenyns, 1832

(Pl. I, Fig. 6; Pl. II, Figs. 3–4, 7; Pl. III, Figs. 3–4)

Pisidium nitidum Jenyns, Herrington, 1954, p. 132. Herrington and Taylor, 1958, p. 15.

Geologic range.—Early Pliocene to Recent. The earliest known record in the southern Great Plains is in the early Pliocene Laverne local fauna, Beaver County, Oklahoma.

Distribution.—Holarctic. Eurasia and North Africa; in North America from Hudson Bay to Mexico, except for the southeastern United States.

Habitat.—Occurs only in perennial water bodies, such as lakes, ponds, rivers, and large creeks.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197549 (121/2), USGS 21042–5 (100/2).

Pisidium walkeri Sterki, 1895

Pisidium walkeri Sterki, Herrington and Taylor, 1958, p. 17.

Geologic range.—Late Pleistocene to Recent. The earliest certain occurrence in the southern Great Plains is in the Sangamon Jinglebob local fauna; also occurs questionably in the Illinoian Butler Spring local fauna.

Distribution.—Northern North America; Canada from Ontario to Alberta, northward to James Bay and Northwest Territories; in the United States, Maine to Virginia, and Michigan, Ohio, Missouri, Iowa, South Dakota, Minnesota, Montana, and Arizona.

Habitat.—*Pisidium walkeri* is found in rivers, creeks, and small lakes.

Occurrence.—? Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197550 (1/2).

Remarks.—H. B. Herrington commented (letter dated January 15, 1958) as follows concerning the single valve: "As the posterior end and dorsal margin are gone I am not positive about its being *walkeri*. *Walkeri* is somewhat like *casertanum* in hinge characters, but the hinge is not parallel to the ventral margin but tilted back, and the anterior end is a long, fairly straight slope descending quite low down."

Class GASTROPODA
Subclass PROSOBRANCHIA
Order MESOGASTROPODA
Family Valvatidae
Genus *Valvata* Müller, 1774
Valvata tricarinata (Say), 1817
(Pl. V, Figs. 14–15)

Valvata tricarinata (Say), Baker, 1928*a*, p. 11, Pl. 1, Figs. 1–3. Frye and Leonard, 1952, p. 158, Pl. 15, Fig. *u*. D. W. Taylor, 1954*a*, p. 12. La Rocque, 1956, p. 13.
Valvata tricarinata Say, A. B. Leonard, 1950, p. 11, Pl. 1, Fig. *B*. van der Schalie, 1953, pp. 84, 88. Frye and Leonard, 1957*b*, p. 60, Pl. 5, Fig. 14.
Valvata tricarinata perconfusa Walker, Baker, 1928*a*, p. 16, Pl. 1, Fig. 4.
Valvata tricarinata unicarinata De Kay, Baker, 1928*a*, p. 16, Pl. 1, Fig. 5.
Valvata tricarinata mediocarinata Nov. Var., Baker, 1928*a*, p. 17, Pl. 1, Fig. 7.
Valvata tricarinata basalis Vanatta, Baker, 1928*a*, p. 17, Pl. 1, Figs. 8–9.
Valvata tricarinata infracarinata Vanatta, Baker, 1928*a*, p. 18.
Valvata tricarinata simplex Gould, Baker, 1928*a*, p. 18, Pl. 1, Figs. 10, 14.

Geologic range.—Early Pliocene to Recent. The only known Tertiary occurrence is in the Laverne local fauna of Beaver County, Oklahoma.

Distribution.—"Eastern United States west to Iowa; Great Slave Lake south to Virginia and the Ohio River" (Baker, 1928*a*, p. 14); an isolated spring occurrence in Cherry County, Nebraska.

Habitat.—A species that lives only in permanent lakes and rivers. In Nebraska it occurred in a spring-fed pond having a temperature of 15°C. The snails were crawling on aquatic plants, largely *Ceratophyllum*, *Elodea*, and algae, near the edge of the pond.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 177369 (41085), USGS 21042–6 (33000); loc. 2, UMMZ 197575 (17).

Remarks.—*Valvata tricarinata* was collected in 1953, considerably west and south of its previously known range, in a spring-fed pond at the old fort reservoir in the Fort Niobrara National Wildlife Refuge, 5 mi. east of Valentine, Cherry County, Nebraska. Existence of this northern species at this locality is presumably made possible because of the insulating effect of the cool spring water; the pond is warmed little if at all during the summer hot spells. Other permanent ponds in Cherry County, apparently similar except that they lack spring sources, were examined for this species but without success. The occurrence in great numbers of *V. tricarinata* in the Butler Spring local fauna is one of the main reasons for inferring a summer-cool climate from that assemblage.

This is the most abundant species at Butler Spring locality 1. The total given for the University of Michigan series, 41,085, is a count of individual specimens. The number of specimens in the U. S. Geological Survey series was estimated from volumetric measurement of 14,125 individually counted shells, and the calculated total, 74,085, is probably accurate to within 2000 specimens.

Family Hydrobiidae

Subfamily Hydrobiinae

Genus *Probythinella* Thiele, 1928

Probythinella lacustris (Baker), 1928

(Pl. IV, Figs. 1–2, 5–6)

Cincinnatia emarginata (Küster), Baker, 1928*a*, p. 126, Text Fig. 54: Nos. 1, 2, 6.

Cincinnatia emarginata lacustris Var. Nov., Baker, 1928*a*, p. 127, Pl. 7, Figs. 20–21; Text Fig. 54: Nos. 3, 4, 5; Text Figs. 55, 56*a*.

Cincinnatia emarginata canadensis Var. Nov., Baker, 1928*a*, p. 130, Text Fig. 54: Nos. 7, 8.

Vancleaveia emarginata canadensis (F. C. Baker), Baker, 1930*a*, p. 189, Fig. 2: Nos. 3–5, 10; Fig. 3.

Vancleaveia emarginata (Kuster), Baker, 1930*a*, p. 191, Fig. 2: Nos. 1, 2, 9; Fig. 3.

Vancleaveia lacustris (F. C. Baker), Baker, 1930*a*, p. 191, Fig. 2: Nos. 6–8, 11; Fig. 3.

Amnicola (Probythinella) binneyana Hannibal, Berry, 1943, p. 36, Pl. 1, Figs. 8–12; Pl. 3, Fig. 5; Pl. 6, Figs. 2, 3; Pl. 7, Fig. 5.

Probythinella lacustris lacustris (F. C. Baker), Morrison, 1947, p. 27.

Probythinella lacustris canadensis (F. C. Baker), Morrison, 1947, p. 27.

Probythinella lacustris limafodens, Nomen Novum, Morrison, 1947, p. 27.

Geologic range.—Late Pleistocene to Recent. In the southern Great Plains the earliest known occurrences are in the Illinoian Butler Spring and Doby Springs local faunas.

Distribution.—North America between the Rocky Mountains and the Appalachians, from Great Slave Lake to Arkansas, Alabama, and New York. The species is known from the Mackenzie River, Hudson Bay, St. Lawrence River and Mississippi River drainages, but not from the shorter streams of the Atlantic or Gulf coastal plains.

During the late Pleistocene, *Probythinella lacustris* occurred far west of its present range, in the southern and central Great Plains. The Illinoian-age occurrences in the Butler Spring and Doby Springs local faunas are from the only known localities at which this species has been found either living or fossil in Kansas and Oklahoma. Fossils (UMMZ 119876) of uncertain age, but probably Illinoian or Wisconsin, were collected by J. A. Singley at Peg Leg Crossing on the San Saba River, Menard County, Texas. These specimens represent the farthest southwest occurrence known for this species.

The distribution map (Fig. 5) is based on records from publications and on collections in the University of Michigan Museum of Zoology and the U. S. National Museum. Since drift specimens and fossils have been excluded from the Recent category, many records from the Great Lakes are not shown. Peripheral localities are as follows:

NORTHWEST TERRITORIES. Mackenzie Dist., Mackenzie R. 30 miles above Fort Providence. Lake Kakisa near mouth of Kakisa R. Sulphur Point, Great Slake Lake. Mills Lake. All from Whittaker, 1924.

MANITOBA. Saskatchewan River, Grand Rapids (Nutting, 1893). Winnipeg (Hanham, 1899). Clear Lake (Berry, 1943).

NORTH DAKOTA. Pembina Co.: Red River, Pembina (UMMZ 30002). Sheyenne R. south of Devils Lake (UMMZ 10963).

SOUTH DAKOTA. Roberts Co.: Lake Traverse (UMMZ 69822, 119894). Brookings Co.: Lake Campbell (Henderson, 1927, p. 20).

IOWA. Lyon Co.: Rock Rapids; B. Shimek, 1899 (USNM 506381).

NEBRASKA. Lancaster Co.: Salt Creek, Lincoln; B. Shimek, 1889 (USNM 526817).

MISSOURI. St. Louis Co.: Meramec R., Kirkwood; L. Hubricht, 1930 (UMMZ 54626; USNM 519982).

ARKANSAS. Lawrence Co.: Black R., Black Rock; A. A. Hinkley (UMMZ 119885). Chicot Co.: Grand Lake; R. Black, 1939 (UMMZ 133328).

ALABAMA. Madison Co.: Huntsville (UMMZ 69852).

INDIANA. Posey Co.: Wabash R., The Chains; A. A. Hinkley (UMMZ 119883).

OHIO. Clark Co.: Springfield; T. G. Lea (USNM 121328).

NEW YORK. Herkimer Co.: Canal, Mohawk; J. Lewis, 1867 (UMMZ 119879).

ONTARIO. Leeds Co.: St. Lawrence R. west of Brockville; H. B. Herrington (UMMZ 183912).

Habitat.—Probythinella lacustris is known almost exclusively from rivers and lakes at depths of about 5 feet or more. In Lake Erie, Berry (1943) found it in water no shallower than 5 feet and as deep as 18. He remarked that the large proportion of this species in the stomachs of whitefish from Canada probably indicates that it is common to depths of 60 or more feet. The deepest known occurrence of *P. lacustris* reported is from northern Lake Michigan. Living specimens were dredged from a depth of 25 meters, three-quarters of a mile north of Waugoshance Point, Emmet County, Michigan, on August 12, 1952, by a University of Michigan limnology class of which D. W. Taylor was a member. The fine sand

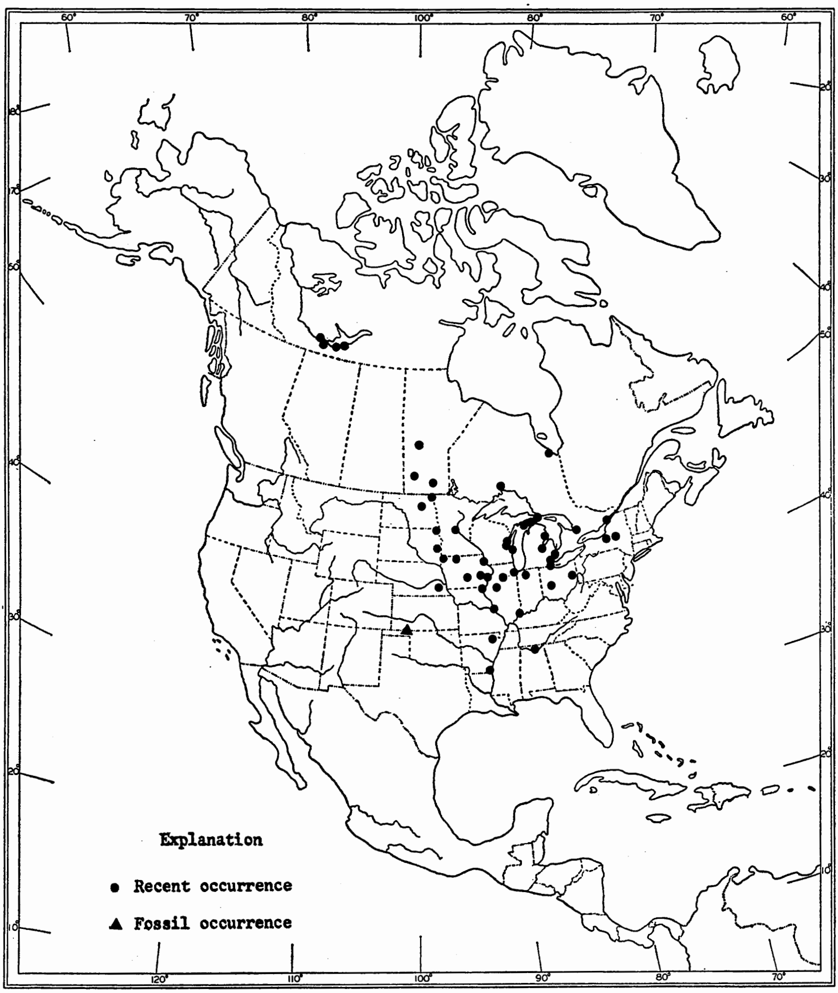

FIG. 5. Distribution of *Probythinella lacustris* (Baker).

bottom there had a *Pisidium–Pontoporeia*–oligochaete fauna. On the basis of what is known of its geographic and bathymetric range, this snail probably occurs on most of the bottom in the majority of the larger lakes of Canada and the northern United States.

The types of substratum on which *Probythinella lacustris* lives range from gravel, marl, and coarse sand (Berry, 1943) to soft mud (Morrison, 1947), but this snail is found on plants as well as on the bottom. Availability of food may, therefore, be a more influential factor in determining its local abundance than the grain size of sediments. At the Doby Springs locality, shells of *P. lacustris* are common in dark-gray sandy clay and mud, which suggests a former habitat of soft organic mud.

Occurrence.—Butler Spring and Doby Springs local faunas.

Material.—Butler Spring locality 1, UMMZ 197551 (2); Doby Springs loc. 4, UMMZ 185790 (3), uncat. (2500).

Remarks.—Various combinations of names have been applied to this species, and the differences between them and the one used here have come about as the result of several taxonomic and nomenclatural factors. These include the different ranks assigned to the generic group, the interpretation of the variation within the species and its nomenclatural expression, and the relationship between the holotype of *Paludina obtusa* Lea, 1841, and the species called *Amnicola binneyana* Hannibal by Berry (1943). Most of the pertinent information has been presented by Berry (1943) and Morrison (1947); the following discussion is intended only to supplement their papers.

Holotype of *Paludina obtusa:* Morrison (1947) asserted that the holotype of *Paludina obtusa* Lea, 1841, *non* Troschel, 1837, does not represent the species, or even the genus, which Berry (1943) called *Amnicola binneyana* Hannibal. Examination of the holotype partly confirmed his assertion. There are differences worthy of specific rank, but until the radula and verge of *Paludina obtusa* Lea are known the question of generic rank will remain uncertain. The name *binneyana,* proposed by Hannibal as a replacement for *obtusa* Lea, *non* Troschel, cannot apply to what Berry termed *binneyana.* The next available names are those of Baker (1928*a*); of them Morrison selected *lacustris* for the species.

The holotype of *Paludina obtusa* Lea (USNM 121394) differs from *Probythinella lacustris,* as considered in this paper, in three significant features: the nuclear whorl is larger, the sutures are more deeply impressed, and the whorls expand more slowly. The upper surface of the first whorl of the holotype lies in a plane, so that the shell in profile does look much like many specimens of *P. lacustris;* however, the shells of *P. lacustris* with proportions similar to the holotype of *P. obtusa* are larger and have half a whorl more. Shells of *P. lacustris* with 3½ whorls, like the holotype of *P. obtusa,* have a relatively larger aperture and body whorl, and a relatively more conspicuously truncate spire.

Variation: On the basis of size of umbilicus, number of planospirally coiled whorls, and shape of spire, Baker (1928*a*) divided the species into three ecological forms. One of them, *lacustris,* he later discriminated further as a distinct species (Baker, 1930*a*). Berry (1943) and Morrison (1947) both regarded the variation as intraspecific, and Berry did not designate Baker's "ecological forms" by formal names, but Morrison did.

From review of the literature and of the large amount of material of

Probythinella lacustris in the collections of the University of Michigan Museum of Zoology and U. S. National Museum, it is evident that the variation within the species is not consistently correlated with either habitat or geographic region. Shells from the Great Lakes are by no means all referable to a single one of the three forms described by Baker. There is no simple correlation of lake habitat with any one variant of shell form. Many shells from the Great Lakes are of the *lacustris* type, believed by Baker (1928*a*) and Berry (1943) to be the lake form, but many are also of the *canadensis* type, later believed by Baker (1930*a*) to be the lake form. Similarly, there is no shell form consistently correlated with a river habitat, and there is no warrant for taxonomic recognition of the known variation within *Probythinella lacustris.*

Rank of *Probythinella:* Whether to rank *Probythinella* as a distinct genus, rather than as a subgenus, is primarily a matter of subjective judgment. The differences in the radula, verge, and shell between *Probythinella* and other known Hydrobiidae appear adequate to justify generic rank. According to the classification of the family proposed by Morrison (1949) and adopted in this paper, *Probythinella* is not only generically distinct but even belongs in a separate subfamily from *Amnicola,* to which Berry (1943) subordinated it.

Subclass PULMONATA
Order BASOMMATOPHORA
Family Carychiidae
Genus *Carychium* Müller, 1774
Carychium exiguum (Say), 1822
(Pl. IV, Fig. 3)

Carychium exiguum (Say), Pilsbry, 1948, p. 1052, Figs. 561*a–b,* 562. A. B. Leonard, 1952, p. 17, Pl. 4, Fig. *G.* Frye and Leonard, 1952, pp. 164, 170, Pl. 16, Fig. *p;* Pl. 17, Fig. *r.* Harry, 1952, p. 5

Carychium exile H. C. Lea, Pilsbry, 1948, p. 1058, Fig. 561*c,* 566*a.* Franzen and Leonard, 1943, p. 407, Pl. 30, Figs. 3–4.

Carychium perexiguum n. sp., Baker, 1938, p. 128.

Carychium perexiguum Baker, A. B. Leonard, 1950, p. 22, Pl. 1, Fig. *D.* A. B. Leonard, 1952, p. 18, Pl. 4, Fig. *D.* Frye and Leonard, 1952, pp. 151, 158, 164, Pl. 14, Fig. *j;* Pl. 15, Fig. *z.* A. B. Leonard, 1957, p. 10, Pl. 1, Fig. 1.

Carychium cf. exiguum (Say), van der Schalie, 1953, p. 83.

Geologic range.—Late Pliocene to Recent. The only known Tertiary occurrence is in the Rexroad local fauna, Meade County, Kansas.

Distribution.—"Newfoundland to Colorado, south to Mobile Bay, Alabama, and near Deming, southwestern New Mexico." (Pilsby, 1948, p. 1052).

Habitat.—In northern Nebraska *C. exiguum* was found among wet leaves in seepage areas and beside a spring-fed brook.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 177380 (81). Cragin Quarry: loc. 1, UMMZ 184470 (2250), USGS 21274–3 (2250); loc. 2, UMMZ 197496 (1600), USGS 21275–1 (1600); loc. 3, UMMZ 184437 (4).

Remarks.—Examination of the type series (UIMNH P6776, P6777) and of a series of topotypes (UMMZ 183026) makes it clear that *Carychium perexiguum* is a synonym of *C. exiguum.* Baker thought it distinguished by "the shorter shell, heavier lip, and the upward bending columellar lamella," but the series of topotypes, as well as the original measurements, exhibit a size range within that given by Pilsbry (1948, p. 1054) for *C. exiguum.* The thickening of the lip in the topotype series appears no different from that in *C. exiguum.* Only two of the types were dissected by Baker, and only one of them shows the principal columellar lamella adequately. The upward bend of this lamella, which is referred to in the original description, is a minor flare on the ventral side of the lamella within the body whorl. This feature is certainly well within the range of variation of *C. exiguum* as figured by Pilsbry (1948).

My discussion of the identity of *C. perexiguum* with *C. exiguum* is based upon the relatively narrow concept of the species as described and illustrated by Pilsbry. From a study of *C. exiguum* in southern Michigan, however, Harry (1952) decided that there was only one species in the region, because the range of variation is greater than previously recognized; hence, by implication *C. exile* and *C. exile canadense* are to be added to the synonymy of *C. exiguum.*

Family Lymnaeidae

Genus *Lymnaea* Lamarck, 1799

Lymnaea stagnalis jugularis Say, 1817

Lymnaea stagnalis appressa (Say), Baker, 1911, p. 137, Pl. 19, Figs. 4–10; Pl. 20, Figs. 1–6; Pl. 22, Figs. 1–3.,

Lymnaea stagnalis jugularis Say, Baker, 1928*a,* p. 198, Pl. 11, Figs. 9–13; Pl. 12, Figs. 1–4, 11–12.

Lymnaea stagnalis subsp. ?, Goodrich, 1940, p. 78.

Lymnaea stagnalis (Linné), Taylor and Hibbard, 1955, pp. 10, 14.

?*Lymnaea* (*Acella*) *haldemani* (Binney), Frye, Leonard, and Hibbard, 1943, p. 41.

Geologic range.—Pleistocene to Recent. The oldest definite occurrence is in the Illinoian Butler Spring local fauna, southwestern Kansas, but the subspecies may occur in the late Kansan Cudahy fauna, in Lincoln County, Kansas.

Distribution.—Found over most of northern North America north of about 41 degrees; southward in the western United States to northern California, Nevada, and southern Colorado; unknown in the northern Great Plains between the Rocky Mountains and the eastern Dakotas and northeastern Nebraska.

Habitat.—"The American form of *stagnalis* is usually found in more or less stagnant parts of ponds or lakes and rivers about vegetation. It may frequently be seen floating among pond weeds and algae, the foot applied to the surface film of the water, the shell hanging downward." (Baker, 1928*a*, p. 202).

Occurrence.—Butler Spring, Bar M, and Jones local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197833 (1). Bar M: loc. 1, UMMZ 184377 (8); loc. 2, UMMZ 184376 (92).

Remarks.—Occurrence of *Lymnaea stagnalis jugularis* in the Cudahy fauna, Lincoln County, Kansas, is uncertain. Frye, Leonard, and Hibbard (1943, p. 41) may have misidentified spires or young shells of this species as *Acella haldemani*. However, neither of these two species is recorded from that locality by A. B. Leonard (1950) or by Frye and Leonard (1952).

The specimens recorded by Goodrich (1940) from the Jones local fauna were never catalogued in the University of Michigan Museum of Zoology, but there is no reason to suspect their misidentification.

The single shell from the Butler Spring collection, like the material from the Jones local fauna, is a fragment of the spire; hence, reference of this material to the subspecies *jugularis* is presumptive.

Genus *Stagnicola* Jeffreys, 1830

Stagnicola exilis (Lea), 1837

(Pl. V, Fig. 13)

Galba exilis (Lea), Baker, 1911, p. 343, Pl. 35, Fig. 4; Pl. 36, Figs. 21–22; Pl. 37, Figs. 1–11.

Stagnicola exilis (Lea), Baker, 1928*a*, p. 226, Pl. 14, Figs. 7–11; Pl. 17, Fig. 16.

Lymnaea macella, new species, A. B. Leonard, 1952*b*, p. 40, Pl. 5, Fig. *J*.

Lymnaea macella Leonard, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *q*.

Lymnaea parexilis, new species, A. B. Leonard, 1952*b*, p. 41, Pl. 5, Fig. *K*.

Lymnaea parexilis Leonard, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *x*.

Lymnaea palustris (Müller), D. W. Taylor, 1954*a*, p. 3; not of Müller. Taylor and Hibbard, 1955, p. 10; in part (not of Müller).

Geologic Range.—Late Pliocene to Recent. The only known Tertiary occurrence is in the late Pliocene Rexroad local fauna, Meade County, Kansas (UMMZ 177599, 181048, 183027, 183053).

Distribution.—"Ohio to Kansas, northward to northern Minnesota and northern Michigan" (Baker, 1928*a*, p. 227).

Habitat.—"*Exilis* is an inhabitant of sloughs, ponds, and streams which dry up more or less during a portion of the year" (Baker, 1928*a*, p. 227).

Occurrence.—Berends and Cragin Quarry local faunas.

Material.—Berends, UMMZ 177527 (40), 177548 (2); Cragin Quarry loc. 1, UMMZ 184461 (300), USGS 21274–4 (300).

Remarks.—Occurrence of *Stagnicola exilis* has been recorded in the Ogallala formation of Kansas by Frye, Leonard, and Swineford (1956) as *Lymnaea macella*. The admittedly poor preservation of these fossils is such that extension of the geologic range of *S. exilis* to include the middle Pliocene is not yet justified.

Lymnaea macella Leonard and *L. parexilis* Leonard are obviously the young and adult of the same species. This is readily demonstrable by breaking the larger *L. parexilis* into a smaller shell, which is then *L. macella*. The differentiae given for *L. macella* were the smaller size, heavier varix, and larger nuclear whorl; all of which are invalid. Varix and nuclear whorl are alike in the specimens examined; if it was meant that they are relatively different, the characters are a function of size. Large series from the Rexroad formation clearly show the intergradation between the two forms. Leonard appears to have reached a similar conclusion, unless a mislabeled illustration gives an erroneous implication. Although Plate 6, Figure *f* (Frye, Leonard, and Swineford, 1956) is captioned *Lymnaea macella* Leonard, this photograph is evidently the same one used by A. B. Leonard (1952*b*) and Frye and Leonard (1952) for *Lymnaea parexilis*.

The Pliocene populations from the Rexroad formation, distinguished by Leonard as distinct species, are here referred to *Stagnicola exilis* on the basis of examination of large University of Michigan series and of published information. The few specimens available from the type locality of *Lymnaea macella* and *L. parexilis* are inadequate to show the range of variation. But series from a stratigraphically equivalent locality (sec. 35, T. 34 S., R. 30 W., Meade Co., Kansas; Rexroad formation), from which Frye and Leonard (1952) recorded *L. parexilis*, agree well with *Stagnicola exilis* as described and figured by Baker (1911, 1928*a*).

According to Leonard (1952*b*, p. 42) "The shell of *Lymnaea parexilis* is similar in general form to that of *L. exilis*, but is much smaller with a relatively more elongate aperture, and more intricate sculpture." The only significant feature of these three is the relatively longer aperture. Recent *Stagnicola exilis* examined, and the University of Michigan fossil series, have a slightly smaller aperture than *Lymnaea parexilis* as figured and described by Leonard (1952*b*). While this character is probably not specific, at least some occurrences of *L. parexilus* represent *Stagnicola exilis*.

Stagnicola palustris cf. *S. palustris blatchleyi* (Baker), 1911

Lymnaea cf. palustris (Müller), van der Schalie, 1953, p. 84; in part.
Lymnaea palustris (Müller), Taylor and Hibbard, 1955, p. 10; in part (not of Müller).

Occurrence.—Jinglebob local fauna.

Material.—UMMZ 181152 (2).

Remarks.—One adult and one nearly adult specimen of *Stagnicola* are referable to the *S. palustris* group on the basis of size, sculpture, convexity of whorls, and unconstricted aperture. The two specimens differ from typical *S. palustris* in smaller size, more convex whorls, and relatively smaller aperture. They are most similar to *S. palustris blatchleyi* of the shells illustrated by Baker (1911). It is not certain whether the fossils represent the same genetic unit as *S. palustris blatchleyi,* or whether they are an independent, parallel derivative from *S. palustris.*

Stagnicola reflexa (Say), 1821

(Pl. V, Figs. 3, 9)

Galba reflexa (Say), Baker, 1911, p. 332, Pl. 30, Figs. 30, 31; Pl. 35, Figs. 3, 5–22; Pl. 36, Figs. 1–11; Pl. 18, Fig. 10.

Stagnicola reflexa (Say), Baker, 1928*a*, p. 221, Pl. 14, Figs. 1–6; Pl. 17, Fig. 15.

Geologic Range.—Pleistocene to Recent.

Distribution.—"Eastern Quebec west to Nebraska, Manitoba south to southern Illinois and southern Kansas" (Baker, 1928*a,* p. 224).

Habitat.—"The typical habitat of *reflexa* in northern Illinois and Wisconsin is in small pools or ponds which may become more or less dry in summer. All of the Wisconsin habitats have been in swales in woods or fields, none have been found in large streams or lakes" (Baker, 1928*a,* p. 224).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc 1, UMMZ 177373 (143), USGS 21042-7 (100).

Stagnicola bulimoides techella (Haldeman), 1867

Galba bulimoides techella (Haldeman), Baker, 1911, p. 214, Pl. 27, Figs. 30–35; Pl. 28, Figs. 1–3, 8.

Galba bulimoides cockerelli (Pilsbry and Ferriss), Baker, 1911; in part: Pl. 28, Figs. 6–7 (not of Pilsbry and Ferriss).

Galba bulimoides cassi Nov. Sp., Baker, 1911, p. 221, Pl. 28, Figs. 9–11.

Lymnaea bulimoides techella (Haldeman), Franzen and Leonard, 1943, p. 405, Pl. 30, Fig. 5.

Lymnaea bulimoides techella Haldeman, A. E. Leonard, 1943, p. 234, Pl. 1, Fig. 21.

Lymnaea bulimoides Lea, A. B. Leonard, 1950, p. 14, Pl. 2, Fig. *E* (not of Lea). Frye and Leonard, 1952, p. 159 (not of Lea). Frye and Leonard, 1954, p. 45 (not of Lea). Frye and Leonard, 1957*b,* pp. 25, 41, 50 (not of Lea).

Lymnaea diminuta, new species, A. B. Leonard, 1952*b,* p. 39, Pl. 5, Fig. *B.*

Lymnaea diminuta Leonard, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *s.*

Limnophysa catascopium, Say, Call, 1885*a,* p. 52 (not of Say).

Geologic Range.—Late Pliocene to Recent. The known Tertiary occurrences are as follows: Red Corral local fauna, Oldham County, Texas (UMMZ 182993); Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 183656); Rexroad local fauna, Meade County, Kansas (UMMZ 183052, 183065); Bender local fauna, Meade and Seward counties, Kansas (UMMZ 183012, 184118, 184147). The species is scarce as a Pleistocene fossil.

Distribution.—Southwestern and south-central United States to central Mexico; from southern California through Utah, Colorado, southernmost Nebraska and Kansas to Missouri and Alabama; south to San Luis Potosí and Oaxaca. Peripheral localities are as follows:

CALIFORNIA. Ventura Co.: Bairds Lake; H. Hannibal (USNM 570346). Bardsdale; H. Hannibal, L. E. Daniels (UMMZ 73591, 64025, 73625). San Bernardino Co.: 10 miles N. of Ontario; J. Henderson (USNM 570344). San Diego Co.: west of Warner Ranch; S. S. Berry, 1928 (USNM 570352).

UTAH. Emery Co.: Castle Dale; J. Henderson (USNM 570359).

COLORADO. Mesa Co.: Whitewater; J. Henderson (USNM 380813, 570385). Otero Co.: La Junta; J. Henderson (USNM 570364, UMMZ 189183). Rocky Ford; J. Henderson (USNM 570365). Pueblo Co.: Pueblo; J. Henderson (USNM 570363). East of Pueblo (USNM 510066).

NEBRASKA. Furnas Co.: Medicine Cr., Cambridge; E. E. Hand (UMMZ 73622).

KANSAS. Shawnee Co.: Topeka; L. E. Daniels (UMMZ 73626, USNM 47676). Douglas Co.: Lawrence; E. C. Johnson, 1910 (USNM 570369).

MISSOURI. Jackson Co.: Kansas City; F. A. Sampson (USNM 570366). Courtney (UMMZ 70141). St. Charles Co.: 1 mi. N. St. Charles; L. Hubricht, 1932 (UMMZ 176553). St. Louis Co.: St. Louis; Lind (USNM 474649). Four mi. W. Pattonville; L. Hubricht, 1935 (UMMZ 176552). One mi. E. Hine; L. Hubricht, 1932 (UMMZ 176555).

ALABAMA. Jackson Co.: Stevenson; H. H. Smith (UMMZ 67091). Greene Co.: Boligee.

SAN LUIS POTOSI. Tamosopo Sugar Co. mill, Tamosopo; A. A. Hinkley (USNM 570319).

OAXACA. Huajuapan de Leon; M. E. Bourgeois, 1946 (USNM 591612). Miahuatlan; M. E. Bourgeois, 1946 (USNM 591618).

BAJA CALIFORNIA. La Grulla; C. R. Orcutt (USNM 162652). Near Alamo; C. R. Orcutt (USNM 162651).

Habitat.—In northeastern Kansas "*Lymnaea bulimoides techella* is locally abundant in roadside ditches . . . throughout the broad terraces of the lower Wakarusa valley. It may be found in ephemeral pools where it appears in large numbers for a few weeks in the early spring. Many of the adults die after the egg laying period and few adults are seen through the hot summer months; immature individuals presumably remain alive, buried in the mud." (Franzen and Leonard, 1943, p. 405).

Occurrence.—Recent in Meade County, Kansas.

Remarks.—*Lymnaea diminuta* Leonard is a synonym of *Stagnicola bulimoides techella*. It was compared by Leonard to *F. humilis* and others of the genus *Fossaria,* but its larger nuclear whorl, simple columella, and wide inner lip indicate that it belongs to the *Stagnicola cubensis* group (*Nasonia* F. C. Baker, 1928*a,* p. 264). *L. diminuta* agrees with *S. bulimoides techella* in having the significant characters of an acutely conic spire, obese body whorl, and broadly reflected inner lip (Baker, 1911, p. 216).

Galba bulimoides cassi Baker is apparently a synonym of *Stagnicola bulimoides techella*. Examination of a series of nine paratypes (USNM

570384) and of the original description suggests it is distinguished only by a somewhat narrower, less swollen body whorl. As a corollary, the aperture is more ovate and the parietal lip not so broadly reflected. The appression of the inner lip is variable in the nine paratypes examined. The difference is minor, and by analogy with the variation in other species of the genus not worthy of even subspecific rank. The exceedingly limited number of occurrences, and the fact that these are within the distribution of *S. bulimoides techella,* tends to confirm such a conclusion.

The series reported from Baja California (near Alamo, coll. by C. R. Orcutt) by Baker (1911) shows variation between his form *cassi* and shells with larger body whorls like typical *S. bulimoides techella.*

Stagnicola bulimoides techella has not yet been found in the late Pleistocene of the southern High Plains, although it is to be expected there. References to *bulimoides* by A. B. Leonard and by Frye and Leonard are based on *bulimoides techella,* as indicated by Leonard's illustration (1950, Pl. 2, Fig. *E*).

Call's (1885*a,* p. 52) report of *catascopium* from Meade, Kansas, is certainly erroneous. His mention that the shells are malleated and of relatively small size (for *catascopium*), together with the geographic location, indicates he was dealing with *bulimoides techella.*

Stagnicola cockerelli (Pilsbry and Ferriss), 1906

Lymnaea bulimoides cockerelli n. subsp., Pilsbry and Ferriss, 1906, p. 162, Figs. 13–17.
Lymnaea cockerelli Pils. and Ferr., Pilsbry and Ferriss, 1910, p. 144.
Galba bulimoides cockerelli (Pilsbry and Ferriss), Baker, 1911, p. 217, Pl. 26, Figs. 5–7; Pl. 28, Figs. 4–5 (not 6–7).
Galba hendersoni (Baker), Baker, 1911, p. 223, Pl. 28, Figs. 15–18.
Lymnaea bulimoides cockerelli Pilsbry and Ferris, A. E. Leonard, 1943, p. 234, Pl. 1, Fig. 20.
Limnophysa bulimoides, Lea, Call, 1885*b,* p. 118 (not of Lea).
Limnaea bulimoides Lea, Pilsbry, 1896, p. 96 (not of Lea).

Geologic Range.—Early Pleistocene to Recent. The earliest known occurrence is in the Hagerman formation, Twin Falls County, Idaho (USGS localities 19223, 19224). In the southern Great Plains, this species is first known from the Illinoian or Wisconsin Bar M local fauna, Harper County, Oklahoma.

Distribution.—Sporadic over most of the United States west of the Mississippi River. Peripheral localities are as follows:

California. San Diego Co.: San Diego; J. S. Newberry (USNM 23425). Lassen Co.: Lake 25 miles west of Susanville.

Nevada. Humboldt Co.: Quinn River crossing.

Idaho. Franklin Co.: Weston; Junius Henderson (UMMZ 73612).

Montana. Missouri River above the Falls. Wibaux Co.: Wibaux; H. Squyer (USNM 129101). Spring 5 miles south of Wibaux; H. Squyer (USNM 151718).

North Dakota. Billings Co.: stream 25 mi. N. of Belfield; H. van der Schalie, 1942 (UMMZ 160272). Williams Co.: Muddy Cr. 16 mi. N. of Williston; H. van der Schalie, 1942 (UMMZ 160104).

SOUTH DAKOTA. Perkins Co.: springhole, Date; W. H. Over (USNM 570387). Pennington Co.: 0.5 mi. S. of Quinn; L. Hubricht, 1938 (UMMZ 176550). Lake Co.: Lake Herman; Trueman, 1884 (UMMZ 189184).

NEBRASKA. Keith Co.: Ogallala (USNM 474661, 570358).

KANSAS. Meade Co.: sinkhole pond, N. ½ sec. 12, T. 32 S., R. 27 W., 7 miles E. of Meade.

TEXAS. Carson Co.: Groom; L. Hubricht, 1935 (USNM 570376, UMMZ 176551). Hunt Co.: Greenville. Fayette Co.: Rutersville.

NEW MEXICO. Quay Co.: sec. 31, T. 9 N., R. 34 E.; H. H. Roberts, 1942 (USNM 568742). San Miguel Co.: Las Vegas; M. E. Cooper (UMMZ 67552, 73604). Bernalillo Co.: Albuquerque. Valencia Co.: McCartys; E. H. Ashmun (UMMZ 73603). McKinley Co.: Gallup; E. H. Ashmun (USNM 152106).

ARIZONA. Navajo Co.: 20 miles N. of Winslow; L. Sinitsin, 1929 (USNM 530845). Cochise Co.: cienaga about midway between Chiricahua and Peloncillo or Stein's Peak ranges. Maricopa Co.: small pool near Cow L., Mesa; U. S. Biol. Surv. (USNM 308928).

Habitat.—*Stagnicola cockerelli* is characteristic of intermittent, seasonal bodies of water. Although the geographic occurrence and the brief notes on labels alone would indicate the ability to withstand drought, in this case there is documentation as well. Pilsbry (1896) recorded that "about two dozen out of 50 or more" individuals revived after being packed in cotton and out of water for 45 days, when they were returned to water. The most common habitat on the Great Plains is in temporary ponds in sinkholes, buffalo wallows, or deflation hollows.

Occurrence.—Bar M and Jones local faunas.

Remarks.—From a review of previous literature and on examination of specimens it appears that *Stagnicola bulimoides cockerelli* is specifically distinct from *S. bulimoides* and *S. bulimoides techella.* This conclusion is based on (1) morphologic distinction, (2) occurrence of *S. cockerelli* in the same areas as *S. bulimoides* and *S. bulimoides techella* without evident intergradation, and (3) distinct geographic distribution.

Subspecific rank was originally given to *S. cockerelli* apparently because of its similarity to the previously named *S. techella* and *S. bulimoides*. Pilsbry and Ferriss noted, however, that it is "readily separable from both." So far as known Baker is the only subsequent author who has critically reviewed the status of this form. He wrote (1911, p. 220): "Specimens from Ventura County, California, show a tendency to vary toward the *techella* form of shell, clearly showing that the *cockerelli* race is an offshoot of *techella*. (Compare plate XXVII, figures 33–35, with plate XXVIII, figures 6–7)."

The particular illustrations cited by Baker are all of shells collected by S. S. Berry at Bardsdale, Ventura County, California, apparently from a single population. Because they are so much alike, there is no reason to doubt that these individuals are all *S. bulimoides techella.* The shells shown on Pl. XXVIII, Figs. 6–7, have a slightly larger, more tumid body whorl than is usual in *techella,* but the narrower spire, with more whorls and a concave outline, features not seen in *cockerelli,* make it clear that the specimens are *techella.* Other illustrations given by Baker (1911) and the review of many lots indicate that *S. cockerelli* does not intergrade with *S. bulimoides* or *S. bulimoides techella. S. cockerelli* does, however, occur within the area of distribution of these two forms. The apparent lack of intergradation might possibly be explained by hypothesizing that *S. cockerelli* is a phenotype controlled by its habitat in temporary ponds. While this interpretation may be reasonable so far as *S. bulimoides* is concerned, both *S. cockerelli* and *S. bulimoides techella* occur together in most of the southwest, and in similar habitats.

That *Stagnicola cockerelli* has its own distribution pattern is another fact that is opposed to giving it infraspecific rank. If it were only an ecologic variant, *S. cockerelli* should occur in suitable habitats within the range of *S. bulimoides* and *S. bulimoides techella.* But Baker's (1911) data and those given herein indicate that it is the only one of the three to occur in the large area of the northern Rocky Mountains and northern Great Plains; east of the Pacific Coast region and north of Utah, Colorado, and southernmost Nebraska the other two are unknown.

Lymnaea hendersoni Baker is within the range of variation of *S. cockerelli* as considered here. Two paratypes (USNM 570386) are smaller than usual for *S. cockerelli,* but can be matched by lots from Colorado and elsewhere. They probably were exposed to acid water, for the first one or two whorls have been etched; hence, on the low spire of these shells the effect is that of a truncate shell. This is an environmental, adventitious effect; the whorls are not "coiled in the same plane" as Baker thought.

Call's (1885*b*, p. 118) record of *Stagnicola bulimoides* is evidently based on *S. cockerelli* rather than *bulimoides techella.* The lack of malleation of the Kansas material suggests *cockerelli;* and the illustrations to which Call compared his specimens have the short spire and globose shape of *cockerelli.*

Stagnicola caperata (Say), 1829

(Pl. V, Figs. 5–7)

Galba caperata (Say), Baker, 1911, p. 225, Pl. 28, Figs. 20–33; Pl. 29, Figs. 1–3.
Stagnicola caperata (Say), Baker, 1928*a,* p. 260, Pl. 18, Figs. 43–47.
Stagnicola caperata Say, H. T. U. Smith, 1940, p. 109.
Lymnaea caperata Say, A. B. Leonard, 1950, p. 14, Pl. 2, Fig. *B.* van der Schalie, 1953, p. 83. Frye and Leonard, 1957*b,* p. 60, Pl. 5, Fig. 15.
Lymnaea caperata (Say), Frye and Leonard, 1952, p. 159.
Lymnaea bulimoides Lea, van der Schalie, 1953, p. 83 (not of Lea).

Geologic Range.—Middle Pliocene to Recent. The known Tertiary occurrences are as follows: middle Pliocene, Buis Ranch local fauna, Beaver County, Oklahoma (UMMZ 181113); late Pliocene, Rexroad local fauna, Meade County, Kansas (UMMZ uncat.); late Pliocene, Bender local fauna, Meade and Seward counties, Kansas (UMMZ 177504, 183011, 184146, 184148). This species is common in Pleistocene deposits of the High Plains.

Distribution.—"From Quebec and Massachusetts west to California; Yukon Territory and James Bay south to Maryland, Indiana, Colorado and California" (Baker, 1928*a*, p. 263).

Habitat.—"In the Mississippi Valley this species seems to almost invariably occupy intermittent streams or small pools, ponds and ditches which dry up in the summer. In Illinois it is usually found in association with *Aplexa hypnorum* and *Sphaerium occidentale,* either in small streams, pools or sloughs, or in spring pools in the woods which become completely dry in late spring and summer . . . In these dry ponds living specimens may frequently be found by digging into the mud, leaves and other debris. In Wisconsin, *caperata* has been found almost invariably in small woodland pools which become dry in summer and fall, or in small streams which become wholly or partially dry." (Baker, 1928*a*, p. 263). In northern Nebraska, *Stagnicola caperata* was found in similar, temporary bodies of water, such as irrigation ditches, and also in the more perennial ponds of the Sand Hills. It was commonly associated with *Stagnicola palustris, Promenetus umbilicatellus,* and *Aplexa hypnorum.*

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 177371 (150), USGS 21042–8 (150); loc. 2, UMMZ 197576 (2). Cragin Quarry: loc. 1, UMMZ 184460 (300), USGS 21274–5 (200); loc. 2, UMMZ 197497 (95); loc. 3, UMMZ 184427 (18); loc. 4, UMMZ 197529 (2).

Remarks.—The habitat of *Stagnicola caperata* is one that is apparently available quite widely in the southern Plains region. But the species has never been recorded alive as far south as Kansas, and its usual common occurrence elsewhere and distinctive shape argue that its absence there is reliable. The most reasonable explanation for the northern restriction is that the hot summers to the south bar its southward dispersal.

Genus *Fossaria* Westerlund, 1885

Fossaria dalli (Baker), 1906

(Pl. V, Figs. 10–12)

Galba dalli (Baker), Baker, 1911, p. 251, Pl. 30, Figs. 13–18.

Fossaria dalli (F. C. Baker), Baker, 1928*a*, p. 288, Pl. 16, Fig. 11.

Lymnaea dalli Baker, A. E. Leonard, 1943, p. 235, Pl. 1, Fig. 17.

Lymnaea turritella, new species, A. B. Leonard, 1952*b*, p. 39, Pl. 5, Fig. *C*.

Lymnaea turritella Leonard, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *r*. D. W. Taylor, 1954*a*, p. 2. Taylor and Hibbard, 1955, p. 10.

Lymnaea parva Lea, A. E. Leonard, 1943, p. 234, Pl. 1, Fig. 18 (not of Lea). Rinker, 1949, p. 110 (not of Lea). Taylor and Hibbard, 1955, pp. 10, 14 (not of Lea).

Lymnaea cf. *galbana* (Say), van der Schalie, 1953, p. 84.
Lymnaea humilis modicella (Say), van der Schalie, 1953, p. 84 (not of Say).
Lymnaea cf. *modicella* Say, Taylor, 1954*a*, p. 12.

Geologic Range.—Early Pliocene to Recent. The oldest known occurrence is in the Laverne local fauna, Beaver County, Oklahoma. All known Tertiary occurrences of this species are as follows: early Pliocene Laverne local fauna, Beaver County, Oklahoma (UMMZ 181259); late Pliocene Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 173595, 177555); late Pliocene Rexroad local fauna, Meade County, Kansas (UMMZ 177598, 181047, 183028, 183054, 183066); late Pliocene Bender local fauna, Meade and Seward counties, Kansas (UMMZ 183013, 184134, 184150).

Distribution.—"Ohio to Northern Michigan and Montana, south to Kansas and Arizona" (Baker, 1928*a*, p. 288).

Habitat.—*Fossaria dalli* is a semiaquatic snail, in that it is more often found out of the water than in it. It lives in marginal situations beside streams or ponds, on wet mud next to the water, among moist leaves and debris, or in marshes. In Meade County State Park it is common around the edges of the ponds, just out of water on the wet mud.

Occurrence.—Butler Spring, Berends, Cragin Quarry, Jinglebob, Bar M and Jones local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 177374 (21); loc. 2, UMMZ 197577 (3). Berends: UMMZ 177526 (37). Cragin Quarry: loc. 1, UMMZ 184459 (104); loc. 2, UMMZ 197498 (18). Jinglebob: UMMZ 181151 (60). Bar M: loc. 2, UMMZ 184374 (28); Jones, UMMZ 142698 (6).

Remarks.—*Lymnaea turritella* Leonard was originally distinguished from *L. dalli* by its somewhat greater size and more slender form. Comparison of a large series of topotypes with other large series of similar fossils from Pliocene and Pleistocene deposits, and with Recent specimens in the U. S. National Museum identified by F. C. Baker, shows that these differences are not constant (Taylor, 1960). *Lymnaea turritella* is based on unusually long, narrow specimens of *Fossaria dalli.* The dimensions of 5 mm. length at 5 whorls given by A. E. Leonard (1943, p. 234) refer to *Fossaria dalli* rather than to *F. parva.*

Fossaria obrussa (Say), 1825

(Pl. V, Figs. 8, 16)

Galba obrussa (Say), Baker, 1911, p. 270, Pl. 26, Figs. 8–13; Pl. 31, Figs. 20–37.
Fossaria obrussa (Say), Baker, 1928*a*, p. 293, Pl. 16, Fig. 14; Pl. 18, Figs. 14–24.
Lymnaea cf. *palustris* (Müller), van der Schalie, 1953, p. 84; in part.
Lymnaea obrussa Say, D. W. Taylor, 1954*a*, p. 14.
Lymnaea humilis rustica Lea, A. E. Leonard, 1943, p. 234, Pl. 1, Fig. 19.
Lymnaea humulus rustica Lea, Rinker, 1949, p. 110.

Geologic Range.—Early Pleistocene (Nebraskan) to Recent. The earliest known occurrences in the southern Great Plains are in the Illinoian Berends and Butler Spring local faunas.

Distribution.—"From the Atlantic to the Pacific oceans, and from Mackenzie Territory, Canada south to Arizona and northern Mexico" (Baker, 1928*a*, p. 296).

Habitat.—"The normal habitat of this species is in small bodies of water, as creeks, ponds, sloughs, bays, and marshy spots along river banks. It is at home on sticks, stones, and any other debris that may be in the water or along its edge" (Baker, 1928*a*, p. 296).

Occurrence.—Butler Spring local fauna; Recent, Meade County, Kansas.

Material.—Butler Spring loc. 1, UMMZ 177372 (84), USGS 21042–9 (56).

Remarks.—A. E. Leonard (1943) may have confused two species under "*Lymnaea humilis rustica.*" The dimensions given in the text (shell about 6 mm. in height, with about 5½ whorls) are for a small species, probably *Fossaria dalli.* The illustration and magnification, however, given in the explanation to her Plate 1 indicate a much larger shell, which is *Fossaria obrussa.* The specimens from the Jinglebob local fauna reported by Rinker (1949) as *Lymnaea humulus rustica* have not been located in the University of Michigan collection, but they are probably *Fossaria obrussa.* The shells recorded by van der Schalie (1953) from the same locality as *Lymnaea* cf. *palustris* are partly *Fossaria obrussa* and partly *Stagnicola palustris* cf. *S. palustris blatchleyi.*

Family Planorbidae
Subfamily Planorbinae
Genus *Anisus* Studer, 1820
Subgenus *Anisus* s. s.
Anisus (s.s.) *pattersoni* (Baker), 1938

(Pl. V, Fig. 4)

Gyraulus pattersoni Baker, A. B. Leonard, 1950, p. 20, Pl. 3, Fig. *I.* Frye and Leonard, 1952, p. 158, Pl. 15, Fig. *g.* A. B. Leonard, 1957, p. 12, Pl. 2, Figs. 4–6.
Anisus pattersoni (Baker), D. W. Taylor, 1958, p. 1149.

Geologic Range.—Middle Pliocene to late Pleistocene (early Wisconsin). In the High Plains known only from the early and middle Pleistocene (Nebraskan to Illinoian).

Distribution.—Pliocene in southwestern Idaho, northern Utah, western Wyoming; early Pleistocene in southwestern Idaho, Nebraska, and Kansas; middle Pleistocene in the central Great Plains; late Pleistocene, Ohio.

Habitat.—Known only by inference, since the species is extinct. Its association with fossils which represent living species suggests that this form lived in shallow, quiet waters, in the backwaters along streams or in semipermanent ponds and sloughs.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197552 (36).

Remarks.—The catalogue numbers of the holotype and two of the paratypes in the Chicago Natural History Museum cited previously by Baker (1938), A. B. Leonard (1957), and D. W. Taylor (1958) are erroneous. These numbers were taken from the specimen labels, but do not correspond to the museum catalogue. According to E. S. Richardson, Jr. (letter dated August 27, 1959), the newly assigned correct numbers are PE5724 (holotype) and PE5725 (paratypes).

Since the publication of a summary of distribution of this species (D. W. Taylor, 1958), collecting by a University of Michigan Museum of Paleontology field party has yielded the first Pliocene record in the Great Plains. At least three specimens (UMMZ uncat.) of *A. pattersoni* were found associated with *Ogmodontomys poaphagus* Hibbard at University of Michigan locality UM-K1-59, Rexroad formation, NW¼, SE¼, sec. 16, T. 33 S., R. 29 W., Meade County, Kansas.

Genus *Gyraulus* Charpentier, 1837

Gyraulus circumstriatus (Tryon), 1866

(Pl. VI, Figs. 10, 13, 14, 16–18)

Gyraulus circumstriatus (Tryon), Baker, 1928*a*, p. 378, Text Fig. 162. Baker, 1930*b*, p. 432. D. W. Taylor, 1954*a*, p. 3.
Gyraulus (*Torquis*) *circumstriatus* (Tryon), Baker, 1945, p. 75.
Planorbis parvus walkeri n. var., Vanatta, 1902, p. 58.
Gyraulus circumstriatus walkeri (Vanatta), Baker, 1928*a*, p. 379, Pl. 23, Figs. 32, 33; Text Fig. 162.
Gyraulus (*Torquis*) *circumstriatus walkeri* Vanatta, Baker, 1945, p. 75.
Planorbis parvus urbanensis Baker, n. var., Baker, 1918, p. 664 (nomen nudum).
Planorbis parvus urbanensis n. var., Baker, 1919, p. 94, Pl. 7, Figs. 4–6.
Planorbis parvus urbanensis Baker, A. B. Leonard, 1957, p. 14, Pl. 2, Figs. 7–9.
Planorbis urbanensis Baker, Baker, 1922, p. 54.
Gyraulus urbanensis (F. C. Baker), Baker, 1929, p. 308.
Gyraulus vermicularis hendersoni n.v., Walker, 1929, p. 104.
Planorbis (*Torquis*) *nathorsti* Westerlund, Dall, 1905, p. 96, in part; Labrador.
Gyraulus similaris (F. C. Baker), van der Schalie, 1953, p. 84, in part (not of Baker).
Gyraulus altissimus F. C. Baker, H. T. U. Smith, 1940, p. 109 (not of Baker).
Gyraulus parvus (Say), Goodrich, 1940, p. 78, in part (not of Say).

Geologic Range.—Middle Pleistocene (Kansan) to Recent. The earliest known occurrences in the southern Great Plains are in the late Kansan Cudahy fauna.

Distribution.—*Gyraulus circumstriatus* is found in a broad belt across central North America, in southern Canada and the northern United States between the Atlantic and Pacific oceans, southward in the Rocky Mountains to northern Arizona.

The accompanying map (Fig. 6) is based only on specimens examined in the collections of the Academy of Natural Sciences of Philadelphia, United States National Museum, and University of Michigan Museum of Zoology. Drift shells and fossils have been excluded from the Recent category. Peripheral localities are as follows:

British Columbia. Christina Lake (UMMZ 178894).

Washington. King Co.: Lake Washington, Seattle; E. J. Post (UMMZ 181008).

Oregon. Jackson Co.: Phoenix; J. Henderson (UMMZ 89932).

Nevada. Washoe Co.: Del Monte Ranch, Reno; P. Bartsch, 1939 (USNM 473960a). Elko Co.: Pinyon Canyon, near Carlin; C. Thompson, 1912 (UMMZ 5529, 5539).

Arizona. Yavapai Co.: Pecks Lake, Jerome; E. H. Ashmun (USNM 160148a).

Utah. Between Staker and Lake creeks, 9 miles north of Scad Valley Divide, Wasatch Plateau, Emery-Sanpete county line; L. Hubricht, 1938 (UMMZ 176389).

Colorado. Delta Co.: North side Grand Mesa; J. Henderson (UMMZ 89871). Rio Grande Co.: 1 mile north of Monte Vista; J. Henderson (UMMZ 89877). Weld Co.: Windsor; J. Henderson, 1910 (UMMZ 178882).

Nebraska. Cherry Co.: Pond on west side of U. S. highway 83, 7.4 miles south of junction with U. S. highway 20; D. W. Taylor, 1953 (USGS). Four miles northeast of Simeon; D. W. Taylor, 1953 (USGS). Brown Co.: 2½ miles south of Long Pine; D. W. Taylor, 1953 (USGS). Calamus River ½ mile west of state highway 7; D. W. Taylor, 1953 (USGS). Lancaster Co.: Lincoln; R. H. Wolcott (UMMZ 88261).

Illinois. Fulton Co.: Canton (UMMZ 88278).

Indiana. Henry Co.: Elwood Pleas (UMMZ 88789).

Ohio. Tuscarawas Co.: New Philadelphia; V. Sterki (USNM 128209).

West Virginia. Jefferson Co.: Leetown; M. S. Briscoe (USNM 530089). Duffield; M. S. Briscoe (USNM 530097).

New York. Richmond Co.: Staten Island (ANSP).

Nova Scotia. Guysborough Co.: Melford; A. G. Huntsman (UMMZ 88328).

Labrador. No specific locality; Storer (USNM 29286).

Quebec. L'Islet Co.: St. Jean Port Joli; A. La Rocque (USNM 572254).

Ontario. Cochrane Dist.: Low Bush; J. L. Hart (UMMZ 88804). Smoky Falls, Mattagami River; R. V. Whelan, 1937 (UMMZ 178908). Fraserdale; S. C. Downing and others, 1939 (UMMZ 178775). Fort Albany, James Bay (UMMZ 179491). Kenora Dist.: Favourable L.; G. M. Neal, 1938 (UMMZ 173395). Camp of Fay Lake expedition; G. M. Neal, 1938 (UMMZ 173398).

Alberta. Sylvan L. near Banff; D. S. Rawson (UMMZ 178896).

Habitat.—*Gyraulus circumstriatus* has been confused with other species for so many years that there is almost no reliable published ecologic information concerning it. On the basis of information on labels, personal collection by Taylor, and habits of associated species, it is characteristic of small, seasonal water bodies, such as woods pools, marshes, ponds on flood plains, or prairie ponds.

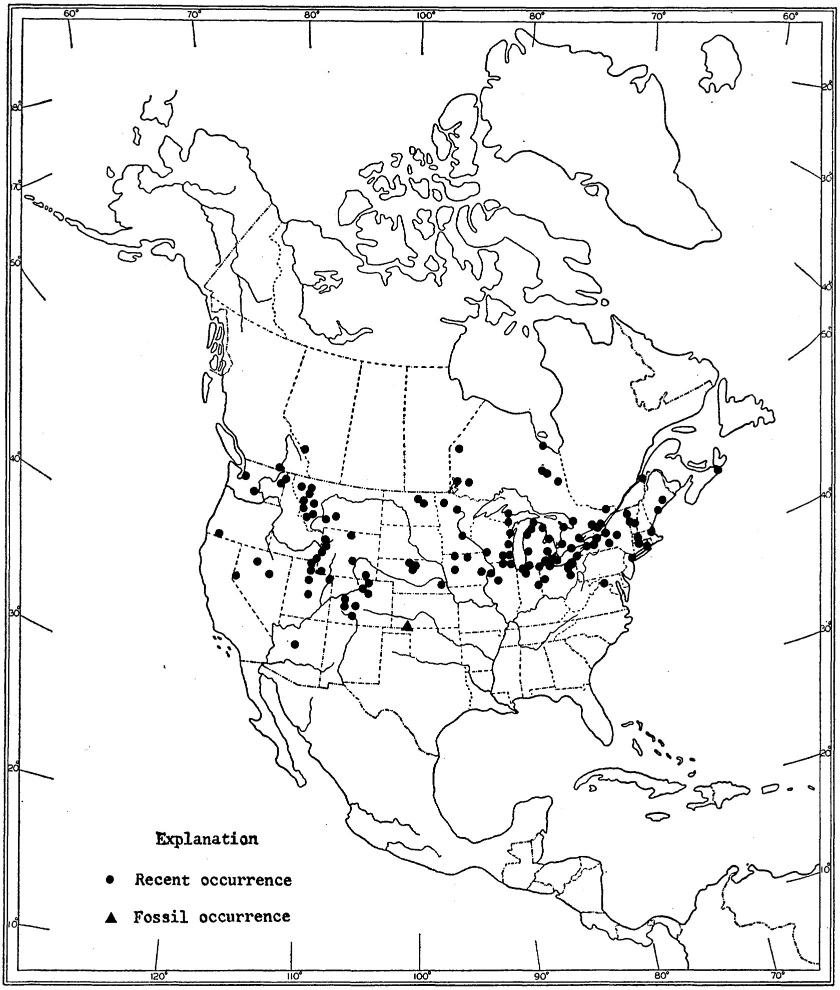

FIG. 6. Distribution of *Gyraulus circumstriatus* (Tryon).

Occurrence.—Butler Spring, Cragin Quarry, and Jones local faunas.

Material.—Butler Spring: loc. 1, UMMZ 181081 (300), USGS 21042–10 (300). Cragin Quarry: loc. 1, UMMZ 184456 (1000), USGS 21274–6 (1000); loc. 2, UMMZ 197499 (55); loc. 3, UMMZ 184426 (37); loc. 4, UMMZ 197530 (1). Jones: UMMZ 181079 (2), 181080 (3).

Remarks.—*Gyraulus circumstriatus* is considerably less variable than *G. parvus*. It is one of the most readily recognizable of the small Planorbidae. Lack of study of *Gyraulus* and the absence of adequate illustrations of the species have prevented appreciation of its wide range and specific identity. Examination of the collections of the U. S. National Museum and

University of Michigan Museum of Zoology is the chief basis for the revision. Practically all of the previously published identifications are unreliable.

Gyraulus circumstriatus is the only North American *Gyraulus* which forms an apertural callus (Pl. VI, Figs. 14, 17). While this feature is frequent enough to be called characteristic, it is often lacking and its absence cannot be relied upon to indicate that specimens are not *G. circumstriatus*. The callus may or may not develop during intervals of desiccation of the habitat, but it is reasonable to suppose that the formation is of adaptive value under such circumstances. A callus that is formed early in the life of an individual is retained thereafter, and many shells show two, three, or even four of these apertural thickenings.

The most reliable criteria for identification are the relatively slow enlargement of the whorls and the symmetrical, planospiral coiling of at least the earlier ones. The whorls of *G. circumstriatus* are more nearly circular in cross section than those of other American species, and expand more slowly. Thus, a shell of *G. circumstriatus* of three whorls is of lesser diameter than those of others, and, in addition, it is of lesser axial height. In contrast, the shells of *G. parvus*, the species most closely related to *G. circumstriatus*, have more rapidly expanding whorls, so that the nucleus appears sunken below the plane of the right side; the whorls are more oval in cross section and deflected toward the left side (on Pl. VI, compare Fig. 14 with Figs. 5–6, 12). Shells of *G. circumstriatus* of about three whorls are nearly plane on both sides, whereas those of *G. parvus* are plane on the right and concave on the left. The symmetrical, planospiral coiling of the earlier whorls of *G. circumstriatus* may persist in unusually large shells, or the last whorl or two may be deflected toward the left side. If the latter is true, the identity of *G. circumstriatus* is established by the slowly enlarging, symmetrical, planospirally coiled earlier whorls.

Gyraulus circumstriatus, defined morphologically in this way, has a distinctive geographic distribution which is far less extensive than that of its relative, *G. parvus*. What information is available also indicates that the two species have different habitat preferences, although the range of suitable types of habitat may overlap. *G. circumstriatus* is common in small, seasonal bodies of water; *G. parvus* is abundant in rivers and lakes, situations where *G. circumstriatus* is not found.

The shell characters discussed are adequate for identification of samples from single populations and of most individuals. In large series of fossils, or in river-drift collections, where many specimens of both *G. parvus* and *G. circumstriatus* are mixed, a small minority of shells are often of uncertain identity.

A. B. Leonard (1959, p. 64) reported *Gyraulus circumstriatus* from Meade County and other localities in Kansas. The Recent shells from Meade County which I have examined, as well as the shell Leonard illustrated (1959, p. 63, Pl. 2, Figs. 4–6) are *G. parvus* rather than *G. circumstriatus.*

Synonymy.—Planorbis parvus urbanensis Baker (1919) was later considered a distinct species by Baker (1922), and still later as a synonym of *Gyraulus circumstriatus* (Baker, 1930*b*). Examination of cotypes and of Baker's original description and illustration confirms that it is *G. circumstriatus.*

Planorbis parvus walkeri (Vanatta, 1902) and *Gyraulus vermicularis hendersoni* (Walker, 1929) were both originally distingished on the basis of an apertural callus. Presence of this feature, and examination of the types, is the basis for considering them *G. circumstriatus.* The type material examined is as follows: ANSP 21487, five cotypes of *G. circumstriatus;* ANSP 81143, three cotypes of *P. parvus walkeri;* ANSP 43639, five cotypes of *P. parvus urbanensis;* and UMMZ 89932, paratypes of *G. vermicularis hendersoni.*

The status of the name *nathorsti* Westerlund is uncertain. The shells (USNM 29286) reported by Dall (1905) under this name are *G. circumstriatus,* but they may not be Westerlund's species.

Gyraulus parvus (Say), 1817

(Pl. VI, Figs. 2–3, 5–6, 8–9, 11–12, 15)

Gyraulus parvus (Say), Baker, 1928*a,* p. 374, Pl. 23, Figs. 27–31, 39; Text Fig. 162. A. E. Leonard, 1943, p. 235, Pl. 1, Fig. 4. Taylor, 1956, p. 123. Frye and Leonard, 1957*a,* p. 60, Pl. 5, Fig. 6.

Gyraulus (Torquis) parvus (Say), Baker, 1945, p. 75, Pl. 77, Figs. 4–6.

Gyraulus labiatus, new species, A. B. Leonard, 1948, p. 45, Pl. 2, Figs. *G–H,* not of Benson, 1850, p. 350.

Gyraulus labiatus Leonard, A. B. Leonard, 1950, p. 19, Pl. 3, Fig. *C.* Frye and Leonard, 1952, p. 158, Pl. 15, Fig. *v.* Lüttig, 1953, p. 83. Frye and Leonard, 1957*b,* p. 60, Pl. 5, Fig. 19.

Gyraulus enaulus, new species, A. B. Leonard, 1952*b,* p. 43, Pl. 5, Figs. *G–I.*

Gyraulus enaulus Leonard, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *u.*

Gyraulus similaris (F. C. Baker), van der Schalie, 1953, p. 84, in part (not of Baker).

Geologic Range.—Middle Pliocene to Recent. In the southern Great Plains the earliest known occurrence is in the early late Pliocene Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 173591, 177556).

Distribution.—"Eastern North America east of the Rocky Mountains from Florida northward to Alaska and northern British America" (Baker, 1928*a,* p. 377). Baker's distribution is based on his relatively narrow concept of the species. Probably other named forms are identical with *G. parvus* and the distribution includes almost all North America. A distinction between the American *G. parvus* and the European *G. glaber* has not been adequately established. If the names prove to be synonyms, then *G. parvus* is nearly circumpolar in distribution. Geyer (1919, p. 141) also implied that these two species might be the same.

Habitat.—"Usually in quiet bodies of water, often of small size. . . . *parvus* is partial to a habitat which has rather thick vegetation. This species is more often found in vegetation than in any other situation" (Baker, 1928*a*, p. 376–77).

Occurrence.—Butler Spring local fauna; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 177375 (27,000), USGS 21042–11 (22,500); loc. 2, UMMZ 197578 (24).

Remarks.—The number of specimens from Butler Spring locality 1 was estimated from a volumetric measurement of 1,890 individually counted shells to be 49,520. This calculated total is probably accurate to within 10 per cent.

In the original descriptions of *Gyraulus labiatus* Leonard and *G. enaulus* Leonard, neither was compared with *G. parvus*. But the range of variation of this widespread and variable Recent species certainly includes both of Leonard's forms. Large series, such as that reported in this paper from the Butler Spring local fauna, show a much greater range of variation than implied in the descriptions of these two fossil forms.

Genus *Armiger* Hartmann, 1840

Armiger crista (Linnaeus), 1758

(Pl. V, Figs. 1–2)

Gyraulus crista (Linn), Baker, 1928*a*, p. 385, Text Fig. 164.
Gyraulus (*Armiger*) *crista* (Linné), Wenz 1923*b*, p. 1625.
Armiger crista Linné, Geyer, 1927, p. 149, Pl. 15. Figs. 25*a–c*, 26*a–c*. Frömming, 1956, p. 192.
Armiger crista (Linn), Baker, 1945, p. 78, Pl. 76, Fig. 6.
Armiger crista (Linnaeus), Kenk, 1949, p. 53.
Armiger crista Linné, D. W. Taylor, 1954, p. 3.
Gyraulus cristatus (Linne), Frye and Leonard, 1954, p. 45.
Gyraulus crista (Linné), Frye and Leonard, 1957*b*, pp. 25, 50.

Geologic Range.—Late Pliocene to Recent. In North America the oldest known occurrence is in the middle Pleistocene Tule formation, Texas.

Distribution.—Holarctic; in North America, north of about 41 degrees, but south of this latitude on the Pacific Coast to San Mateo County, California, and southward in central Utah. This species is among the rarer American freshwater snails and, hence, the distribution is only known from relatively few, scattered localities.

The accompanying distribution map (Fig. 7) is based on records from publications and examination of the collections of the University of

Michigan Museum of Zoology, United States National Museum, Academy of Natural Sciences of Philadelphia, and Carnegie Museum (CM). Drift shells and fossils have been excluded from the Recent category. Peripheral localities are as follows:

ALASKA. Fort Yukon; J. E. Winecoff (USNM 332769).

CALIFORNIA. San Mateo Co.: Crystal Springs Reservoir; H. Hannibal (UMMZ 87600).

UTAH. Emery Co.: Pond between Staker and Lake creeks, 9 mi. N. of Scad Valley Divide, Emery-Sanpete county line; L. Hubricht, 1938 (UMMZ 176388).

NEBRASKA. Cherry Co.: Creek at junction of dirt road and paved road to Alkali

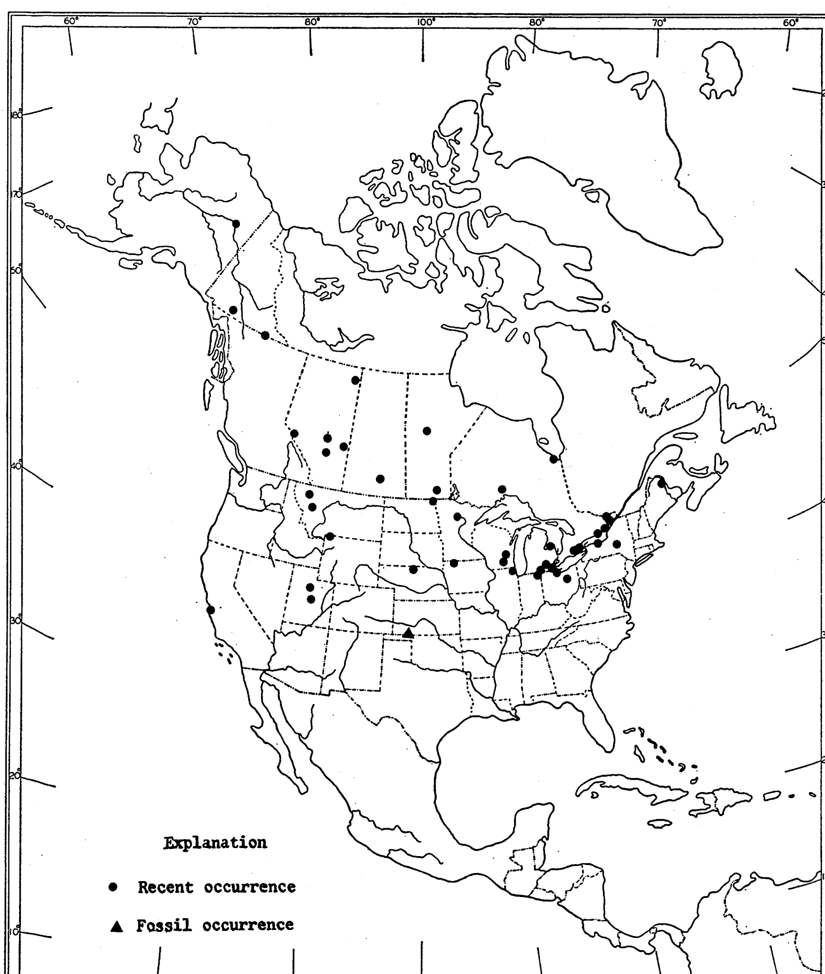

FIG. 7. Distribution in North America of *Armiger crista* (Linnaeus).

Lake, 4.4 miles west of junction with U.S. highway 83; D. W. Taylor, 1953 (USGS).
IOWA. Dickinson Co.: Lake Park; B. Shimek, 1912 (USNM 535131).
ILLINOIS. McHenry Co.: Algonquin (Baker, 1906, p. 120).
OHIO. Ashland Co.: Long Lake; V. Sterki, 1919 (CM 62.24959).
NEW YORK. Madison Co.: Eaton (UMMZ 87598).
MAINE. Aroostook Co.: Barren Brook, Caribou; N. W. Lermond (UMMZ 87599).
ONTARIO. Cochrane Dist.: Moose Factory; F. B. Johansen (UMMZ 87607).
MANITOBA. Wabowden; D. E. Beetle, 1959 (DEB 59–201).
ALBERTA. Athabaska River delta; U.S. Biological Survey (USNM 341563).

Habitat.—"In ponds and marshes, even in those thickly overgrown. *A. crista* for the most part tends toward malformations with detached and distorted whorls. It is supposed that the malformations are caused by the vegetation." (Geyer, 1927, p. 149; translation).

Ecologic information on this species in America is sparse, probably because it has not been collected often. Kenk found it common in a temporary pond in southern Michigan. He wrote (1949, p. 53): "*Armiger crista* (Linnaeus) was taken in Pond I from March to June. Numerous individuals appeared also in the culture of a soil sample from the bottom of the pond, prepared in October. No specimens were collected from December to February. The animals obviously estivated buried in the dry mud and, after the pond had filled, remained inactive in the soil until the latter part of the winter."

Occurrence.—Cragin Quarry and Jones local faunas.

Material.—Cragin Quarry loc. 3, UMMZ 197520 (1); Jones, UMMZ 142690 (9).

Subfamily Helisomatinae
Genus *Helisoma* Swainson, 1840
Subgenus *Helisoma* s.s.
Helisoma (s.s.) *anceps* (Menke), 1830

(Pl. X, Figs. 1, 6–7)

Planorbis bicarinatus Say, Walker, 1909, pp. 1, 21–28, Pl. 1, Fig. 3; Pls. 2–3.
Helisoma antrosa (Conrad), Baker, 1928*a*, p. 317, Pl. 19, Figs. 8–15. A. B. Leonard, 1950, p. 16, Pl. 3, Fig. *B;* 1952*a,* p. 21, Pl. 2, Figs. *H, I.* Frye and Leonard, 1952, pp. 151, 158, 164, Pl. 14, Fig. *w;* Pl. 15, Fig. *y;* Pl. 16, Fig. *r.*
Helisoma anceps anceps (Menke), Baker, 1945, p. 128, Pl. 80, Figs. 1–6; Pl. 82, Figs. 1–19, 26, 30; Pl. 83, Figs. 23–26; Pl. 84, Fig. 1; Pl. 96, Figs. 23–30.

Geologic Range.—Late Pliocene to Recent. The known Tertiary occurrences are all in the late Pliocene of southwestern Kansas: Saw Rock Canyon local fauna, Seward County, and Rexroad local fauna, Meade County.

Distribution.—Oregon to Maine, southward to western Mexico and Alabama.

Habitat.—". . . primarily a river and creek species, not living in the large lakes" (Baker, 1928*a*, p. 319).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197553 (2).

Remarks.—Pilsbry (1934, p. 45) considered the name *antrosa* a junior synonym of *anceps*, and he (1950, p. 68) has discussed the reasons for acceptance of the latter. The name *anceps* has been used by all subsequent writers except A. B. Leonard (1950, p. 16, and later papers).

Subgenus *Pierosoma* Dall, 1905

Helisoma (*Pierosoma*) *trivolvis* (Say), 1817

(Pl. X, Figs. 10, 14, 17)

Helisoma trivolvis (Say), Baker, 1928*a*, p. 330, Pl. 20, Figs. 1–13, 22–23. A. E. Leonard, 1943, p. 235, Pl. 2, Fig. 30. Franzen and Leonard, 1943, p. 407, Pl. 30, Fig. 2. A. B. Leonard, 1950, p. 16, Pl. 3, Fig. *A*. Frye and Leonard, 1952, pp. 159, 164, 179, Pl. 16, Fig. *v*. Frye and Leonard, 1957*b*, p. 60, Pl. 5, Fig. 20.

Helisoma trivolvis trivolvis (Say), Baker, 1945, p. 149, Pl. 80, Figs. 13–15; Pl. 85, Figs. 17–30; Pl. 86, Figs. 1–4, 20, 21; Pl. 88, Figs. 1–3; Pl. 89, Figs. 28–29.

Helisoma trivolvis lentum (Say), A. B. Leonard, 1952*a*, p. 21, Pl. 2, Fig. *A, C* (not of Say). Frye and Leonard, 1952, p. 176, Pl. 18, Fig. *k* (not of Say). Leonard and Goble, 1952, p. 1028, Pl. 100, Fig. 9 (not of Say).

Helisoma trivolvis lentum Say, H. T. U. Smith, 1940, p. 109 (not of Say).

Helisoma lentum (Say), Goodrich, 1940, p. 78 (not of Say).

Helisoma lentum Say, Rinker, 1949, p. 110 (not of Say).

Helisoma cf. *lentum* (Say), van der Schalie, 1953, p. 84.

Geologic Range.—Early Pleistocene to Recent. The oldest known occurrence is in the Nebraskan or Aftonian Dixon local fauna, Kansas (UMMZ 182202, 191511).

Distribution.—"Atlantic Coast and Mississippi River drainages, northward to Arctic British America and Alaska and southward to Tennessee and Missouri. The southern distribution is not clear owing to mixing with related species." (Baker, 1928*a*, p. 332).

Habitat.—"Typical *trivolvis* is always an inhabitant of quiet, more or less stagnant water" (Baker, 1928*a*, p. 332). In Meade County, Kansas, A. E. Leonard found this a common species. She reported (1943, p. 235): "It thrives in the temporary sinkhole ponds as well as more permanent bodies of water. It can survive long periods of drouth, apparently by burrowing into the mud in the bottom of drying pools."

Occurrence.—Butler Spring, Cragin Quarry, Jinglebob, and Jones local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 177376 (24), USGS 21042–12 (22). Cragin Quarry: loc. 1, UMMZ 184469 (13), USGS 21274–7 (13). Jinglebob: UMMZ 171585 (1), 181155 (32). Jones: UMMZ 142693 (20).

Subfamily Planorbulinae

Genus *Planorbula* Haldeman, 1842

Planorbula armigera (Say), 1818

Planorbula armigera (Say), Baker, 1928*a*, p. 355, Pl. 8, Figs. 27–30.

Planorbula vulcanata Leonard, D. W. Taylor, 1954*a*, p. 3. Taylor and Hibbard, 1955, p. 10.

Geologic Range.—Pleistocene to Recent.

Distribution.—"New England west to Nebraska, south to Georgia and Louisiana, north to Great Slave Lake" (Baker, 1928*a*, p. 359).

Habitat.—"*Planorbula armigera* is largely a species of swales or of small and stagnant bodies of water" (Baker, 1928*a*, p. 358).

Occurrence.—Berends local fauna.

Material.—UMMZ 177531 (150), 177550 (1).

Remarks.—Fossil shells from the Berends local fauna are closely similar to *Planorbula armigera,* as represented in University of Michigan collections, both in external features and in apertural lamellae. The range of variation in this species seems to have been underestimated by previous authors; possibly *crassilabris* Walker, *nebrascensis* Leonard, *vulcanata* Leonard, and *vulcanata occidentalis* Leonard are all synonyms of *armigera.*

Genus *Promenetus* Baker, 1935

Promenetus kansasensis (Baker), 1938

(Pl. VII, Figs. 1–3; Pl. VIII, Figs. 1–4; Pl. IX, Figs. 1–9; Pl. XIV, Figs. 6, 9, 16)

Menetus kansasensis n. sp., Baker, 1938, pp. 129–31.

Menetus kansasensis F. C. Baker, Baker, 1945, p. 516, Pl. 140, Figs. 26–29.

Menetus kansasensis Baker, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *t*. A. B. Leonard, 1957, p. 13, Pl. 2, Figs. 1–3.

Menetus pearlettei, new species, A. B. Leonard, 1948, p. 46, Pl. 2, Figs. *I–J*.

Menetus pearlettei Leonard, A. B. Leonard, 1950, p. 19, Pl. 3, Fig. *G*. Frye and Leonard, 1952, p. 158, Pl. 15, Fig. 1. Frye and Leonard, 1957*b*, p. 60, Pl. 5, Fig. 18.

Promenetus pearlettei (Leonard), D. W. Taylor, 1954*a*, p. 3. Taylor and Hibbard, 1955, p. 10.

Promenetus kansasensis (Baker), Taylor, 1956, p. 123, Fig. 4.

Geologic Range.—Middle Pliocene to late Pleistocene (Sangamon). In the southern Great Plains the known range is from the late Pliocene Saw Rock Canyon local fauna to the Sangamon Cragin Quarry local fauna.

Distribution.—Pliocene in southern Idaho, northern Texas, and southwestern Kansas; early Pleistocene in Nebraska and Kansas; middle Pleistocene in the Great Plains, from Iowa to Texas; late Pleistocene in southwestern Kansas.

Habitat.—Presumably *Promenetus kansasensis* lived in situations similar to those in which its close relative, *P. exacuous,* lives today.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 177377 (600), USGS

21042–13 (600); loc. 2, UMMZ 197579 (3). Cragin Quarry: loc. 1, UMMZ 184453 (1600), USGS 21274–8 (1600); loc. 3, UMMZ 184435 (5).

Remarks.—Just as the range of variation has been underestimated for Recent *Promenetus exacuous,* so has it been for the fossil relatives of that species. But examination of large series of fossil shells of *Promenetus* (s. s.) from different stratigraphic horizons has revealed no consistent differences in size, compression of whorls, strength of carina, or expansion of body whorl. The range of variation in fossil series is similar to that in Recent ones, from relatively large shells, with an expanded compressed body whorl and strong carina (see Pl. VII, Fig. 3 and Pl. VIII, Fig. 4; the form *megas* Dall is of this type) to smaller shells with a less expanded and compressed body whorl and weaker carina (Pl. VIII, Figs. 1–3).

Pliocene to late Pleistocene series of *P. kansasensis* differ consistently from *P. exacuous* in that all or most shells have a sculpture of riblets instead of growth lines. In this respect, Sangamon populations, from the Cragin Quarry and Jinglebob local faunas, are transitional to the Recent *P. exacuous*. In both populations some shells lack riblets, others have them. Shells from the Jones local fauna have no riblets; in those from the Berends and Butler Spring local faunas they are usually well-developed.

All the evidence from successive large samples of known stratigraphic position suggests that the change from the more strongly sculptured species to the more weakly sculptured *P. exacuous* took place during the Sangamon interval. The name *kansasensis* Baker is the earliest one for the older species; it was based on a late Pliocene sample, from the Rexroad local fauna. The range of variation of the series from the Cudahy fauna of Kansan age, from which A. B. Leonard described *Menetus pearlettei,* overlaps the older samples to such an extent that it cannot be consistently distinguished. Although the difference between the earlier Sangamon Cragin Quarry sample and the late Sangamon Jinglebob specimens is slight, between these two is the most convenient place to make the nomenclatural change from *P. kansasensis* to *P. exacuous*. Material from other Sangamon deposits is necessary to check the consistency and the precise stratigraphic location of the transition in sculpture.

Several shells from the Butler Spring local fauna are illustrated to show the range of variation. Axial riblets, the most conspicuous element of sculpture, vary from strong and widely spaced (Pl. IX, Figs. 4, 6, 8) through weaker and closely spaced (Pl. VII, Figs. 1–2) to a point at which the sculpture may be said to consist of growth lines rather than riblets (Pl. IX, Figs. 5, 7, 9). Spiral striation, not regularly evident, is conspicuous on a few shells (Pl. VIII, Fig. 3; Pl. XIV, Figs. 6, 16). The periphery of the shell may be obtusely rounded (Pl. VIII, Fig. 1), simply carinate (Pl. XIV, Fig. 9), or strongly carinate with a shallow trough next to the carina so that the periphery has a pinched aspect (Pl. IX, Fig. 3). Rate of enlargement of the whorls is so variable that the extremes of a narrow (Pl. VIII, Figs. 2–3) or broad (Pl. IX, Figs. 1–2) body whorl are conspicuously different. The axial sculpture may or may not change through ontogenetic development. Varying degrees of such change in shells which initially have nearly the same strong axial sculpture are shown (Pl. IX, Figs. 1, 4, 8; and Pl. VIII, Figs. 2–3).

Promenetus exacuous (Say), 1821

Planorbis exacuous, Say, 1821, p. 165.
Menetus exacuous (Say), Baker, 1928*a,* p. 361, Pl. 23, Figs. 1–5. A. E. Leonard, 1943, p. 235, Pl. 1, Fig. 2.
Promenetus exacuous exacuous (Say), Baker, 1945, p. 182.
Paludina hyalina, Lea, 1838, p. 17, Pl. 23, Fig. 81.
Planorbis (?var.) *Harni* Pils., Harn, 1891, p. 137 (*nomen nudum*).
Planorbis (?var.) *Harni* Pilsbry, Pilsbry, 1899, p. 51.
Planorbis exacutus Say var. *rubellus,* n., Sterki, 1894, p. 7.
Planorbis rubellus Sterki, Pilsbry, 1899, p. 51.
Promenetus rubellus (Sterki), Baker, 1945, p. 182.
Planorbis (*Menetus*) *exacuous* Say variety *megas* Dall, nov., Dall, 1905, p. 91.
Menetus exacuous megas (Dall), Baker, 1928*a,* p. 363, Pl. 23, Figs. 6–7.
Promenetus exacuous megas (Dall), Baker, 1945, p. 182.
Planorbis imus n. sp., Vanatta, 1911, p. 669, Fig. 3.
Promenetus imus (Vanatta), Baker, 1945, p. 182.
Menetus hudsonicus, new species, Pilsbry, 1934, p. 64, Figs. 7*c–e.*
Promenetus hudsonicus (Pilsbry), Baker, 1945, p. 182.
Menetus coloradoensis, New Species, Baker, 1945, p. 230, Pl. 122, Figs. 23–25.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. *Promenetus exacuous* was probably evolving from *P. kansasensis* during the Sangamon interglacial interval. The earliest occurrence in the southern Great Plains is in the Jinglebob local fauna, Meade County, Kansas.

Distribution.—North America north of about 39°; south in the Colorado Plateau and Rocky Mountains to New Mexico; south along the Atlantic Coastal Plain to North Carolina; an isolated occurrence in cool springs, Meade County, Kansas.

Collecting in the Great Plains is inadequate, but the lack of records suggests that the species may not come as far south as 39°. No specimens are known from the Yukon, where the species is to be expected, nor from northern Arizona, northeastern Kansas, or northern Kentucky, where it may also occur. Peripheral records are as follows:

ALASKA. Fort Yukon; J. E. Winecoff (USNM 218910).

CALIFORNIA. San Francisco Co.: Lobos Cr.; Crandall (UMMZ 177644).

NEVADA. Washoe Co.: Pyramid Lake Indian Agency (S. S. Berry colln). Elko Co.: Humboldt R., Carlin (ANSP).

UTAH. Iron Co.: Spring Lake (ANSP). Piute Co.: Sevier R. below Marysvale (UCMNH 17315).

COLORADO. Rio Grande Co.: North of Monte Vista (UCMNH 12265).

NEW MEXICO. Valencia Co.: San Rafael; E. H. Ashmun (UMMZ 85927).

NEBRASKA. Colfax Co.: Lake MacPherson, S. of Richland (UMMZ 150770). Otoe Co.: drift, Nebraska City (Shimek, 1904, p. 379).

MISSOURI. Pettis Co.: Sedalia; Crandall (UMMZ 85944).

ILLINOIS. Champaign Co.: Urbana (Baker, 1906, p. 108).

INDIANA. Marion Co.: near Indianapolis (Stein, 1880, p. 459). Dearborn Co.: near Lawrenceburg (Call, 1900, p. 412).

OHIO. Washington Co.: Marietta; W. Holden (USNM 26480).

WEST VIRGINIA. Jefferson Co.: Harpers Ferry (Tryon, 1861, p. 398).

VIRGINIA. Jefferson Co.: Belchers Pond, Petersburg; R. Bray, 1940 (USNM 521987). 521987).

NORTH CAROLINA. Columbus Co.: Lake Waccamaw; J. B. Henderson (UMMZ 86841).

NORTHWEST TERRITORIES. Mackenzie Dist.: near Gros Gap, Great Slave Lake (Oughton, 1945, p. 78).

ONTARIO. Cochrane Dist.: Moose Factory; F. A. Johansen (UMMZ 86725).

QUEBEC. Grindstone Is., Magdalen Ids. (ANSP).

KANSAS. Meade Co.: Meade County State Park.

Habitat. Promenetus exacuous is found in shallow, perennial or subpermanent, quiet-water bodies, such as ponds, oxbow lakes, marshes, and sloughs or backwaters along streams. It is usually on the submerged vegetation in such habitats. The isolated occurrence in Meade County, Kansas, can be explained by the summer-cool habitat that is furnished by the artesian water in which this snail lives.

Occurrence.—Jones local fauna; Recent in Meade County, Kansas.

Material.—Jones, UMMZ 142699 (11).

Synonymy.—The seven names considered synonyms of *Promenetus exacuous* are treated below in chronological order.

Paludina hyalina Lea (1838, p. 17) was based on a single scalariform specimen. Haldeman (1844, p. 21) and all later authors have considered it a synonym of *Promenetus exacuous.*

Planorbis (?var.) *Harni* Pilsbry (Harn, 1891, p. 137) is a *nomen nudum* later synonymized by Pilsbry (1899, p. 52) with *P. rubellus* Sterki.

Planorbis exacutus var. *rubellus* Sterki (1894, p. 7) was more fully described and raised subsequently to specific rank by Pilsbry (1899). The differentiae given by Pilsbry were (1) the smaller size, (2) narrower whorl, wide and shallower umbilicus, and smaller aperture, and (3) deeper suture and more sunken apex. Five cotypes (UMMZ 5631, 86838) indicate that these criteria do not adequately distinguish this form from *P. exacuous*. The proportions of the whorl are a continuous variable, from narrow to wide, and the degree of impression of apex and suture is also inconstant in specimens of *P. exacuous* examined. Furthermore, the occurrence of *P. rubellus* is sporadic and everywhere within the known range of *P. exacuous*. This pattern of distribution is to be expected of an extreme of variation, such as *P. rubellus* appears to represent.

Planorbis exacuous variety *megas* Dall (1905, p. 91) was differentiated because "the variety is of a slightly milky translucency; on the base the whorl is more or less impressed within the peripheral keel and the spiral striation is much more marked than in the typical form," and because of its larger size and pinched periphery. This is the most common form in the northern Plains region. Its intergradation with typical *P. exacuous* has always been recognized (cf. Baker, 1937, p. 116). Inasmuch as the larger shells with more expanded body whorl, pinched periphery, and only sometimes stronger sculpture may be found in large lots intergrading with axially ribbed shells (*P. kansasensis*) or with smooth shells (*P. exacuous*), and since a correlation with habitat has not been demonstrated, this shell form is not considered worthy of taxonomic recognition.

Planorbis imus Vanatta (1911, p. 669), described from Bermuda, was said to differ from *P. exacuous* "by the smaller size, the position of the keel at the periphery instead of near the base, the more vertical aperture and shallower umbilicus." The size (3.03 mm) is well within the range of variation of *P. exacuous* having that number of whorls (2½); the keel of *P. exacuous* is usually peripheral; and the other two characters have no meaning. Examination of the two type specimens (ANSP 82410) confirms the belief that *P. imus* is not different from *P. exacuous*. Haas (1952, p. 102) could not find the species in Bermuda and concluded the locality given is erroneous. Evidently, specimens or labels have been confused.

Menetus hudsonicus Pilsbry (1934, p. 64) was described as "similar to *P. rubellus* except that it is smaller with nearly the same number of whorls; the last whorl is far less compressed on both sides of the peripheral angle, which is much blunter. The aperture is less oblique, more widely open in a face view; the right margin of peristome is *arcuate*, and the left is evenly curved, and more curved than the right." None of these characters nor their combination is valid, for all are continuous variates. Examination of the type series (ANSP 157617) and one nonparatypic specimen from the type lot (UMMZ 156771) confirms the belief that *M. hudsonicus* is merely an extreme of the normal variation of *Promenetus exacuous*. One lot (UMMZ 28256) contains individuals referable to the forms *exacuous* s.s., *megas, rubellus, hudsonicus,* and perhaps new ones at this scale of division.

Menetus coloradoensis Baker (1945, p. 230) was distinguished from *Promenetus exacuous* "in the pinched nature of the periphery, the swollen or tumid base near the suture, and the heavy (in some instances, costate) sculpture." This form represents the combination of two extremes, (1) a strongly pinched periphery, which crowds the lumen of the whorl against the preceding one, and (2) persistence to the adult stage of relatively strong sculpture, usually occurring (if at all) on the early whorls only. This sculpture is common or usual only in fossil shells, where it is considered the differentiating feature of *P. kansasensis*. The rare occurrence in Recent specimens of this feature is interpreted as an atavistic trait. Examination of the two paratypes (UCMNH 10114*a*) confirms the belief that *M. coloradoensis* is a synonym of *P. exacuous*. As noted previously (D. W. Taylor, 1952, p. 44), the original description as *Menetus* is probably attributable to the incomplete state of Baker's notes.

Promenetus umbilicatellus (Cockerell), 1887

(Pl. XIII, Figs. 5, 7, 9)

Gyraulus umbilicatellus (Cockerell), Baker, 1928*a*, p. 383, Pl. 22, Figs. 18–21.

Promenetus umbilicatellus (Cockerell), Baker, 1945, p. 182, Pl. 123, Figs. 34–36. A. B. Leonard, 1950, p. 18, Pl. 3, Fig. *H*. Frye and Leonard, 1952, p. 159. D. W. Taylor, 1956, p. 123; 1957, p. 660.

Promenetus blancoensis, new species, A. B. Leonard, 1952*b*, p. 42, Pl. 5, Figs. *D–F*.

Promenetus blancoensis Leonard, Frye and Leonard, 1952, p. 151, Pl. 14, Fig. *o*.

Gyraulus similaris Baker, A. B. Leonard, 1952*a*, p. 20, in part?; Pl. 3, Figs. *D–E* (not of Baker).

Geologic Range.—Middle Pliocene to Recent. The known Tertiary occurrences are as follows: middle Pliocene, Salt Lake formation, Power County, Idaho (USGS loc. 21671); middle Pliocene, Teewinot formation, Jackson Hole, Teton County, Wyoming, and Grand Valley and Star Valley, Lincoln County, Wyoming, and Bonneville County, Idaho; middle Pliocene, White Cone local fauna, Navajo County, Arizona; late Pliocene, Red Corral local fauna, Oldham County, Texas (UMMZ 182996); late Pliocene, Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 177515, 177558); late Pliocene, Rexroad local fauna, Meade County, Kansas (UMMZ 183056); late Pliocene, Bender local fauna, Meade and Seward counties, Kansas (UMMZ 177505, 184120, 183014, 184151); late Pliocene, Sand Point local fauna, Owyhee County, Idaho (USGS locality 19128); late Pliocene, Cache Valley formation of N. Smith (1953), Cache and Box Elder counties, Utah (USGS locality 20093).

Distribution.—North America north of about the forty-first parallel from Nevada and Alaska east and southeast to western New York; south in the Rocky Mountains to southern Colorado; sporadic in eastern Kansas and northeastern Oklahoma.

The accompanying map (Fig. 8) is based on records from publications and examination of the collections of the University of Michigan Museum of Zoology, United States National Museum, Academy of Natural Sciences of Philadelphia, University of Colorado Museum of Natural History, and Carnegie Museum. Peripheral localities are as follows:

ALASKA. Chena; Mrs. C. S. Rathbun (USNM 193099).

WASHINGTON. Pierce Co.: Ashford; J. A. Allen, 1904 (USNM 572319). Clark Co.: Lewis R., Lewisville; J. Henderson (UCMNH 20818).

OREGON. Klamath Co.: Upper Klamath Lake; A. A. Beetle, 1957 (DEB 57-54).

UTAH. Cache Co.: Logan; W. H. Krull, 1940 (USNM 522641).

IDAHO. Bear Lake Co.: Paris; W. H. Krull, 1941 (USNM 536400). Bannock Co.: Portneuf River near McCammon (Henderson, 1924, p. 180).

WYOMING. Platte Co.: Slater; J. P. E. Morrison, 1922 (USNM 431867).

COLORADO. Boulder Co.: southwest of Lake Eldora (UCMNH 10098). Gunnison Co.: Gunnison (UCMNH 12241a). Alamosa Co.: Alamosa (ANSP).

NEBRASKA. Cheyenne Co.: Sidney; C. C. Engberg (USNM 362015a). Lancaster Co.: near Lincoln; C. C. Engberg (USNM 347892).

KANSAS. Leavenworth Co.: southeastern part. Barton Co.: Cheyenne Bottoms east of Hoisington. Miami Co.: Miami County Lake. (All from A. B. Leonard, 1959).

OKLAHOMA. Cherokee Co.: drift, Illinois River; A. A. Hinkley (USNM 572299).

IOWA. Johnson Co.: Iowa City; B. Shimek (USNM 476437a).

ILLINOIS. Cook Co.: Bowmanville, Chicago; F. C. Baker, 1898 (USNM 752298).

INDIANA. Kosciusko Co.: Tippecanoe Lake (Blatchley and Daniels, 1903, p. 599).

OHIO. Tuscarawas Co.: New Philadelphia (ANSP).

NEW YORK. Cattaraugus Co.: Lime Lake; M. E. Walker (UMMZ 89814). Erie Co.: Buffalo; M. E. Walker (UMMZ 89818).

ALBERTA. 3 miles N. of Spirit River (Mozley, 1934, p. 144). Edmonton (USNM 382127a). Wainwright (Mozley, 1934, p. 144).

SASKATCHEWAN. Kelliher (Mozley, 1930, p. 84). Touchwood (Mozley, 1930, p. 84).

MANITOBA. North of Birtle (Mozley, 1930, p. 84). Grande Pointe (Mozley, 1930, p. 84).

MINNESOTA. St. Louis Co.: Vermilion Lake; F. C. Baker (USNM 572301).

MICHIGAN. Wexford Co.: Clam L.; Walker (UMMZ 89843).

ONTARIO. Welland Co.: Ft. Erie; M. E. Walker (UMMZ 89817).

Habitat.—"All specimens in Wisconsin have been found in swales" (Baker, 1928*a*, p. 384). In northern Nebraska (Brown and Cherry counties) it was found moderately common in temporary water bodies, such as drainage ditches and ponds in the Sand Hills. Common associates were *Stagnicola caperata, S. palustris,* and *Aplexa hypnorum.* This species seems to be most abundant in the northern Great Plains, from Nebraska to southern Canada, and as far west as Montana, southeastern Idaho, and Wyoming. In other areas its occurrence is sporadic or in small numbers.

Occurrence.—Butler Spring, Cragin Quarry, and Jones local faunas.

Material.—Butler Spring loc. 1, UMMZ 197554 (57); Cragin Quarry loc. 1, UMMZ 184457 (1000), USGS 21274–9 (1000); Jones, UMMZ 181109 (1).

Remarks.—Promenetus blancoensis appears to be a synonym of *P. umbilicatellus,* easily falling within the range of variation of the latter. The differentiae given by Leonard (1952*b*, p. 42) were the "smaller size, lesser number of whorls (always less than 4), non-striate nucleus, absence of spiral sculpture, and depressed spire." The great majority of Recent specimens examined have less than four whorls and have a diameter of

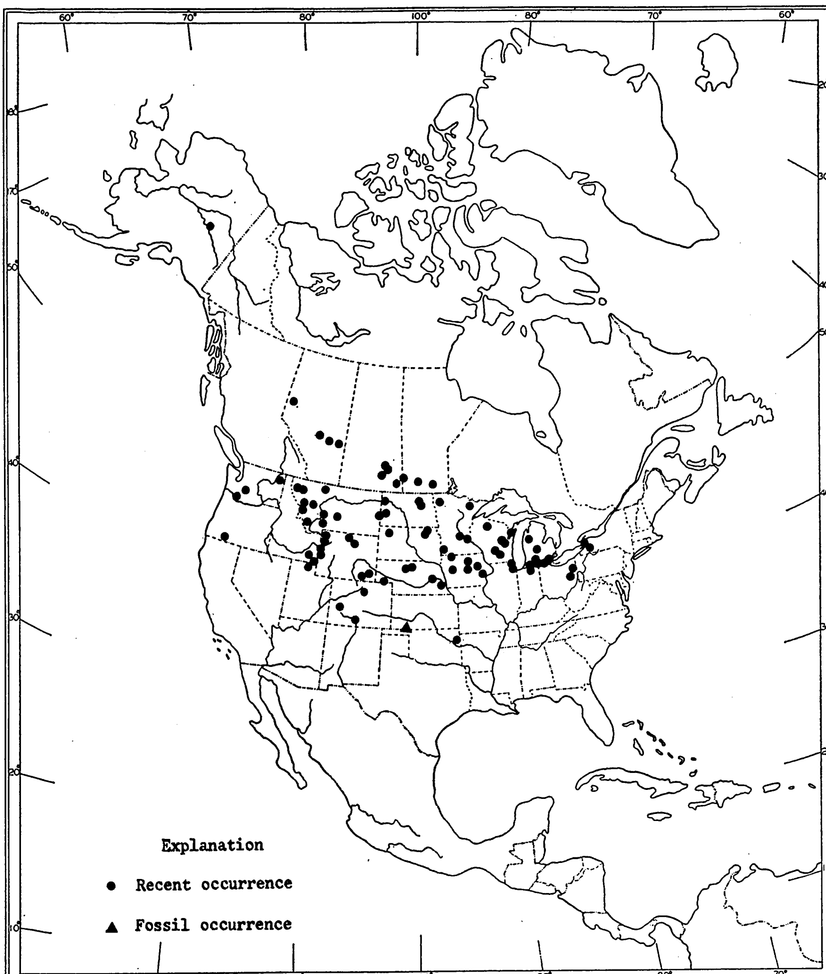

FIG. 8. Distribution of *Promenetus umbilicatellus* (Cockerell).

approximately 4 millimeters, thus agreeing with the measurements of *P. blancoensis*. To the "non-striate nucleus" not much significance should be attached. All other characters are in agreement with those of *P. umbilicatellus,* and the nuclear striation might easily be lost through wear. The apparent absence of spiral sculpture does not differentiate the form from *P. umbilicatellus,* for this character is often very difficult to observe in unworn Recent specimens, and in fossils faint spiral sculpture might have been lost or easily overlooked. The depressed spire is also a character which may be present in Recent specimens, although it is not common.

Material from the Saw Rock Canyon and Rexroad local faunas (from which Leonard recorded *P. blancoensis*) confirms the synonymization. The specimens agree in size and form with *P. umbilicatellus,* and less worn individuals show spiral striation and nuclear sculpture typical of that species.

Family Ferrissiidae

This group is ranked as a family following Zilch (1959, p. 126).

Genus *Ferrissia* Walker, 1903

Ferrissia meekiana (Stimpson), 1863

(Pl. X, Figs. 15–16, 18–19)

Gundlachia meekiana, Stimpson, Binney, 1865, p. 150.

Ancylus pumilus Sterki, Walker, 1904, p. 82, Pl. 6, Figs. 20–22; 1914, p. 129.

Ferrissia cf. *pumila* (Sterki), D. W. Taylor, 1954*a*, p. 15. Taylor and Hibbard, 1955, pp. 11, 16.

Ferrissia parallela (Haldeman), van der Schalie, 1953, p. 84, in part (not of Haldeman).

Geologic Range.—Early Pleistocene (Nebraskan) to Recent. The earliest record in the southern Great Plains is from the Nebraskan or Aftonian Dixon local fauna.

Distribution.—Probably the species ranges over most of the eastern United States. It is known from scattered localities in Alabama, Kansas, Missouri, Virginia, the District of Columbia, and from Iowa eastward to New York.

Habitat.—Uncertain. It has been found in temporary pools, ponds, and sloughs, but may occur in other habitats as well.

Occurrence.—Butler Spring, Cragin Quarry, Jinglebob, and Bar M local faunas.

Material.—Butler Spring loc. 1, UMMZ 197834 (6); Cragin Quarry loc. 1, UMMZ 184447 (17); Jinglebob, UMMZ 181159 (3).

Remarks.—The kinds of shells regarded as *Ferrissia meekiana* in this paper have been found at several localities in Pleistocene deposits of the Great Plains. Frequently the very small, septate, immature shells (Pl. X, Figs. 15–16) are associated with larger, nonseptate shells (Pl. X, Figs. 18–19) similar to *F. pumila.* Only one sample was large enough to show the range of variation adequately; it is from the Dixon local fauna, Kingman County, Kansas (Taylor, 1960). From the range of variation in the Dixon sample and Recent material in the University of Michigan Museum of Zoology, and the similarity of the fossils to specimens identified by Walker as *Gundlachia meekiana,* it appears (1) that the small septate shells and larger nonseptate specimens represent one species and (2) that *Ancylus pumilus* Sterki represents the nonseptate form of *"Gundlachia" meekiana.* Walker (1914, p. 129) had reached similar conclusions from study of Recent shells. Regardless of nomenclature, however, the *Gundlachia* *meekiana* of Leonard (1959) and the *Ferrissia meekiana* of this author are one and the same species.

Watson (*in* Connolly, 1938, p. 525–26) presented convincing evidence that reference of all septum-forming Ancylidae to *Gundlachia* is unjustified. He restricted *Gundlachia* to tropical American and West Indian species with a smooth apex and an asymmetrical central tooth, and placed apically striate septum-forming species (*Kincaidilla*) in *Ferrissia*. In accordance with his classification *Gundlachia meekiana* (including *Ancylus pumilus*) is referred to *Ferrissia*.

Genus *Laevapex* Walker, 1903

This group is treated as a genus following Basch (1959).

Laevapex fuscus (Adams), 1840

Ancylus fuscus Adams, Walker, 1903, p. 15, Pl. 1, Figs. 1–15.
Ferrissia fusca (C. B. Adams), Baker, 1928*a*, p. 404, Pl. 24, Figs. 10–13.
Ferrissia rivularis (Say), van der Schalie, 1953, p. 84, in part (not of Say). Taylor and Hibbard, 1955, p. 11, in part (not of Say).

Geologic Range.—Late Pleistocene to Recent. The first known occurrence in the southern Great Plains is in the Sangamon Jinglebob local fauna, southwestern Kansas.

Distribution.—"Massachusetts west to the Mississippi Valley, south to New Orleans" (Baker, 1928*a*, p. 405).

Habitat.—This species lives on stones, reeds, logs, and the like in quiet or gently flowing shallow water.

Occurrence.—Jinglebob and Jones local faunas.

Material.—Jinglebob, UMMZ 181157 (6); Jones, UMMZ 142691 (1).

Laevapex kirklandi (Walker), 1903
(Pl. X, Fig. 20)

Ancylus kirklandi, Walker, 1903, p. 29, Pl. 2, Figs. 1–12.
Ferrissia kirklandi (Walker), Baker, 1928*a*, Pl. 24, Figs. 19–21.
Ferrissia parallela (Haldeman), van der Schalie, 1953, p. 84, in part (not of Haldeman). Taylor and Hibbard, 1955, p. 11, in part (not of Haldeman).

Geologic Range.—Late Pleistocene to Recent. The earliest known occurrence is in the Illinoian Butler Spring local fauna.

Distribution.—Wisconsin and Michigan south to eastern Kansas and Arkansas, east to New Jersey and Virginia.

Habitat.—Almost unknown in detail. Baker (1928*a*, p. 407) recorded it in Wisconsin from "Sturgeon Bay, on naiad shells near shore."

Occurrence.—Butler Spring and Jinglebob local faunas.

Material.—Butler Spring loc 1, UMMZ 197557 (126), USGS 21042–14 (95); Jinglebob, UMMZ 181158 (2).

Remarks.—This is the first record of this species from the Pleistocene of the Great Plains.

Family Physidae

Genus *Physa* Draparnaud, 1801

I have limited the systematic work on the species of *Physa* to establishing the number of species in the faunas, to verification of the nomenclature used by examination of the pertinent types, and to study of the types of *Physa* described from Kansas.

Many thousands of Recent and fossil shells of *Physa* from the Great Plains region have been examined, and it appears that there are only three recognizable late Cenozoic species in this area. *Physa skinneri,* with its small shell and obtusely rounded apex (Pl. X, Fig. 8), is conspicuously distinct and known only as a fossil. The other two species, *Physa gyrina* and *P. anatina,* are less easily separated but are nevertheless valid. The differences between them are as follows:

Physa gyrina (Pl. X, Figs. 4–5, 9, 13) has a larger and heavier shell than *P. anatina* (Pl. X, Figs. 2–3, 11–12) and the apertural callus is often conspicuous and usually thicker. The two species overlap in shape of spire, but most specimens of *P. gyrina* are lower and broader, most *P. anatina* higher and narrower. The sutures of *P. anatina* are usually more impressed. Sculptural differences are almost entirely in the periostracum. The fossils, therefore, usually do not show any consistent differences in these features. The periostracum of *P. anatina* has little if any spiral sculpture and is smooth and shining. In *P. gyrina* there is well-developed spiral and axial sculpture, consisting of numerous fine axial lines cut by numerous spiral incised lines. Both series of lines are conspicuous when examined microscopically or with a lens, but are so fine that the surface of the shell may appear smooth to the naked eye. According to these criteria the shells figured by Leonard (1959, p. 71, Pl. 3) are identifiable as follows: Figures 7, 8, 14, 18, *Physa gyrina;* Figure 13, *P. anatina.*

Many immature shells may be unidentifiable when both species occur together as fossils. But, inasmuch as the adults are readily recognizable by the criteria given and the two species are not confused when living in association, specific status of both forms seems established.

One of the two species is identifiable as *Physa gyrina hildrethiana* as described by Baker (1928*a*), the other is the *P. anatina* of some of A. B. Leonard's publications. Verification of these authors' identifications has led to an examination of type material of several species.

The *Physa* material from Kansas described by Lea (1864, 1867*a, b*) and contained in the U. S. National Museum collections is listed in Table VIII. The labels and Lea's papers identify the collector of most of the shells as F. Hawn, a civil engineer.

TABLE VIII
IDENTIFICATION OF TYPE SPECIMENS OF *Physa* FROM KANSAS

Locality	USNM Cat. No.	Number of Specimens	Type	Identification
Verdigris River, Kansas	119896	1	Paratype *P. whitei*	*P. anatina*
	29188	5	Paratypes *P. saffordii*	*P. gyrina*
	119928	56	Paratypes *P. saffordii*	*P. gyrina*
	29183	1	Holotype *P. hawnii*	*P. gyrina*
		3	Paratypes *P. hawnii*	*P. gyrina*
		1	Paratype *P. hawnii*	*P. anatina*
	172321	1	Holotype *P. parva*	*P. anatina*
		1	Paratype *P. parva*	*P. anatina*
Rock Creek, Kansas	29201	1	Paratype *P. parva*	*P. anatina*
	172322	6	Paratypes *P. parva*	*P. anatina*
Northern tributary, Arkansas River, Kansas	172317	1	Holotype *P. anatina*	*P. anatina*
		1	Paratype *P. anatina*	*P. anatina*
Santa Rita Valley, Kansas?	170753	1	Holotype *P. grosvenorii*	*P. anatina*
		3	Paratypes *P. grosvenorii*	*P. anatina*

"Verdigris River, Kansas" is the locality given for most of the specimens listed in Table VIII. All shells identified as *Physa gyrina* are so closely similar that they probably come from a single collection. They are bleached, mostly lack the periostracum, and many are slightly worn, so that possibly they were collected from river drift. Shells identified as *Physa anatina* are fewer and retain the periostracum. They, too, may be from drift, for none contains the dried body, and they are much smaller and could have been carried with less wear than the larger and heavier shells of *P. gyrina*. The paratype of *P. whitei* is an adult *P. anatina* with a relatively short spire and broad body whorl; the other *P. anatina* from Verdigris River are immature. All of the shells of *P. gyrina* are so much alike that it is difficult to understand why Lea discriminated between them.

Physa anatina Lea, 1864

(Pl. X, Figs. 2–3, 11–12)

Physa anatina, Lea, 1864, p. 115; 1867*a,* p. 171, Pl. 24, Fig. 94; 1867*b,* p. 127, Pl. 24, Fig. 94.

Physa anatina Lea, Crandall, 1901, p. 57. A. B. Leonard, 1950, p. 21, Pl. 2, Fig. *F;* 1952*a,* p. 22, Pl. 2, Fig. *B.* Frye and Leonard, 1952, pp. 151, 158, 164, 179, Pl. 14, Fig. *z;* Pl. 16, Fig. *s;* Pl. 18, Fig. *j.* Frye and Leonard, 1957*b,* p. 60, Pl. 5, Fig. 10.

Physa cf. *anatina* Lea, van der Schalie, 1953, p. 84.

Physella anatina Lea, Baker, 1928*a,* p. 470, Pl. 19, Fig. 5 (not 7).

Physa parva, Lea, 1864, p. 115; 1867*a,* p. 177, Pl. 24, Fig. 104; 1867*b,* p. 133, Pl. 24, Fig. 104.

Physa Whitei, Lea, 1864, p. 114, in part (Verdigris R., Kansas); 1867*a,* p. 172, in part (Verdigris R., Kansas); 1867*b,* p. 128, in part (Verdigris R., Kansas).

Physa Grosvenorii, Lea, 1864, p. 114; 1867*a,* p. 175, Pl. 24, Fig. 100; 1867*b,* p. 131, Pl. 24, Fig. 100.

Physa Hawnii, Lea, 1864, p. 115, in part; 1867*a,* p. 165, in part (not Pl. 24, Fig. 84); 1867*b,* p. 121, in part; not Pl. 24, Fig. 84.

Physa hawni Lea, A. E. Leonard, 1943, p. 238, Pl. 1, Figs. 8, 16 (not of Lea). Franzen and Leonard, 1943, p. 408, Pl. 30, Fig. 11 (not of Lea). Frye, Leonard, and Swineford, 1956, p. 35, Pl. 6, Fig. *a* (not of Lea).

Geologic Range.—Late Pliocene to Recent. The known Tertiary occurrences are all in the southern Great Plains: Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 172364, 177560); Red Corral local fauna, Oldham County, Texas (UMMZ 182998); Rexroad local fauna, Meade County, Kansas (UMMZ 177600, 181049, 183030, 183057, 183067); Bender local fauna, Meade and Seward counties, Kansas (UMMZ 184121, 184135, 184152).

Distribution.—Very poorly known, because the genus has not been studied. Probably, the species occurs in most of the central and southern Great Plains. Crandall (1901, p. 57) stated that "It is plentiful around Wichita, Kansas, and has been reported from Missouri, Kansas, Nebraska and Michigan. It probably inhabits all the intervening territory."

Habitat.—Almost any sort of perennial, shallow water body, in either flowing or standing water. In Meade County the species is found in small streams, in spring-fed ponds in the State Park, and in stock tanks.

Occurrence.—Butler Spring, Cragin Quarry, and Jones local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 177378 (5000), USGS 21042–15 (2500); loc. 2, UMMZ 197580 (70), USGS 21043–1 (15). Cragin Quarry: loc. 1, UMMZ 197489 (86), USGS 21274–10 (50); loc. 2, UMMZ 197500 (14); loc. 3, UMMZ 197521 (1). Jones, UMMZ 137788 (300), 142701 (75).

Remarks.—*Physa anatina* was recorded by Frye, Leonard, and Swineford (1956) from the Ogallala formation. The quality of the fossils they described was so poor that one can not justify extension of the range of the species downward into the middle Pliocene.

Physa grosvenorii and *Succinea grosvenorii* were both reported by Lea (1867*b,* p. 131, 135) from the "Santa Rita valley, Kansas?." But, like A. B. Leonard (1950, p. 24), I have been unsuccessful in learning of a valley of this name in Kansas.

Physa gyrina Say, 1821, form *hildrethiana* Lea, 1841

(Pl. X, Figs. 4–5, 9, 13)

Physa Hildrethiana, Lea, 1841, p. 32; 1844, p. 7; 1848, p. 7.

Physella gyrina hildrethiana (Lea), Baker, 1928*a*, p. 453, Pl. 27, Fig. 36; Pl. 28, Figs. 2–4, 7–14.
Physa Altonensis, Lea, 1864, p. 114; 1867*a,* p. 164, Pl. 24, Fig. 82; 1867*b,* p. 120, Pl. 24, Fig. 82.
Physa Hawnii, Lea, 1864, p. 115, in part; 1867*a,* p. 165, in part, Pl. 24, Fig. 84; 1867*b,* p. 121, in part, Pl. 24, Fig. 84.
Physa hawnii Lea, H. T. U. Smith, 1940, p. 109.
Physa hawni Lea, Rinker, 1949, p. 110. Leonard and Goble, 1952, p. 1027, Pl. 100, Fig. 2.
Physella gyrina hawni (Lea), Baker, 1928*a,* p. 453.
Physa Saffordii, Lea, 1864, p. 115, in part (Verdigris R., Kansas); 1867*a,* p. 167, in part (Verdigris R., Kansas); 1867*b,* p. 123, in part (Verdigris R., Kansas).
Physa elliptica Lea, A. B. Leonard, 1950, p. 21, Pl. 2, Fig. *G.* Frye and Leonard, 1952, p. 159, Pl. 15, Fig. *aa.* D. W. Taylor, 1954*a,* pp. 4, 15. Taylor and Hibbard, 1955, pp. 10, 15.
Physa cf. *elliptica* Lea, van der Schalie, 1953, p. 84.
Physa gyrina Say, Taylor and Hibbard, 1955, pp. 10, 15.
Physa anatina Lea, Franzen and Leonard, 1943, p. 408, Pl. 30, Fig. 10 (not of Lea). Frye, Leonard, and Swineford, 1956, p. 32, Pl. 6, Fig. *b* (not of Lea).

Geologic Range.—Early Pleistocene (Nebraskan) to Recent. In the southern Great Plains, *P. gyrina* is known first from the late Nebraskan or early Aftonian Dixon local fauna, Kingman County, Kansas.

Distribution.—Probably found in most of North America north of Mexico. According to Baker (1928*a*), *Physa gyrina* is found "from the Arctic regions south to Alabama and Texas"; the form *hildrethiana* "is common east of the Mississippi River from western New York and Pennsylvania to Illinois and south to Alabama. Occurs also in Iowa and possibly in other states west of the Mississippi River." The species has not been found living in Meade County and may not occur in the southern Great Plains except as a fossil. It probably does not live in the southwestern United States.

Habitat.—"*Hildrethiana* is characteristic of swales and summer-dry ponds, where it is deprived of moisture for a large part of the year. The variety in such localities rarely reaches maturity, the usual form being a small, short, shell with dome-shaped spire, greatly resembling *oleacea* and *elliptica*. These small forms usually show no rest marks, living only as long as the water remains in the pool. Mature shells may often be found by digging in the mud or in cracks in the bottom of the pool where the mollusk has descended for moisture. Large specimens may have as many as four rest marks on the shell. In some sloughs the water may become very low in summer but does not completely disappear. In such locations *hildrethiana* attains its finest development (see Baker, 1924, for descriptions of habitats near Oshkosh)." (Baker, 1928*a*, p. 454.).

Occurrence.—Butler Spring, Cragin Quarry, and Jones local faunas.

Material.—Butler Spring loc. 1, UMMZ 177379 (300), USGS

21042–16 (25); Cragin Quarry loc. 1, UMMZ 184471 (39), USGS 21274–11 (8); Jones, UMMZ 142700 (11).

Remarks.—In addition to the holotype and paratypes of *Physa hawnii* and the paratypes of *P. saffordii* from Kansas, which are referred to *P. gyrina* form *hildrethiana,* the holotype of *P. altonensis* was examined. This also falls within the range of variation of this form as understood here. The holotype of *P. hildrethiana* has not been located in the U. S. National Museum; identification is based upon the illustration of it by Binney (1865, p. 78).

The specific distinction of *Physa elliptica* and *P. gyrina* that is maintained by Baker (1928*a*) is doubtful, but settling this question is beyond the scope of this paper. On the basis of the specimens and illustrations examined, the shells recorded from Kansas as *Physa elliptica* appear to be *P. gyrina* form *hildrethiana* rather than *P. elliptica.*

Physa skinneri Taylor, 1954

(Pl. X, Fig. 8)

Physa skinneri, new species, Taylor, 1954*a,* pp. 4, 9, 15.

Physa skinneri Taylor, Johnston and Savage, 1955, p. 46. Miller and Scott, 1955, pp. 1438, 1443. Taylor and Hibbard, 1955, p. 16.

Geologic Range.—Early Pleistocene (Nebraskan) to Recent. In the southern Great Plains this species is first known in the Nebraskan or Aftonian Dixon local fauna (UMMZ 182208, 191518).

Distribution.—Alaska southward to northern Utah; eastward across southern Canada to western Ontario and northern Minnesota. All known Recent localities are listed below, and plotted on the map (Fig. 9).

ALASKA. Fort Yukon; J. E. Winecoff (USNM 218912). Umiat; L. A. Jachowski, 1944 (UMMZ 178568).

ALBERTA. Slough on Calgary trail; Owen Bryant, 1924 (USNM 382161). Edmonton; Owen Bryant, 1924 (USNM 382160, 382176).

SASKATCHEWAN. Tyvan (UMMZ 188771). Tyvan Reservoir (UMMZ 188768). Gull Lake (UMMZ 188782). Hanley Reservoir (UMMZ 188783). Pike Lake (UMMZ 188815).

MANITOBA. Oak Point; R. W. Coleman, 1957 (USNM uncat.). Grassmere Drain at highway 7; R. W. Coleman, 1957 (USNM uncat.). Winnipeg Beach; R. W. Coleman, 1957 (USNM uncat.).

ONTARIO. Kenora Dist.: Fort Severn; W. B. Scott, 1940 (UMMZ 193178). Lake Attawapiskat; W. B. Scott, 1939 (UMMZ 193599). Wabigoon; J. J. Miller, 1937 (UMMZ 193081). Two miles north of Reed Narrows along highway 70; R. W. Coleman, 1957 (USNM uncat.). Rainy River Dist.: Eight miles south of Finland along highway 70; R. W. Coleman, 1957 (USNM uncat.).

MINNESOTA. Polk Co.: Shallow slough on L. Larson farm, Erskine; H. J. Griffiths, 1958 (USNM uncat.).

WYOMING. Lincoln Co.: Center E½ sec. 1, T. 24 N., R. 120 W., Cokeville quadrangle; oxbow pond on NE side of road, 6150′ elev.; D. W. Taylor, 1956 (USGS). Near Afton; W. H. Krull, 1941 (USNM 536462). Sublette Co.: NE¼, NE¼, sec. 1,

T. 39 N., R. 111 W., Gros Ventre quadrangle; kettle pond, ±8700′ elev.; D. W. Taylor, 1959 (USGS). Uinta Co.: Heward Ranch, slough by Bear River 1 mile above Utah line; Honess (USNM uncat.).

UTAH. Summit Co.: Lost Cr., Uinta Mts. (T. 1 S., R. 5 E., 6000′ elev.); N. D. Richmond, 1940 (USNM 533484). Davis Co.: Temporary pond at head of Confusion Canyon, 4700′ elev., 5 mi. S. of Ogden; J. H. Feth (USNM uncat.).

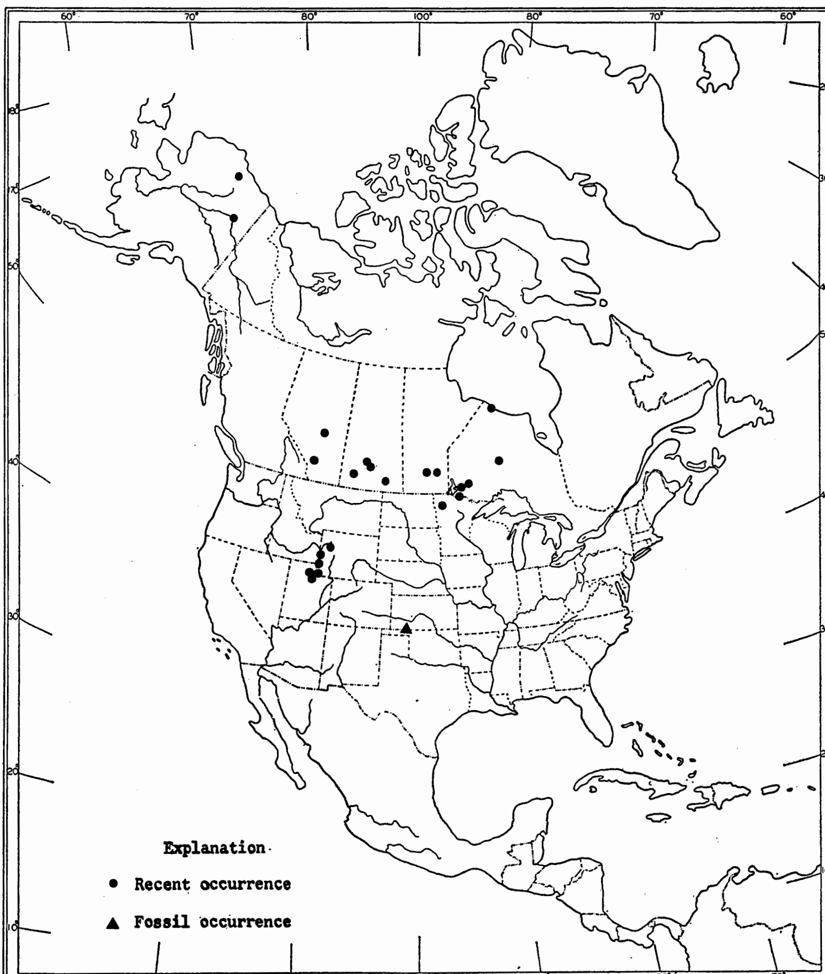

FIG. 9. Distribution of *Physa skinneri* Taylor.

Habitat.—The scanty information from the Recent occurrences suggests this species lives in shallow bodies of water, either perennial or seasonal, such as temporary ponds, sloughs, and backwaters along streams. In Lincoln County, Wyoming, Taylor collected it from a small, shallow, perennial pond on the flood plain of the Bear River. This pond contained a rich growth of submergent aquatic plants growing in a soft organic mud bottom, marginal cattails, and many mollusks. *Valvata, Lymnaea, Promenetus,* and the *Physa* were common.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197555 (19).

Genus *Aplexa* Fleming, 1820

Aplexa hypnorum (Linnaeus), 1758

Aplexa hypnorum (Linné), Baker, 1928*a,* p. 473, Pl. 19, Figs. 1–4. A. B. Leonard, 1950, p. 22, Pl. 2, Fig. *H.* Frye and Leonard, 1952, p. 159. D. W. Taylor, 1954*a,* p. 15.
Aplexa hypnorum Linné, Geyer, 1927, p. 153, Pl. 15, Fig. 8. Frömming, 1956, p. 152, Figs. 36–38.

Geologic Range.—Early Pleistocene (Nebraskan) to Recent. In the southern Great Plains this species is first known in the Aftonian Sanders local fauna (UMMZ 182151).

Distribution.—Holarctic. In North America "from east of the Cascade Mountains to the Atlantic and from Alaska and Hudson Bay south to the vicinity of the Ohio River" (Baker, 1928*a,* p. 474).

Habitat.—"*Aplexa hypnorum* is a species of swales and intermittent streams or stagnant pools in Wisconsin, as far as present data goes. It is especially abundant in woodland pools which become dry in summer . . ." (Baker, 1928*a,* p. 474). In north-central Nebraska Taylor found it locally abundant in roadside drainage ditches with temporary water.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197556 (3).

Order STYLOMMATOPHORA

Family Strobilopsidae

Genus *Strobilops* Pilsbry, 1893

Subgenus *Strobilops* s. s.

Strobilops (s. s.) *labyrinthica* (Say), 1817

Strobilops labyrinthica (Say), Pilsbry, 1948, p. 854, Fig. 463. Franzen and Leonard, 1943, p. 422, Pl. 31, Figs. 22–24. Leonard and Goble, 1952, p. 1038, Pl. 101, Fig. 16.
Strobilops texasiana (Pilsbry and Ferriss), van der Schalie, 1953, p. 83 (not of Pilsbry and Ferriss). Taylor and Hibbard, 1955, p. 11 (not of Pilsbry and Ferriss).

Geologic Range.—Late Pliocene to Recent. The only known Tertiary occurrence is in the Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 177561).

Distribution.—"Maine and Quebec west to Manitoba, Minnesota, Kansas and Arkansas, south to Georgia and Alabama" (Pilsbry, 1948, p. 854).

Habitat.—"Its usual stations are 'under loose bark of logs, in halfdecayed wood, among dead leaves and in sod at bases of trees' " (Pilsbry, 1948, p. 854). In northeastern Kansas Franzen and Leonard (1943) and Leonard and Goble (1952) noted that *S. labyrinthica* is restricted to woodland habitats where moist logs are present.

Occurrence.—Jinglebob and Bar M local faunas.

Material.—Jinglebob, UMMZ 181176 (150); Bar M loc. 2, UMMZ 184393 (6).

Remarks.—The specimens from the Jinglebob local fauna recorded by van der Schalie (1953) as *S. texasiana* have the finer, closer riblets and smoother base characteristic of *S. labyrinthica*.

Family Pupillidae
Subfamily Gastrocoptinae
Genus *Gastrocopta* Wollaston, 1878
Subgenus *Gastrocopta* s. s.
Gastrocopta (s.s.) *cristata* (Pilsbry and Vanatta), 1900
(Pl. XI, Fig. 16)

Gastrocopta cristata (Pilsbry & Vanatta), Pilsbry, 1948, p. 911, Fig. 493 in part, Nos. 6, 8–12. A. B. Leonard, 1950, p. 32, Pl. 6, Fig. *k*.
Gastrocopta cristata (Pilsbry and Vanatta), Franzen and Leonard, 1947, p. 344, Pl. 19, Fig. 1; Pl. 20, Fig. 1. Frye and Leonard, 1957*b*, p. 60, Pl. 5, Fig. 4.
Gastrocopta cristata Pilsbry & Vanatta, Frye and Leonard, 1952, p. 158.
Gastrocopta cristata Pilsbry and Vanatta, D. W. Taylor, 1954*a*, p. 12.
Gastrocopta cristata, A. E. Leonard, 1943, p. 239, Pl. 1, Figs. 9–10.
Gastrocopta procera (Gould), Goodrich, 1940, p. 77, in part (not of Gould).

Geologic Range.—Late Pliocene to Recent. The single late Pliocene occurrence referable to *G. cristata* is in the Bender local fauna, Meade County, Kansas (UMMZ 177506, 184122, 183015). The species is common as a Pleistocene fossil.

Distribution.—Northern Nebraska to southern Texas, west to Arizona.

Habitat.—"*Gastrocopta cristata* has, in Kansas, usually been found associated with *G. procera* (Gould) on timbered slopes near streams" (Franzen and Leonard, 1947, p. 345). In Meade County, Kansas, "*Gastrocopta cristata* is common in the grassy meadowlands of the Park area, and it occurs sparingly in similar situations elsewhere" (A. E. Leonard, 1943, p. 239). In northern Brown County, Nebraska, it was found in a wooded ravine, among damp leaves and dead wood (Taylor, 1960).

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197562 (400), USGS 21042–17 (400); loc. 2, UMMZ 197581 (1). Cragin Quarry: loc. 1, UMMZ 184451 (89); loc. 2, UMMZ 197505 (500), USGS 21275–6

(500); loc. 3, UMMZ 184438 (500), USGS 21276-1 (500); loc. 4, UMMZ 197533 (4).

Remarks.—Of the three shells (UMMZ 137785) recorded by Goodrich (1940) as *G. procera,* two are fossil *G. cristata,* and one is a Recent *G. procera.*

Gastrocopta (s. s.) *procera* (Gould), 1840

(Pl. XI, Fig. 15)

Gastrocopta procera (Gld.), Pilsbry, 1948, p. 907, Fig. 492 in part, Nos. 1–5.

Gastrocopta procera sterkiana, Pilsbry, Pilsbry, 1948, p. 908, Fig. 492 in part, Nos. 7–8; Fig. 493 in part, No. 7.

Gastrocopta procera mcclungi (Hanna & Johnston), Pilsbry, 1948, p. 910, Fig. 493 in part, Nos. 1–5.

Gastrocopta procera duplicata (Sterki), Franzen and Leonard, 1943, p. 419, Pl. 32, Fig. 31.

Gastrocopta procera mcclungi (Hanna and Johnston), A. E. Leonard, 1943, p. 239, Pl. 1, Fig. 14. Franzen and Leonard, 1943, p. 419, Pl. 32, Fig. 32.

Gastrocopta procera (Gould), Franzen and Leonard, 1947, p. 341 in part, Pl. 18, Fig. 3 (not Fig. 6). A. B. Leonard, 1950, p. 32, Pl. 6, Fig. *J.* Leonard and Goble, 1952, p. 1033, Pl. 101, Fig. 15.

Geologic Range.—Early Pleistocene to Recent. The geologically oldest occurrence is in the Nebraskan or Aftonian Dixon local fauna, Kingman County, Kansas (UMMZ 182217, 191520). Pliocene records are based on another species (Taylor, 1960).

Distribution.—Maryland to South Carolina and Alabama; west to South Dakota and Arizona.

Habitat.—"This pupillid lives on timbered slopes of streams. Its general distribution in Kansas indicates an ability to withstand periods of summer drought." (Franzen and Leonard, 1947, p. 342). In southwestern Kansas, according to A. E. Leonard (1943, p. 239), "This snail is not common in the area; a small series was taken in Clark County in a wooded ravine."

Occurrence.—Butler Spring local fauna; Recent in Clark County, Kansas.

Material.—Butler Spring loc. 1, UMMZ 197563 (23); loc. 2, UMMZ 197838 (1).

Gastrocopta (s.s.) *pellucida hordeacella* (Pilsbry), 1890

Gastrocopta pellucida hordeacella (Pilsbry), Pilsbry, 1948, p. 913, Figs. 494 *a–d,* 495. Franzen and Leonard, 1947, p. 349, Pl. 19, Fig. 8. Pilsbry, 1953, p. 162.

Geologic Range.—Late Pliocene to Recent. The two known late Pliocene occurrences are as follows: Red Corral local fauna, Oldham County, Texas (UMMZ 183002, USGS locality 21040); Rexroad local fauna, Meade County, Kansas (UMMZ 183037). The species is rare as a fossil.

Distribution.—Southern and Baja California (locally) through southeastern Colorado and Kansas to Florida; south to Sinaloa and Tampico, Mexico; northward on the Atlantic Coastal Plain to southern New Jersey. "The northward extension along the Atlantic coast is very narrow, discontinuous so far as known, and perhaps mainly confined to the coastal islands." (Pilsbry, 1948, p. 914).

Habitat.—Uncertain. From the geographic distribution, frequent occurrence in stream drift in the southern Great Plains, and occasional occurrence in samples of fossils washed from bulk collections of matrix, it appears this species may live among the grass roots, perhaps sometimes even on exposed slopes. So far as known, the snail has not been collected alive in the Plains.

Occurrence.—Cragin Quarry local fauna; Recent in Meade County, Kansas.

Material.—Cragin Quarry loc. 1, UMMZ 197491 (4); loc. 2, UMMZ 197506 (9); loc. 3, UMMZ 184443 (300), USGS 21276–2 (300).

Subgenus *Albinula* Sterki, 1892

Gastrocopta (*Albinula*) *armifera* (Say), 1821

(Pl. XI, Fig. 13)

Gastrocopta armifera (Say), Pilsbry, 1948, p. 874, Fig. 472 in part, Nos. 1–4. Franzen and Leonard, 1947, p. 328, Pl. 17, Figs. 3–5. A. B. Leonard, 1950, p. 29, Pl. 6, Fig. *P;* 1952*a,* p. 19, Pl. 5, Fig. *L.* Frye and Leonard, 1952, pp. 159, 164, 170, 179, Pl. 16, Fig. *a;* Pl. 17, Fig. *a;* Pl. 18, Fig. *a.* Leonard and Goble, 1952, p. 1029, Pl. 101, Fig. 23. D. W. Taylor, 1954*a,* p. 12.

Gastrocopta armifera armifera (Say), Franzen and Leonard, 1943, p. 415, Pl. 32, Figs. 38–39.

Gastrocopta armifera similis Sterki, H. T. U. Smith, 1940, p. 109.

Gastrocopta armifera abbreviata (Sterki), Pilsbry, 1948, p. 877, Fig. 474, Nos. 1–3. Goodrich, 1940, p. 77. A. E. Leonard, 1943, p. 238, Pl. 1, Fig. 11. Franzen and Leonard, 1943, p. 416, Pl. 32, Figs. 36–37. Rinker, 1949, p. 110. van der Schalie, 1953, p. 83.

Gastrocopta armifera ruidosensis (Cockerell), Pilsbry, 1948, p. 877, Fig. 472 in part, Nos. 10–11.

Gastrocopta armifera clappi (Sterki), Pilsbry, 1948, p. 878, Fig. 472 in part, Nos. 7–9; Fig. 472*a.*

Columella tridentata, new species, A. B. Leonard, 1946, p. 20, Pl. 3, Figs. 1–2.

Columella tridentata Leonard, Franzen and Leonard, 1947, p. 381, Pl. 22, Fig. 6.

Gastrocopta tridentata (Leonard), Pilsbry, 1948, p. 880, Fig. 473, Nos. 1–2. A. B. Leonard, 1950, p. 30, Pl. 6, Fig. *R.* Frye and Leonard, 1952, p. 158.

Gastrocopta proarmifera, new species, A. B. Leonard, 1946, p. 21, Pl. 3, Figs. 3–5.

Gastrocopta proarmifera Leonard, Franzen and Leonard, 1947, p. 326, Pl. 17, Figs. 1–2. Pilsbry, 1948, p. 878, Fig. 473 in part, Nos. 3–5. A. B. Leonard, 1950, p. 30, Pl. 6, Fig. *O.* Frye and Leonard, 1952, p. 158, Pl. 15, Fig. *h.* Frye and Leonard, 1957*b,* p. 60, Pl. 5, Fig. 1. Wayne, 1958, p. 11.

Geologic Range.—Early Pliocene to Recent. The single known Tertiary occurrence is in the early Pliocene Laverne local fauna, Beaver County, Oklahoma.

Distribution.—Quebec to northern Florida, west to the Rocky Mountains.

Habitat.—"*Gastrocopta armifera* is a gregarious species occurring commonly on wooded slopes, near or removed from a stream. It is to be found under dead wood, limestone rocks, or light cover of leaf mold or other debris. *G. armifera* frequently occurs under boards or rocks in gardens." (Franzen and Leonard, 1947, p. 329). Concerning occurrence of this species in Meade County, southwestern Kansas, A. E. Leonard (1943, pp. 238–39) stated that it "has a distinct preference for woodlands, although a single tree with dead wood about it is generally sufficient to support a colony. It is often found in great numbers in small groves in which leaves and twigs have been allowed to accumulate."

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197558 (100), USGS 21042–19 (100). Cragin Quarry: loc. 1, UMMZ 197490 (6); loc. 2, UMMZ 197501 (200), USGS 21275–2 (200); loc. 3, UMMZ 184439 (42); loc. 4, UMMZ 197531 (23).

Remarks.—The fossil shell described as *Columella tridentata* Leonard is probably an aberrant individual, a "giant" of *Gastrocopta armifera.* Its large size, many whorls, and obtusely conic apex suggest relationship with *G. armifera,* one of the largest American pupillids. The shape of the aperture and angulopariétal lamella of *Columella tridentata* are further evidence for such an affinity. Pilsbry (1948, p. 880) suggested: "This enigmatic species may turn out to be a case of gigantism; further collecting is needed to demonstrate its status." In the light of present knowledge of fossil Pupillidae of the High Plains and of the morphological features mentioned, rank of *C. tridentata* as a valid species seems extremely improbable.

Giant individuals of *G. armifera* are recorded from Lincoln, Nebraska (Pilsbry, 1948, p. 877); they agree in number of whorls and size with *Columella tridentata,* but have normal apertures.

Several infraspecific forms of the variable *Gastrocopta armifera* have been named. These do not have the geographically separate ranges which might qualify them as subspecies, nor have they particular morphologic variations shown to correlate with ecologic conditions. Until an exclusive distribution in a given area or a correlation with habitat is demonstrated for them, they are better not accorded taxonomic recognition. "Shells agreeing well with the types are to be found over nearly or quite the whole range of the species, but there are also several incipient races which have been defined by Dr. Sterki. The most tangible differential features of these races are found in the shape of the columellar lamella, but all details vary by easy stages. The areas of the several named forms are not well defined. Most of the named forms do not appear sufficiently detached to be named as races . . ." (Pilsbry, 1948, p. 876–77).

Gastrocopta proarmifera Leonard does not seem sufficiently distinct from the demonstrably variable *G. armifera* to qualify as a distinct species. Material seen from early Pliocene and early Pleistocene deposits represents *G. armifera;* hence, *G. proarmifera* is not stratigraphically distinct.

Gastrocopta (*Albinula*) *contracta* (Say), 1822

Gastrocopta contracta (Say), Pilsbry, 1948, p. 880, Fig. 474 in part, Nos. 9–12. Franzen and Leonard, 1947, p. 330, Pl. 18, Fig. 9. A. B. Leonard, 1950, p. 30, Pl. 6, Fig. *I*. Frye and Leonard, 1952, p. 159, Pl. 15, Fig. *a*. Leonard and Goble, 1952, p. 1031, Pl. 101, Fig. 11. D. W. Taylor, 1954*a*, p. 12.

Gastrocopta contracta contracta (Say), Franzen and Leonard, 1943, p. 417, Pl. 32, Figs. 34–35.

Gastrocopta (*Albinula*) *contracta* (Say), Pilsbry, 1953, p. 161.

?*Gastrocopta* sp., van der Schalie, 1953, p. 83.

Geologic Range.—Early Pliocene to Recent. The single known Tertiary record is from the early Pliocene Laverne local fauna, Beaver County, Oklahoma.

Distribution.—Maine to Florida; west to Manitoba, South Dakota, central Kansas, western Texas, and Sonora; southward in Mexico to the states of Morelos and Vera Cruz. In the Gulf Coastal Plain from Alabama to Texas, and northward in the Mississippi lowlands to Arkansas, the typical form is replaced by another subspecies.

Habitat.—"On shaded slopes along the water courses, under dead wood, leaf mold and grass" (Franzen and Leonard, 1947, p. 331).

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197559 (19). Cragin Quarry: loc. 1, UMMZ 184449 (126), USGS 21274–12 (100); loc. 2, UMMZ 197502 (125), USGS 21275–3 (125); loc. 3, UMMZ 184440 (3); loc. 4, UMMZ 197532 (1).

Remarks.—A single shell (UMMZ 181171) from the Jinglebob local fauna was reported by van der Schalie (1953) as *Gastrocopta* sp. The identity remains uncertain, but most probably it is an aberrant *G. contracta.*

Gastrocopta (*Albinula*) *holzingeri* (Sterki), 1889

(Pl. XI, Fig. 14)

Gastrocopta holzingeri (Sterki), Pilsbry, 1948, p. 883, Fig. 474 in part, Nos. 4–6; Fig. 475. A. B. Leonard, 1950, p. 31 in part; not Pl. 6, Fig. *A;* 1952*a*, p. 20 in part; not Pl. 5, Fig. *B*. Frye and Leonard, 1952, pp. 151, 158, 164, 170 in part; not Pl. 16, Fig. *f*, nor Pl. 17, Fig. *j*.

Gastrocopta holzingeri Sterki, Franzen and Leonard, 1947, p. 333, Pl. 18, Fig. 2.

Geologic Range.—Late Pliocene to Recent. The two known late Pliocene occurrences are as follows: Saw Rock Canyon local fauna, Seward County, Kansas; Rexroad local fauna, Meade County, Kansas (UMMZ 183035, 183059, 183070).

Distribution.—"Ontario and western New York to Helena, Montana, south to Illinois, Kansas, and Albuquerque and Mesilla, New Mexico" (Pilsbry, 1948, p. 883).

Habitat.—"*Gastrocopta holzingeri* is found on timbered slopes under leaf mold. Although it may occur in large numbers, it is probably overlooked because of its small size . . . In order to remain established in northwestern Kansas, as it is doing to some extent, it must be tolerant of the hot, dry climatic conditions which obtain in the summertime. *G. holzingeri* is not one of the predominating species of the fauna of Kansas. According to its general distribution in North America, it prefers decidedly cooler climates." (Franzen and Leonard, 1947, p. 334–35).

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197560 (49). Cragin Quarry: loc. 1, UMMZ 184450 (92); loc. 2, UMMZ 197503 (500), USGS 21275-4 (500); loc. 3, UMMZ 184441 (73).

Subgenus *Vertigopsis* Sterki, 1893

Gastrocopta (*Vertigopsis*) *tappaniana* (Adams), 1842

(Pl. XI, Figs. 11–12)

Gastrocopta tappaniana (C. B. Adams), Pilsbry, 1916, p. 33, Pl. 3, Fig. 9; Pl. 5, Figs. 42–53; 1948, p. 889, Fig. 477 in part, No. 9. Franzen and Leonard, 1947, p. 336, Pl. 18, Fig. 8. A. B. Leonard, 1950, p. 31, Pl. 6, Fig. *D;* 1952*a*, p. 20, Pl. 5, Fig. *E*. Frye and Leonard, 1952, pp. 151, 158, 164, Pl. 14, Fig. *k;* Pl. 16, Fig. *e*.

Gastrocopta tappaniana curta (Sterki), A. E. Leonard, 1943, p. 239, Pl. 1, Fig. 15.

Gastrocopta holzingeri (Sterki), A. B. Leonard, 1950, p. 31 in part, Pl. 6, Fig. *A* (not of Sterki); 1952*a*, p. 20 in part, Pl. 5, Fig. *B* (not of Sterki). Frye and Leonard, 1952, p. 164 in part, 170 in part; Pl. 16, Fig. *f;* Pl. 17, Fig. *j* (not of Sterki).

Gastrocopta pentodon (Say), Franzen and Leonard, 1943, p. 417, Pl. 32, Fig. 33 (not of Say). Leonard and Goble, 1952, p. 1032, Pl. 101, Fig. 12 (not of Say). van der Schalie, 1953, p. 83 (not of Say).

?*Gastrocopta* cf. *tappaniana* (C. B. Adams), van der Schalie, 1953, p. 83.

Geologic Range.—Late Pliocene to Recent. The three known late Pliocene occurrences are as follows: Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 177517, 177564); Rexroad local fauna, Meade County, Kansas (UMMZ 177604, 181053, 183038, 183072); Bender local fauna, Meade County, Kansas (UMMZ 177508, 184126, 184139).

Distribution.—"Ontario and Maine to Virginia and Alabama, west to South Dakota and Kansas, southwest to Arizona, but not known from the southeastern Atlantic States, Virginia to Florida" (Pilsbry, 1948, p. 889).

Habitat.—This species is ". . . found in low, moist places, under wood, often with *Vertigo ovata*" (Pilsbry, 1948, p. 889). "*Gastrocopta tappaniana* is a common snail in Kansas. Its most frequent habitat is on shaded slopes near streams. However, it has been taken from among the grass roots on an unshaded slope near a pasture pond." (Franzen and Leonard, 1947, p. 337).

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197561 (150), USGS 21042–18 (150); loc. 2, UMMZ 197582 (19). Cragin Quarry: loc. 1, UMMZ 184448 (1400), USGS 21274–13 (1400); loc. 2, UMMZ 197504 (1000), USGS 21275–5 (1000); loc. 3, UMMZ 184442 (49); loc. 4, UMMZ 197534 (4).

Remarks.—The relationship between *Gastrocopta tappaniana* and *G. pentodon* has been thoroughly discussed by Vanatta and Pilsbry (1906) and Sterki (1906). Examination of large series from throughout the range of these species showed that, although occasional intergrades are found, the great majority of lots are readily distinguishable. This morphologic distinction is correlated with differences in habitat and geographic range. Sterki (1906, p. 134) noted that "The habits of the two species are rather different, and they are not often found associated. Thus *B. pentodon* is common among moss and grass in forest and on open slopes, even steep, stony and rocky hillsides, where *tappaniana* is hardly ever found. The latter is prevalent in low, damp places, under wood, etc."

Gastrocopta pentodon and *G. tappaniana* both occur over a large part of North America, but *G. pentodon* ranges far south of *G. tappaniana,* to Guatemala. In the southeastern United States from Virginia to Florida *G. tappaniana* is absent, although *G. pentodon* is present (Pilsbry, 1948, pp. 888–89). Oughton (1948, p. 53) has noted different ranges for the two species in Ontario. This evidence suggests strongly that two distinct species, rather than ecologic forms, are involved. Leonard and Goble (1952, p. 1033), however, concluded from study of Kansas specimens that *G. tappaniana* is a synonym of *G. pentodon.*

The identity of the specimen recorded by van der Schalie (1953, p. 83) as *Gastrocopta* cf. *tappaniana* remains uncertain. If it is an aberrant individual of one of the already described species with which it is associated, it belongs to *G. tappaniana.*

Subfamily Pupillinae

Genus *Pupoides* Pfeiffer, 1854

Subgenus *Pupoides* s. s.

Pupoides (s.s.) *albilabris* (Adams), 1841

(Pl. XI, Fig. 1)

Pupoides albilabris (C. B. Adams), Pilsbry, 1948, p. 921, Fig. 499 in part, Nos. 1–7. A. B. Leonard, 1950, p. 29, Pl. 6, Fig. *Q;* 1952*a*, p. 22, Pl. 5, Fig. *M*. Frye and

Leonard, 1952, pp. 151, 158, 164, Pl. 14, Fig. *b;* Pl. 16 Fig. *k*. Leonard and Goble, 1952, p. 1035, Pl. 101, Fig. 22. Pilsbry, 1953, p. 164.

Pupoides albilabris (Adams), Frye and Leonard, 1957*b*, p. 60, Pl. 5, Fig. 2.

Pupoides marginatus (Say), Goodrich, 1940, p. 77. A. E. Leonard, 1943, p. 239, Pl. 1, Fig. 12. Franzen and Leonard, 1943, p. 421, Pl. 32, Fig. 30; 1947, p. 370, Pl. 21, Figs. 3–4. Rinker, 1949, p. 110.

Geologic Range.—Early Pliocene to Recent. The known Tertiary occurrences are as follows: early Pliocene, Laverne local fauna, Beaver County, Oklahoma; late Pliocene, Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 177565); late Pliocene, Rexroad local fauna, Meade County, Kansas (UMMZ 177571, 177605, 181054, 183039, 183061, 183073); late Pliocene, Bender local fauna, Meade County, Kansas (UMMZ 177509, 183018, 184127, 184140, 184155). The species is common in the southern High Plains, both living and as a Pleistocene fossil.

Distribution.—*Pupoides albilabris* is widespread over much of eastern North America: from Maine to the Gulf of Mexico, westward to the Dakotas, Colorado, western Arizona, and islands in the Gulf of California; southward in Mexico to Sinaloa and Tampico; Cuba; Haiti; Porto Rico; Bermuda.

Habitat.—"This species, tolerant of high summer temperatures and drought, is found in woodlands, in deep grass, or even among the roots of short grass in unshaded areas" (Franzen and Leonard, 1947, p. 371).

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 177383 (100), USGS 21042–20 (100). Cragin Quarry: loc. 1, UMMZ 197492 (8); loc. 2, UMMZ 197507 (3); loc. 3, UMMZ 184444 (86), USGS 21276–3 (76); loc. 4, UMMZ 197535 (2).

Subgenus *Ischnopupoides* Pilsbry, 1926

Pupoides (*Ischnopupoides*) *inornatus* Vanatta, 1915

(Pl. XI, Fig. 2)

Pupoides inornatus Vanatta, Pilsbry, 1948, p. 926, Fig. 499 in part, No. 10. Franzen and Leonard, 1947, p. 374.

Pupoides cf. *inornatus* Vanatta, D. W. Taylor, 1954*a*, p. 12.

Pupoides hordaceus (Gabb), Franzen and Leonard, 1947, p. 372 in part (not of Gabb); not Pl. 21, Fig. 2.

Geologic Range.—Early Pliocene to Recent. The Tertiary occurrences are as follows: early Pliocene Laverne local fauna, Beaver County, Oklahoma; late Pliocene Red Corral local fauna, Oldham County, Texas (UMMZ 183005, USGS locality 21040); late Pliocene Rexroad local fauna, Meade County, Kansas (UMMZ 183040, 183074). Pleistocene occurrences are rare.

Distribution.—A number of localities in the High Plains and Rocky

Mountains, from South Dakota to New Mexico, are represented by shells of uncertain age. Only four Recent occurrences can be affirmed:

COLORADO. El Paso Co.: Pikes Peak (the shells are "quite fresh," according to Pilsbry, 1948). Larimer Co.: Beside U. S. highway 287 near turnoff to Red Feather Lakes (at Livermore); D. E. Beetle, 1953 (DEB 53–74); the shells retain the periostracum, but are empty.

NEBRASKA. Cheyenne Co.: Sidney (USNM 424028). "Sidney Bluffs"; C. C. Engberg (USNM 363054). Shells in both lots retain the periostracum, and some contain bodies. Garden Co.: SE¼NE¼ sec. 29, T. 16 N., R. 44 W.; D. W. Taylor, 1959 (USGS); two live snails and one empty shell were found.

Habitat.—The snails from Garden County, Nebraska, were collected from the under sides of limey talus blocks from the caprock of the Ogallala formation, on steep, east-facing slopes with bunch grass and yucca. A similar habitat is quite possible for the shells from Sidney. The shells from Larimer County, Colorado, were empty when collected, but evidently can not have been transported any considerable distance. They were found in crevices and under blocks of red sandstone at the top of the cliffs beside the highway.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197564 (24), USGS 21042–21 (20).

Remarks.—The shells recorded by Goodrich (1940) from the Jones local fauna are *P. inornatus;* hence, the material recorded from that assemblage by Franzen and Leonard as *P. hordaceus* is believed to be misidentified.

Genus *Pupilla* Leach, 1828

Pupilla blandi Morse, 1865

(Pl. XI, Figs. 5–6)

Pupilla blandi Morse, Pilsbry, 1948, p. 931, Fig. 502 in part, Nos. 1–3. Franzen and Leonard, 1947, p. 378, Pl. 22, Fig. 1. A. B. Leonard, 1950, p. 28, Pl. 6, Fig. *L;* 1952*a*, p. 22, Pl. 5, Fig. *K;* Pl. 1, Figs. *E, S, HH*. Frye and Leonard, 1952, pp. 159, 164, 170, Pl. 16, Fig. *c;* Pl. 17, Fig. *c*.

Pupilla muscorum (Linnaeus), Goodrich, 1940, p. 77 (not of Linnaeus).

Vertigo modesta (Say), Goodrich, 1940, p. 77 (not of Say).

Geologic Range.—Late Pliocene to Recent. The single known Tertiary occurrence is in the Red Corral local fauna, Oldham County, Texas (USGS locality 21040). *Pupilla blandi* is common in Pleistocene deposits in the Great Plains (chiefly of Illinoian and Wisconsin age); it is a characteristic loess fossil.

Distribution.—Rocky Mountains, from New Mexico (at high elevations) to southern Alberta; northern Great Plains east to western North Dakota; Black Hills, South Dakota. The distribution given by Pilsbry (1948) for the species applies to fossil and river-drift specimens. But examination of the collections of the University of Michigan Museum of Zoology and U. S. National Museum has revealed Recent specimens from only three localities in the Great Plains. The Montana and North Dakota shells are fresh appearing, retain the periostracum, and despite their collection from drift are probably of local origin. The South Dakota specimen was not obtained from drift and retains the dried animal.

MONTANA. Wibaux Co.: Wibaux (USNM, several lots).
NORTH DAKOTA. Billings Co.: Medora (USNM 477544).
SOUTH DAKOTA. Pennington Co.: Hill City (USNM 123687).

Habitat.—In the higher, forested parts of the Rocky Mountains *Pupilla blandi* is widespread. It occurs in forest, or in meadows and parks where cover and some moisture are available. Together with *Vallonia,* it may often be found in protected situations somewhat less damp than those required by other snails, such as *Vitrina, Vertigo,* or *Discus.*

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197835 (27); loc. 2, UMMZ 197839 (9). Cragin Quarry: loc. 3, UMMZ 184436 (9).

Remarks.—The citations by Goodrich (1940) of *Pupilla muscorum* and *Vertigo modesta* from the Jones local fauna were both placed by Franzen and Leonard (1947) in the synonymy of *P. blandi.* The shells recorded as *V. modesta* (UMMZ 137796) are *P. blandi;* those identified as *P. muscorum* have not been found. Specimens intermediate between *Pupilla muscorum* and *P. blandi* were recorded by Franzen and Leonard (1947, p. 379). The evidence is inadequate to determine whether hybridization may have occurred, but it is not suggested by Recent material. Among the fossils from the Butler Spring local fauna, where both *P. muscorum* and *P. blandi* occur, there are no intermediate examples.

From a review of the material of *Pupilla blandi* in the University of Michigan Museum of Zoology and the U. S. National Museum, it appears that either the species is more variable than other American species of the genus or, as presently conceived, *P. blandi* is a composite of more than one species. The form *pithodes* and the wide shells from North Park, Colorado, and Sapello Canyon, New Mexico (Pilsbry, 1948, p. 931) may be specifically distinct from *P. blandi,* but sufficient material has not been seen to provide a basis for decision. Whatever the status of these mountain shells, all the living and fossil ones from east of the Rocky Mountains are conspecific with the type specimen of *P. blandi* from North Dakota and the form *obtusa* Cockerell.

Pupa sublubrica Ancey was considered both by Ancey and Pilsbry (1948) to be a synonym of *Pupilla blandi.* The dimensions of 3¾ by 1½ mm. indicate a longer and hence proportionally narrower shell than any *P. blandi* seen. If not a separate species, it is probably a well-marked subspecies of *P. blandi*. The type locality is not more precisely known than Nevada.

Pupilla muscorum (Linnaeus), 1758
(Pl. XI, Fig. 7)

Pupilla muscorum (Linnaeus), Pilsbry, 1948, p. 933, Fig. 503 in part, Nos. 12–16. Franzen and Leonard, 1947, p. 375, Pl. 22, Fig. 2. A. B. Leonard, 1950, p. 28, Pl. 6, Fig. *N*.

Pupilla (Pupilla) muscorum (Linné), Wenz, 1923*b*, p. 956.

Pupilla (Pupilla) submuscorum (Gottschick et Wenz), Wenz, 1923*b*, p. 957.

Pupilla muscorum Müller, Geyer, 1927, p. 123, Pl. 6, Figs. 19*a–c*; Pl. 21, Figs. 17–18.

Pupilla muscorum (Linné), A. B. Leonard, 1952*a*, p. 22, Pl. 5, Fig. *J*; Pl. 1, Figs. *D*, *O*, *Y*. Frye and Leonard, 1952, pp. 159, 164, 170, Pl. 15, Fig. *c*; Pl. 16, Fig. *b*; Pl. 17, Fig. *b*. D. W. Taylor, 1956, p. 123, Fig. 9. Frye and Leonard, 1957*b*, p. 60, Pl. 5, Fig. 3.

Pupilla muscorum L., Frömming, 1954, p. 36.

Sphyradium hasta, new species, Hanna, 1911, p. 372, Fig. 1.

Columella hasta (Hanna), Franzen and Leonard, 1947, p. 383, Pl. 22, Fig. 5. Pilsbry, 1948, p. 1005, Fig. 535 in part, No. 18.

Geologic Range.—Late Miocene to Recent. Fossils from Steinheim am Albuch, Württemburg Germany, were described as *P. submuscorum*, but Geyer (1927) refers them to *P. muscorum*. The only known Tertiary occurrence in North America is of middle Pliocene age: Teewinot formation, Jackson Hole, Teton County, Wyoming (USGS locality 19105).

In the High Plains, *Pupilla muscorum* is known only in Kansan, Illinoian, and Wisconsin faunas. It is more abundant in the younger than in the older deposits, and it is particularly common in loess. This species is characteristic of glacial faunas in the southern High Plains.

Distribution.—Holarctic. In North America "from Anticosti Island south to Atlantic City, New Jersey, westward in Canada and the northern tier of states to Milton, Oregon; south in the Rocky Mountain region through Colorado to Socorro Co., New Mexico, and northern Arizona; north to Anuk, Alaska" (Pilsbry, 1948, p. 934). During glacial intervals, *Pupilla muscorum* spread much farther east and south than its present limits of range, into Texas, Oklahoma, Kansas, and Nebraska.

Habitat.—In the Rocky Mountains *Pupilla muscorum* is found in the higher, forested parts of the range. It occurs in places with some moisture, under logs, bark, stones, or other cover. Together with *Pupilla blandi* and *Vallonia*, it may often be found in protected situations somewhat less damp than those required by other snails, such as *Vitrina* and *Vertigo*.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197565 (41), USGS 21042–22 (37); loc. 2, UMMZ 197583 (4).

Remarks.—The holotype (USNM 214302) of *Sphyradium hasta* Hanna appears to be an aberrant individual of *Pupilla*. Both *P. blandi* and *P. muscorum* are known from the Pleistocene of the part of Kansas from which Hanna described his species, and the absence of apertural lamellae suggests *P. muscorum*. In shape of apex, diameter of spire, sculpture, and relatively simple aperture *S. hasta* agrees closely with *P. muscorum,* but it differs in the greater number of whorls, lack of crest, narrower aperture, basal angularity, and weak angle on the body whorl at the level of the suture. All of these distinctions can be explained by the hypothesis that it is an example of gigantism. In the characters interpreted here as significant—shape of apex, diameter of spire, proportions of earlier whorls, and sculpture—the holotype of *S. hasta* is much more like *Pupilla* than any other known member of the Pupillidae of the Great Plains, living or fossil.

Pupilla sinistra Franzen, 1946

Pupa syngenes Pils., Dall, 1894, p. 35 (not of Pilsbry).
Pupa syngenes Pilsbry, Squyer, 1894, p. 64 (not of Pilsbry).
Pupilla muscorum sinistra, new subspecies, Franzen, 1946, p. 24.
Pupilla muscorum sinistra Franzen, Franzen and Leonard, 1947, p. 377, Pl. 22, Fig. 4. Pilsbry, 1948, p. 935. A. B. Leonard, 1950, p. 28, Pl. 6, Fig. *M*. Frye and Leonard, 1952, pp. 158, 183, Pl. 15, Fig. *i*. Johnston and Savage, 1955, p. 46.

Geologic Range.—Middle Pleistocene (Kansan) to Recent. In the southern Great Plains known only from Kansan and Illinoian assemblages.

Distribution.—The only known Recent specimens are from drift of Beaver Creek, near Wibaux, Wibaux County, Montana.

Habitat.—Unknown.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197566 (1); loc. 2, UMMZ 197584 (4).

Remarks.—*Pupilla muscorum sinistra* Franzen has previously been known only from the late Kansan Cudahy fauna, in Kansas and Texas. On the basis of new data and interpretations, it is of Recent and Illinoian occurrence as well, and is a distinct species rather than a subspecies of *Pupilla muscorum.* The specimens from the Butler Spring local fauna are all fragments of spires. A large series of specimens from USGS Cenozoic locality 21339, Meek's gravel pit, SW¼ sec. 20, T. 16 N., R. 26 W., Roger Mills County, Oklahoma, is the principal basis for this discussion. David B. Kitts, of the University of Oklahoma, who collected the fossils in the course of geologic studies, considers them to be of late Pleistocene age (personal communication, February 1959).

Pupilla sinistra differs from *P. syngenes* (Pilsbry, 1948, p. 939) in the following characters: (1) the apex is less blunt than in many individuals of *P. syngenes,* which are relatively truncate in appearance; (2) the spire is cylindrical or slightly constricted in the later whorls, but not as conspicuously as in *P. syngenes;* (3) the number of whorls does not exceed seven; (4) the aperture is well callused within; and (5) a columellar lamella is absent.

Pupilla sinistra differs from *P. muscorum* by (1) sinistral coiling, and (2) a more narrowly constricted base, as noted by Franzen, and also by (3) more steeply inclined sutures, and (4) the elongate parietal lamella, which may extend for nearly one-fourth of a whorl. In size, shape, and apertural callus *P. sinistra* is very like *P. muscorum,* probably its nearest relative, but the differences between them are worthy of specific rank.

Two lots of shells (USNM 126831, 128215) from drift of Beaver Creek near Wibaux, Montana, evidently served as the basis for the reports by Dall (1894) and Squyer (1894) of *Pupilla syngenes* in Montana. Since these specimens are the only basis for the citation of *P. syngenes* s.s. outside of New Mexico, Arizona, and Utah, their identification as *P. sinistra* will simplify the known distribution pattern of the former.

Of the seven Montana specimens of *Pupilla sinistra,* only three are adult and unbroken. The three agree in shape, size, number of whorls, and palatal callus with the Oklahoma fossils and the original description by Franzen (1946). All of them lack apertural lamellae, in contrast to *P. syngenes* and to the Oklahoma fossils, but Franzen noted such edentulous shells among her specimens. Some of the differences between the Montana shells and *P. syngenes* were noted by Victor Sterki. In his handwriting on the back of the label to lot 126831 is the note "Somewhat different from the type: the apex is less rounded, & the upper pt of lesser diam; the whorls fewer and comp.y higher . . ." These features are among those which distinguish the two species, *P. syngenes* and *P. sinistra.*

The age of most of the Montana specimens of *P. sinistra* is unknown. Like many drift samples, the two lots may include shells from several intervals within the Pleistocene and Recent. Most of the shells are so bleached and worn that they may be fossil. One adult, however, retains all of the periostracum and is scarcely or not at all bleached. Two immature or fragmentary specimens in the same lot retain the periostracum also, but are slightly bleached. These three shells (USNM 126831), especially the adult, are interpreted as demonstrating the Recent occurrence of this species on the Plains of easternmost Montana. *Pupilla sinistra,* like *Physa skinneri,* is a species which was first described as a fossil but subsequently found to be still living.

Subfamily Vertigininae

Genus *Vertigo* Müller, 1774

Subgenus *Vertigo* s. s.

Vertigo (s. s.) *gouldi* (Binney), 1843

(Pl. XI, Fig. 10)

Vertigo gouldi (Binney), Pilsbry, 1948, p. 971, Fig. 515 in part, Nos. 4, 5, 8. A. B. Leonard, 1950, p. 27, Pl. 6, Fig. *E.* Frye and Leonard, 1952, p. 158.

Vertigo gouldii (Binney), Franzen and Leonard, 1947, p. 358, Pl. 20, Fig. 3.

The present classification of the *Vertigo gouldi* group is unsatisfactory. Until it has been revised the relationship of the fossils from Kansas to similar Recent snails will remain uncertain, and inferences about details of habitat will not be reliable. The fossil *Vertigo gouldi* (s.l.) from the Butler Spring local fauna represents a species not living in Kansas, and which is rare there as a fossil (Franzen and Leonard, 1947, p. 359).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197569 (1).

Vertigo (s.s.) *ovata* Say, 1822
(Pl. XI, Fig. 8)

Vertigo ovata Say, Pilsbry, 1948, p. 952, Fig. 513 in part, Nos. 1–3, 4, 7. A. E. Leonard, 1943, p. 239, Pl. 1, Fig. 13. Franzen and Leonard, 1947, p. 354, Pl. 19, Fig. 6. A. B. Leonard, 1950, p. 26, Pl. 6, Fig. *F;* 1952*a,* p. 26, Pl. 5, Fig. *G.* Frye and Leonard, 1952, p. 158, Pl. 15, Fig. *b.* Leonard and Goble, 1952, p. 1034, Pl. 101, Fig. 14.

Vertigo ovata (Say), Franzen and Leonard, 1943, p. 420, Pl. 32, Fig. 28.

Geologic Range.—Early Pliocene to Recent. There are only two known Tertiary occurrences, as follows: early Pliocene Laverne local fauna, Beaver County, Oklahoma; middle Pliocene Buis Ranch local fauna, Beaver County, Oklahoma (UMMZ 181115).

Distribution.—Labrador to the West Indies, west to Arizona, Utah, Oregon, and Alaska.

Habitat.—". . . only in moist environs afforded by shaded slopes near streams and shores of ponds. Its range in Kansas extends westward into the generally dry region of the High Plains. In these regions are local ponds and streams, many of which are fed by artesian springs, along whose shaded slopes *V. ovata* is found, though not in great numbers." (Franzen and Leonard, 1947, p. 355).

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197567 (150), USGS 21042–24 (150); loc. 2, UMMZ 197586 (4). Cragin Quarry: loc. 1, UMMZ 184452 (250), USGS 21274–14 (250); loc. 2, UMMZ 197508 (48); loc. 3, UMMZ 184446 (3); loc. 4, UMMZ 197536 (3).

Subgenus *Angustula* Sterki, 1888
Vertigo (*Angustula*) *milium* (Gould), 1840

Vertigo milium (Gould), Pilsbry, 1948, p. 944, Fig. 509. Franzen and Leonard, 1947, p. 365, Pl. 20, Fig. 8. A. B. Leonard, 1950, p. 26, Pl. 6, Fig. *C;* 1952*a,* p. 25, Pl. 5, Fig. *A.* Frye and Leonard, 1952, pp. 151, 158, 170, Pl 17, Fig. *i.*

Geologic Range.—Late Pliocene to Recent. All Tertiary records are from northern Texas and southwestern Kansas, as follows: Red Corral local fauna, Oldham County, Texas (UMMZ 183006; USGS 21040); Saw Rock Canyon local fauna, Seward County, Kansas; Rexroad local fauna, Meade County, Kansas (UMMZ 177606, 181055, 183042, 183076); Bender local fauna, Meade County, Kansas (UMMZ 177510, 183019, 184128, 184141). Pleistocene occurrences in the Great Plains are common.

Distribution.—Maine to South Dakota, southward to Arizona, Mexico, and the West Indies.

Habitat.—"Moist situations afforded by timbered stream banks, or marshes. It is not found in areas of low relative humidity or low annual precipitation and high summer temperatures, features which are characteristic of the climate of the western half of the state [Kansas]." (Franzen and Leonard, 1947, p. 367.).

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197568 (45); loc. 2, UMMZ 197585 (38), USGS 21043-3 (35). Cragin Quarry: loc. 1, UMMZ 197493 (2); loc. 2, UMMZ 197509 (1); loc. 3, UMMZ 184445 (2).

Family Valloniidae
Genus *Vallonia* Risso, 1826
Vallonia cyclophorella Sterki, 1892

(Pl. XII, Figs. 7–9)

Vallonia cyclophorella Sterki, Pilsbry, 1948, p. 1035, Fig. 554.
Vallonia cyclophorella Ckll., Pilsbry and Ferriss, 1919, pp. 302, 327.
Vallonia sp. cf. *V. cyclophorella* Sterki, D. W. Taylor, 1954*b*, p. 75, Pl. 20, Figs. 24–26.
Vallonia, D. W. Taylor, 1956, p. 123.

Geologic Range.—Late Miocene to Recent. There are only two known Tertiary occurrences: late Miocene Barstow formation, San Bernardino County, California; middle Pliocene Teewinot formation, Teton County, Wyoming (USGS locality 19105). Probably there are Pleistocene occurrences within the known area of Recent distribution, but these records have not been sought.

This is the first definite record of this species in the southern High Plains. Pilsbry (1948) listed an occurrence 15 miles southeast of Amarillo, Texas, based on specimens collected by J. B. Henderson. Since a series (USNM 306361) obtained from this locality by Henderson is *V. gracilicosta,* which is not listed by Pilsbry from Texas, the material reported by Pilsbry may have been thin-lipped, immatures of that species. In either case, the specimens probably were derived from a Pleistocene deposit.

Distribution.—Widespread in the mountainous parts of the western United States, north into Alberta and probably British Columbia; at high elevations as far south as Arizona and New Mexico; eastward across the northern Great Plains to Minnesota. A Texas record is probably based on Pleistocene specimens and the identification is doubted. Peripheral localities are as follows:

ALBERTA. Calgary (USNM 382091).

MONTANA. Lewis and Clark Co.: Helena. Powell Co.: Garrison.

NORTH DAKOTA. Benson Co.: woods near Mauvaise Coulee; M. Winslow, 1919 (UMMZ 195998). Drift, Sweetwater Lake; M. Winslow, 1919 (UMMZ 195999). Woods near second coulee N. of Minnewaukan; C. Thompson, 1919 (UMMZ 195997). Woods above Minnewaukan Coulee; M. Winslow, 1919 (UMMZ 10645). Chautauqua grounds, Devils Lake; C. Thompson, 1922 (UMMZ 195992).

MINNESOTA. Pennington Co.: Thief River Falls (UMMZ).

WYOMING. Albany Co. Converse Co.

COLORADO. Boulder, Custer, El Paso, Jefferson, Larimer, Teller counties.

NEW MEXICO. Colfax Co. San Miguel Co.: Beulah, 8000' elev. (USNM 203930). Divide between Sapello Cr. and Pecos R. (USNM 193844). Lincoln Co.: White Oaks; L. E. Daniels (UMMZ 108692). Capitan Mts. (USNM 152364). Otero Co.: Cloudcroft, Sacramento Mts. (USNM 424034, 443734, 443739, 527725e, 527948d). Grant and Sierra counties: crest of Black Range.

ARIZONA. Cochise Co.: Wickersham's gulch, Huachuca Mts.; L. E. Daniels (UMMZ 108842). Miller Canyon, Huachuca Mts.; L. E. Daniels (UMMZ 108845). Graham Co.: Cosper's pasture, and southern rim of Blue Mts., 9500 to 12,000 feet elev. Pima Co.: Marble Peak, Santa Catalina Mts., 8000 feet elev. Mt. Lemon, Santa Catalina Mts., 9000 to 9500 feet elev.

NEVADA. Lincoln Co.: Charleston Mtn.

CALIFORNIA. Lassen Co.: near Susanville. Glen Alpine Gorge, Lake Tahoe, 6700 feet elev. (USNM 186060). San Bernardino Co.: Mill Creek Canyon, San Bernardino Mts.; L. E. Daniels (UMMZ 108841, USNM 270974). Tulare Co.

OREGON. Klamath Co.: Ouxy siding (USNM 406027). Umatilla Co.: above Weston.

WASHINGTON. Grant Co.: near Blue Lake, Grand Coulee. Walla Walla Co.: Walla Walla.

Habitat.—*Vallonia cyclophorella* generally occurs in the higher, forested parts of mountains in the western United States, in either coniferous or deciduous forest. It is to be found under logs, bark, stones, or other cover in places with some moisture. Together with *Pupilla,* it often lives in protected situations somewhat less damp than those required by other snails, such as *Vitrina, Vertigo,* or *Discus.*

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197571 (250), USGS 21042–25 (125); loc. 2, UMMZ 197588 (27).

Vallonia gracilicosta Reinhardt, 1883

(Pl. XII, Figs. 1–6)

Vallonia gracilicosta Reinhardt, Pilsbry, 1948, p. 1028, Fig. 549. A. B. Leonard, 1950, p. 33, Pl. 5, Fig. *D; 1952a,* p. 24, Pl. 4, Figs. *B, C.* Frye and Leonard, 1952, pp. 151, 158, 164, 170, 179, Pl. 14, Fig. *f;* Pl. 15, Fig. *x;* Pl. 16, Fig. *g;* Pl. 17, Fig. *o;* Pl. 18, Fig. *c.* Hibbard, 1941, p. 95.

Vallonia costata (Müller), Goodrich, 1940, p. 77 (not of Müller).

Geologic Range.—Late Pliocene to Recent. There are only two known Tertiary occurrences: late Pliocene Cache Valley formation of N. Smith (1953), Cache and Box Elder counties, Utah (USGS locality 20093); late Pliocene Rexroad local fauna, Meade County, Kansas (Hibbard, 1941, and UMMZ 183043). The species is common in Pleistocene deposits of the Great Plains.

Distribution.—Rocky Mountains from southern Arizona and New Mexico (at high elevations) northward to Montana; Nebraska eastward to Minnesota and Iowa. A single California record is given by Pilsbry (1948, p. 1030). Shells from farther south (Texas, Oklahoma, Kansas, Missouri) are apparently all fossil. The northern and northeastern limits of distribution are uncertain.

Habitat.—In northern Nebraska *Vallonia gracilicosta* occurred with *V. parvula* on moist leaf mold under logs, bark, and stones in wooded areas (Taylor, 1960).

Occurrence.—Butler Spring, Cragin Quarry, and Jones local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197570 (100), USGS 21042–26 (75); loc. 2, UMMZ 197587 (12). Cragin Quarry: loc. 1, UMMZ 197494 (7); loc. 3, UMMZ 184430 (300), USGS 21276–4 (300). Jones, UMMZ 137794 (250).

Remarks.—The difficulty in distinguishing *Vallonia gracilicosta* from *V. albula* has been mentioned by Pilsbry (1948, p. 1032). He did not suggest the identity of these two species, but neither is the single criterion that he gave for their separation ("*albula* has a narrower lip") very useful. If *V. albula* proves to be a synonym of *V. gracilicosta,* the distribution of the latter as given above will be extended northward and eastward.

Vallonia parvula Sterki, 1893

(Pl. XI, Figs. 3–4, 9)

Vallonia parvula Sterki, Pilsbry, 1948, p. 1027, Fig. 547. A. E. Leonard, 1943, p. 240, Pl. 1, Fig. 7. Frye and Leonard, 1952, p. 179, Pl. 18, Fig. *d.* Leonard and Goble, 1952, p. 1037, Pl. 101, Figs. 18–19.

Geologic Range.—Late Pliocene to Recent. Only one Pliocene record is known: Bender local fauna, Meade County, Kansas (UMMZ 183020, 184129). The species occurs occasionally in the Pleistocene of the High Plains.

Distribution.—Great Plains from South Dakota to north-central Oklahoma; eastward to northern Missouri, northern Ohio, southern Ontario, and western New York. More southern records, in western Oklahoma and the Texas Panhandle, are based on drift shells of uncertain age. Peripheral localities are as follows:

SOUTH DAKOTA. Lincoln Co.

IOWA. Lyon Co.: Rock Rapids (USNM 478657, 478646). Winnebago Co.: woods north of Forest City (USNM 478663). Winneshiek Co.: northwest corner (USNM 478741). Lee Co.: Keokuk (USNM 478701). Van Buren Co.: 3 miles east of Willit (USNM 478643). Pottawattamie Co.: Council Bluffs (USNM 478637, 478638).

ILLINOIS. McHenry Co.: Algonquin; L. E. Daniels (UMMZ 108774). Will Co.: Birds Bridge. Joliet; J. H. Ferriss (UMMZ 108890, USNM 214460, 506339). La Salle Co.: Ottawa.

OHIO. Erie Co.: Sandusky. Ottawa Co.: Put-in-Bay Island; B. Walker and C. Goodrich (UMMZ 108876). Catawba Island; C. Goodrich (UMMZ 108893).

ONTARIO. Kent Co.: Rondeau Park; J. Oughton, 1937 (UMMZ 180678). Hastings Co.: Moira R., Scuttle Hole; H. B. Herrington, 1939 (UMMZ 180705). Welland Co.: Niagara Glen; J .Oughton, 1934 (UMMZ 180667).

NEW YORK. Herkimer Co.: Mohawk; L. E. Daniels (UMMZ 109294).

MISSOURI. St. Louis Co.: Creve Coeur L. (UMMZ 53332). Jackson Co.: Kansas City; M. E. Walker (UMMZ 108880).

KANSAS. Clark Co., Cowley Co.: 8 mi. SE Winfield (UMMZ 58109). Dickinson Co.: Abilene; H. P. Mera (UMMZ 108884). Marion Co.: City Park, Marion (USNM 404413). 3⅓ mi. S. Marion (USNM 404414). Meade Co. Sedgwick Co.: Wichita. Woodson Co.: Cedar Ridge (USNM 526656).

OKLAHOMA. Payne Co.: banks of Cimarron R.; J. D. Micelle (UMMZ 142625).

NEBRASKA. Brown Co.: Bluffs on south side Niobrara River valley at state highway 7; D. W. Taylor, 1953 (USGS). Cherry Co.: Ft. Niobrara National Wildlife Refuge; D. W. Taylor, 1953 (USGS).

Habitat.—In northern Nebraska *Vallonia parvula* was found on moist leaf mold, under logs, bark, and stones in wooded areas (Taylor, 1960). Leonard and Goble (1952) reported that in northeastern Kansas this species lived in a variety of habitats, but was most abundant on wooded slopes. In Meade and Clark counties, Kansas, the southwesternmost known occurrence, *V. parvula* is common. A. E. Leonard (1943) commented: "This small species is very successful in this arid region; large numbers may be found in ravines which have even scant timber."

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197572 (108), USGS 21042–27 (92). Cragin Quarry: loc. 1, UMMZ 184462 (600), USGS 21274–15 (600); loc. 2, UMMZ 197510 (750), USGS 21275–7 (750); loc. 3, UMMZ 184431 (100), USGS 21276–5 (80); loc. 4, UMMZ 197537 (3).

Family Succineidae

Land snails of the family Succineidae are common and often conspicuous members of the Recent molluscan fauna of the central High Plains. Their shells are common as fossils in both Pliocene and Pleistocene deposits of this area. But even the best preserved fossils may be unidentifiable because the shells alone are often not specifically diagnostic. After studying the Succineidae of Kansas, Miles (1958) wrote that most species could not be identified by shell characters, and that two of the three genera were indistinguishable from their shells. *Oxyloma,* with the one species *O. retusa* in Kansas, may be separated from *Succinea* and *Quickella. Succinea ovalis* and adult specimens of *Succinea concordialis* can be identified by shell features, but the other species of *Succinea* and *Quickella* must be determined by anatomical criteria.

The fossil succineid shells considered in this paper include only one of the specifically identifiable types: *Oxyloma retusa.* For the present, all others are lumped as "cf. *Succinea*", even though there is clearly more than one species at some localities. Perhaps future detailed study of the shells of dissected Recent snails will enable more of the fossils to be identified specifically.

Genus *Succinea* Draparnaud, 1801

Succinea concordialis Gould, 1848

Succinea concordialis Gould, Pilsbry, 1948, p. 833, Figs. 452*a–h*, 453, 454. A. E. Leonard, 1943, p. 240, Pl. 2, Fig. 31. Miles, 1958, p. 1514, Pl. 1, Figs. *F, I;* Figs. 3, 10*b*.

Geologic Range.—Unknown.

Distribution.—Illinois and Iowa south and southwest to Texas and Louisiana; eastward through the Gulf States to Florida.

Habitat.—"*Succinea concordialis* has been found in Kansas in two distinct habitats. Generally, it occurs near the edges of streams in wet situations, clinging to vegetation near or in water, or living in the wet leaf mold at the edge of the water.

"Elsewhere, the species inhabits comparatively dry environments. In Meade County State Park, a number were found near the lake, in a low area overgrown by thick vegetation, but several isolated places were sandy and barren. The sand was only slightly damp. *S. concordialis* was found here, inhabiting the damper places in the sand. *Quickella vagans* was also present in approximately equal numbers. The only shade was provided by a dead bush.

"On a few other occasions, *Succinea concordialis* was found in drier situations, and the species is observed in the open, exposed to the sun, more than other species of Succineidae in Kansas." (Miles, 1958, p. 1516–1517).

Occurrence.—Recent in Meade County, Kansas.

Succinea vaginacontorta Lee, 1951

Succinea (*Calcisuccinea*) *vaginacontorta,* new species, Lee, 1951, p. 2, Pl. 1, Figs. 2–3; Pl. 2, Figs. 1–3.
Succinea (*Heysuccinea,* n. sect.) *vaginacontorta* Lee, Webb, 1953, p. 216, Figs. 32–33.
Succinea vaginacontorta Lee, Miles, 1958, p. 1517, Pl. 1, Fig. *C;* Fig. 4.

Geologic Range.—Unknown.

Distribution.—The species is so far known only from Kansas.

Habitat.—So few localities are known for this species that its range of habitats is uncertain. At the type locality in Meade County it was found in relatively dry situations on a sagebrush flat. When collected after a rain the snails were crawling about between the sagebrush plants and clumps of grass; in dry periods they presumably take shelter under the litter around sagebrush or crawl into the tussocks of grass and cracks in the ground.

Occurrence.—Recent in Meade County, Kansas.

cf. *Succinea*

Succinea grosvernori Lea, Goodrich, 1940, p. 77.
Succinea grosvenori Lea, H. T. U. Smith, 1940, p. 109. van der Schalie, 1953, p. 83.
Succinia concordalis Gould, Rinker, 1949, p. 110.
Succinea cf. *avara* (Say), van der Schalie, 1953, p. 83. Taylor and Hibbard, 1955, p. 11.
Succinea cf. *grosvenori* Lea, D. W. Taylor, 1954*a*, p. 5. Taylor and Hibbard, 1955, p. 11.
Succinea spp., Taylor and Hibbard, 1955, p. 18.
Succinea cf. *concordialis* Gould, Taylor and Hibbard, 1955, p. 11.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 177380 (600), USGS 21042–28 (600); loc. 2, UMMZ 197589 (26). Cragin Quarry: loc. 1, UMMZ 184465 (150), USGS 21274–16 (150); loc. 2, UMMZ 197511 (100), USGS 21275–8 (45); loc. 3, UMMZ 184434 (13); loc. 4, UMMZ 197538 (4).

Genus *Oxyloma* Westerlund, 1885
Oxyloma retusa (Lea), 1834

Oxyloma retusa (Lea), Pilsbry, 1948, p. 785, Figs. 421, 422*C*. Miles, 1958, p. 1521, Pl. 1, Figs. *G–H.;* Figs. 6–7.
Oxyloma haydeni (W. G. Binney), Pilsbry, 1948, p. 797, Fig. 427*e*.
Oxyloma haydeni (Binney), D. W. Taylor, 1954*a*, p. 5. Taylor and Hibbard, 1955, p. 12.
Oxyloma cf. *haydeni* (Binney), Taylor and Hibbard, 1955, p. 18.
Succinea haydeni Binney, A. E. Leonard, 1943, p. 240, Pl. 2, Fig. 32. Rinker, 1949, p. 110.
Oxyloma navarrei, new species, A. B. Leonard, 1950, p. 23, Pl. 4, Fig. *H*.
Oxyloma navarrei Leonard, Frye and Leonard, 1952, p. 158, Pl. 15, Fig. *ee*.
Succinea concordialis Gould, Leonard and Goble, 1952, p. 1036, Pl. 100, Fig. 3 (not of Gould).
Succinea ovalis Say, van der Schalie, 1953, p. 83 (not of Say).

Geologic Range.—Early Pleistocene to Recent. The earliest known occurrence is in the Nebraskan or Aftonian Dixon local fauna, Kingman County, Kansas (UMMZ 182212, 191528).

Distribution.—Ohio west to Montana, south to Kansas. If *Oxyloma sillimani* is a synonym, as suggested by Pilsbry (1948, p. 796), the range may include parts of Nevada and Washington.

Habitat.—In north-central Nebraska, *Oxyloma retusa* was always close to perennial water, crawling about on dead wood or among riparian vegetation and debris (Taylor, 1960). Although the species is not strictly aquatic, its habitat overlaps that of the semiaquatic *Fossaria dalli.* In Meade County State Park "this snail thrives on the moist marshes and borders of the pools in the artesian basin, where it is frequently found on watercress" (A. E. Leonard 1943, p. 240).

Occurrence.—Butler Spring local fauna; Recent in Meade County, Kansas.

Material.—Butler Spring loc. 1, UMMZ 197573 (17).

Remarks.—According to Miles (1958) *Oxyloma retusa* exhibits considerable variation in shell form, even within a single population. On the basis of his evidence, geographic proximity and close similarity in shell features, *O. haydeni* and *O. navarrei* appear to be identical and the names belong in synonymy. The original figures of *O. haydeni* (Pilsbry, 1948, p. 796, Fig. 427*e*) show a striking resemblance to the established *O. retusa* (Miles, 1958, p. 1537, Pl. 1, Fig. *H*); hence, *O. haydeni* was originally distinguished by shell characters that are invalid.

The illustration given by A. B. Leonard (1950) for *O. navarrei* appears to represent a shell conspecific with those figured by Pilsbry and Miles.

Genus *Quickella* Boettger, 1939
Quickella vagans (Pilsbry), 1900

Quickella vagans (Pilsbry), Pilsbry, 1948, p. 843, Figs. 443*d*, 456*a–c*. Miles, 1958, p. 1525, Pl. 1, Figs. *E, J;* Fig. 8.

Geologic Range.—Unknown.

Distribution.—"*Quickella vagans* is generally distributed over the State and is by far the most abundant representative of the Succineidae in Kansas. . . . This species is undoubtedly distributed over much of North America, but has been, and is, confused with species of *Succinea.*" (Miles, 1958, p. 1527).

Habitat.—It is common around the edges of streams and lakes, but also lives some distance from open water, in dryer habitats. "*Q. vagans* invariably lives beneath logs or other vegetation and has not been observed moving in places exposed to the rays of the sun . . ." "In June 1956, large individuals were numerous in low, sandy, areas, barren of vegetation, in Meade County State Park of western Kansas. The sand was damp beneath small dead branches, scattered over the sand." (Miles, 1958, pp. 1527–1528).

Occurrence.—Recent in Meade County, Kansas.

Family Philomycidae

Genus *Philomycus* Rafinesque, 1820

Philomycus carolinianus (Bosc), 1802

Philomycus carolinianus (Bosc), Pilsbry, 1948, p. 753, Figs. 403–404. A. B. Leonard, 1959, p. 138, Pl. 6, Fig. 1.

Distribution.—New Jersey to Florida, westward to Illinois, Kansas, and Arkansas.

Habitat.—"*Philomycus carolinianus* is a species of forests, where it lives beneath the trunks of fallen trees, under started bark, or in deep leaf litter" (A. B. Leonard, 1959, p. 139).

Occurrence.—Recent in Meade County, Kansas.

Remarks.—Although the distribution map (A. B. Leonard, 1959, p. 138) does not show a record of this slug in Meade County, a specific record and the description of the habitat given in the text establish its occurrence there.

Family Endodontidae

Subfamily Endodontinae

Genus *Discus* Fitzinger, 1833

Subgenus *Discus* s. s.

Discus (s.s.) *cronkhitei* (Newcomb), 1865

(Pl. XIII, Figs. 1–3)

Discus cronkhitei (Newcomb), Pilsbry, 1948, p. 600, Figs. 328*a–d*. A. B. Leonard, 1950, p. 35, Pl. 4, Fig. *C;* 1952, p. 19, Pl. 1, Figs. *K, FF;* Pl. 4, Figs. N–O. Frye and Leonard, 1952, pp. 159, 164, 170, Pl. 15, Fig. *q;* Pl. 16, Fig. *q;* Pl. 17, Fig. *q.* D. W. Taylor, 1956, p. 123. Frye and Leonard, 1957, p. 60, Pl. 5, Fig. 7.

Geologic Range.—Middle Pliocene to Recent. The single known Tertiary occurrence is in the Teewinot formation, Jackson Hole, Teton County, Wyoming (USGS locality 19105). In the southern High Plains it is known from Kansan, Illinoian, and Wisconsin deposits.

Distribution.—Alaska to the mountains of Southern California; Rocky Mountains south into Arizona and New Mexico; Colorado and northern Canada east to northern Nebraska, northern Illinois, Maryland, Newfoundland, and Labrador; also Missouri.

Habitat.—"In the east it lives in humid forest, under dead wood, and among rotting leaves or grass in rather wet situations. It is a common snail in the Canadian and Transition faunas, and occurs sporadically in the Carolinian." (Pilsbry, 1948, p. 604). In the High Plains, the southernmost localities are in northern Nebraska: Cherry, Hooker, and Brown counties. Here it was found under sticks and logs on moist leaf mold, always close to running water (Taylor, 1960).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, UMMZ 197836 (4); loc. 2, UMMZ 197590 (2).

Subfamily Helicodiscinae
Genus *Helicodiscus* Morse, 1864
Subgenus *Helicodiscus* s.s.
Helicodiscus (s.s.) *parallelus* (Say), 1821
(Pl. XIV, Figs. 1–3)

Helicodiscus parallelus (Say), Pilsbry, 1948, p. 625, Fig. 339. A. E. Leonard, 1943, p. 238, Pl. 1, Fig. 3. Franzen and Leonard, 1943, p. 414, Pl. 31, Fig. 19. A. B. Leonard, 1950, p. 34, Pl. 4, Fig. *A;* 1952*a*, p. 21, Pl. 1, Figs. *B, Q, GG;* Pl. 5, Figs. *P–Q*. Frye and Leonard, 1952, p. 159, 164, 170, 179, Pl. 15, Fig. *f;* Pl. 16, Fig. *m;* Pl. 17, Fig. *l;* Pl. 18, Fig. *e*. Leonard and Goble, 1952, p. 1039, Pl. 101, Figs. 24–25.

Geologic Range.—Early Pleistocene to Recent. The earliest known occurrence is in the Nebraskan or Aftonian Dixon local fauna, Kingman County, Kansas (UMMZ 191529).

Distribution.—Eastern North America, from Newfoundland south to Georgia and Alabama; westward to South Dakota and Oklahoma.

Habitat.—"It lives on decaying wood in shady or humid places, also on damp leaves" (Pilsbry, 1948, p. 627). "In eastern Kansas the species may occur in grassy fields, on sparsely timbered slopes, and on rocky ledges as well as in more moist places. In the more arid parts of the state, however, *H. parallelus* is limited to woodland cover, and usually occurs around decaying timber." (Leonard and Goble, 1952, p. 1039). In southwestern Kansas it is a rare snail, presumably because of its woodland habitat; only two localities are known in Meade County (A. E. Leonard 1943, p. 238; A. B. Leonard 1959, p. 131).

Occurrence.—Cragin Quarry local fauna; Recent in Meade County, Kansas.

Material.—Cragin Quarry: loc. 1, UMMZ 197495 (7); loc. 2, UMMZ 197513 (6); loc. 3, UMMZ 184433 (300), USGS 21276-6 (300); loc. 4, UMMZ 197540 (2).

Subgenus *Hebetodiscus* Baker, 1929
Helicodiscus (*Hebetodiscus*) *singleyanus* (Pilsbry), 1890
(Pl. XIV, Figs. 5, 8, 11)

Helicodiscus singleyanus (Pilsbry), Pilsbry, 1948, p. 636, Fig. 346. A. B. Leonard, 1952*a*, p. 21, Pl. 1, Figs. *M, CC;* Pl. 4, Fig. *H*. Frye and Leonard, 1952, pp. 151, 164, 170, Pl. 16, Fig. *i;* Pl. 17, Fig. *n*.
Helicodiscus singleyanus Pilsbry, H. T. U. Smith, 1940, p. 109.

Geologic Range.—Late Pliocene to Recent. The three known Tertiary occurrences are all from southwestern Kansas: Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 181289); Rexroad local fauna, Meade County, Kansas (UMMZ 181287, 183046, 183079); Bender local fauna, Meade County, Kansas (UMMZ 181288, 183022, 184131, 184142, 184157).

Distribution.—New Jersey to Florida, west to South Dakota, Colorado, and Arizona.

Habitat.—The species has apparently never been collected alive in the High Plains. In southwestern Kansas, however, fresh shells have been frequently found by University of Michigan field parties, when washing bulk matrix through screens. In this process any Recent shells which may be present are recovered along with the fossils. From the localities represented, it is probable that *Helicodiscus singleyanus* lives among grass roots, even on exposed slopes that become hot and dry during the summer.

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 197837 (72); loc. 2, UMMZ 197840 (3). Cragin Quarry: loc. 1, UMMZ 197828 (1); loc. 3, UMMZ 184432 (450), USGS 21276–7 (450); loc. 4, UMMZ 197541 (1).

Family Limacidae

Genus *Deroceras* Rafinesque, 1820

Subgenus *Deroceras* s.s.

Deroceras (s.s.) *laeve* (Müller), 1774

Deroceras laeve (Müller), Pilsbry, 1948, p. 539, Figs. 289–91. A. B. Leonard, 1952, p. 19, Pl. 1, Figs. *H, P, Z;* Pl. 4, Fig. *J.* Frye and Leonard, 1952, pp. 164, 170, Pl. 16, Fig. *j;* Pl. 17, Fig. *t.* Leonard and Goble, 1952, p. 1041, Pl. 100, Fig. 7.

Agriolimax laevis Müller, Geyer, 1927, p. 66, Pl. 5, Figs. 8–9.

Deroceras (*Hydrolimax*) *laeve* Müller, Frömming, 1954, p. 206, Fig. 37.

Deroceras cf. *aenigma* Leonard, van der Schalie, 1953, p. 83, in part.

Deroceras cf. *laeve* (Müller), D. W. Taylor, 1954*a*, p. 6. Taylor and Hibbard, 1955, p. 12.

Deroceras gracilis Rafinesque (?), A. E. Leonard, 1943, p. 240, Pl. 1, Fig. 1.

Deroceras gracile Rafinesque (?), Franzen and Leonard, 1943, p. 425, Pl. 32, Fig. 25.

Geologic Range.—Pleistocene, in both Europe and America. In America the range is middle Pleistocene (Illinoian) to Recent.

Distribution.—"North America generally, from the Arctic to middle Florida and Central America, the southern limit not determined" (Pilsbry, 1948, p. 540).

Habitat.—Moist to fairly wet places, often beside streams, ponds, springs, and in marshy places; also, in protected spots afforded by stones, logs, leaves, and so on. Several authors have concluded that *Deroceras laeve* is strongly hygrophilous, even to the extent of hibernating under water. After reviewing the evidence Frömming (1954) found that this latter point is far from proved, at least with respect to the western European slug generally called *D. laeve.*

In studying the mollusks of the Wakarusa River valley, northeastern Kansas, Franzen and Leonard (1943) observed that this slug "is widely distributed through this area in woods and about rocky ledges and slopes, but the animals are not seen about except when atmospheric humidity runs rather high. At drier times they seclude themselves under logs and stones." In Meade County, southwestern Kansas, "it is locally abundant in marshes, and most other shaded places" (A. E. Leonard, 1943, p. 240).

Occurrence.—Recent in Meade County, Kansas.

Remarks.—In an earlier review of fossil slug shells from the High Plains, Taylor (1954*a*, p. 6) recognized two distinct kinds: *Deroceras aenigma* and *D.* cf. *laeve.* Qualification of the latter species offers no advantage, for implicitly the identification is based on shell characters, which, so far as they go, agree with Recent specimens of *D. laeve.*

Subgenus Indeterminate

Deroceras aenigma Leonard, 1950

(Pl. XIII, Figs. 10–11)

Deroceras aenigma, new species, A. B. Leonard, 1950, p. 38, Pl. 5, Fig. *E.*

Deroceras aenigma Leonard, Frye and Leonard, 1952, pp. 151, 158, Pl. 14, Fig. *c;* Pl. 15, Fig. *d.* D. W. Taylor 1954*a,* pp. 6, 15.

Deroceras cf. *D. aenigma* Leonard, La Rocque and Conley, 1956, p. 326.

Deroceras cf. *aenigma* Leonard, van der Schalie, 1953, p. 83, in part.

?Limacid, species indet., Baker, 1920, p. 144.

Geologic Range.—Late Pliocene to late Pleistocene (Wisconsin). The species is known only from the central United States, chiefly from the Great Plains. In the southern High Plains, the known geologic range is late Pliocene to Sangamon.

Habitat.—Unknown. Like the living species of *Deroceras, D. aenigma* probably favored damp riparian habitats.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, UMMZ 184466 (1600), USGS 21274–17 (1600); loc. 2, UMMZ 197512 (38); loc. 3, UMMZ 197522 (6); loc. 4, UMMZ 197539 (1).

Family Zonitidae

Subfamily Euconulinae

Genus *Euconulus* Reinhardt, 1883

Euconulus fulvus (Müller), 1774

(Pl. XIII, Figs. 4, 6, 8)

Euconulus fulvus (Müller), Pilsbry, 1946, p. 235, Fig. 117. A. B. Leonard, 1950, p. 37, Pl. 5, Fig. *F;* 1952*a,* p. 19, Pl. 4, Fig. *I.* Frye and Leonard, 1952, pp. 159, 170, Pl. 15, Fig. *n;* Pl. 17, Fig. *k.*

Euconulus fulvus (O. F. Müller), Wenz, 1923*a,* p. 321.

Euconulus trochiformis Montagu, Geyer, 1927, p. 68, Pl. 2, Fig. 13*a–c.* Frömming, 1954, p. 104, Fig. 13.

Euconulus chersinus cf. *polygyratus* (Pilsbry), Franzen and Leonard, 1943, p. 412, Pl. 31, Fig. 16 (not of Pilsbry). Leonard and Goble, 1952, p. 1045, Pl. 101, Fig. 17 (not of Pilsbry).

Geologic Range.—Middle Pliocene to Recent. In North America the earliest known occurrence is middle Pleistocene (Kansan), where it is known from the Cudahy fauna of Kansas and Oklahoma.

Distribution.—"Almost throughout the Holarctic realm, but wanting in the Gulf and South Atlantic States from Texas to North Carolina" (Pilsbry, 1946, p. 236).

Habitat.—"*E. fulvus* lives among damp leaves in well-shaded places, and may usually be obtained by leaf sifting where its presence would otherwise be unsuspected. It is often common in the drift debris of creeks and rivers." (Pilsbry, 1946, p. 236). In northeastern Kansas on the University of Kansas Natural History Reservation, Leonard and Goble (1952) found that this species "is nowhere abundant and it is limited to the wooded hillsides . . . where it occurs under rotten logs, decaying leaves, and other debris."

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, UMMZ 184458 (107), USGS 21274–18 (75); loc. 2, UMMZ 197514 (46); loc. 3, UMMZ 197523 (1).

Remarks.—From their illustrations and descriptions, the shells recorded by Franzen and Leonard (1943) and by Leonard and Goble (1952) do not appear distinguishable from *Euconulus fulvus*. Although *E. chersinus* may possibly occur in northeastern Kansas, the more widespread *E. fulvus* would be expected to be more common. The subspecies *E. chersinus polygyratus* is known only from areas much farther north and east, and a Kansan occurrence is most unlikely.

Subfamily Zonitinae
Genus *Nesovitrea* Cooke, 1921
Subgenus *Perpolita* Baker, 1928
Nesovitrea (*Perpolita*) *electrina* (Gould), 1841

(Pl. XIV, Figs. 13, 15, 18)

Nesovitrea (Perpolita) electrina (Gould), Forcart, 1957, p. 110.

Retinella electrina (Gould), Pilsbry, 1946, p. 256, Fig. 126. Franzen and Leonard, 1943, p. 411, Pl. 31, Fig. 12. A. B. Leonard, 1950, p. 36, Pl. 5, Fig. *H;* 1952*a,* p. 22, Pl. 1, Fig. *II;* Pl. 4, Fig. *K, M.* Frye and Leonard, 1952, pp. 151, 158, 164, 170, Pl. 14, Fig. *l;* Pl. 16, Fig. *l;* Pl. 17, Fig. *x.* Leonard and Goble, 1952, p. 1042, Pl. 102, Figs. 28–29.

Retinella cf. *rhoadsi* (Pilsbry), van der Schalie, 1953, p. 82. Taylor and Hibbard, 1955, p. 12.

Geologic Range.—Late Pliocene to Recent. The single known Tertiary occurrence is in the Rexroad local fauna, Meade County, Kansas (UMMZ 183049).

Distribution.—North America north of about latitude 38°, southward in the Rocky Mountains to Arizona and New Mexico.

Habitat.—"*Retinella electrina* is an inhabitant of woodlands where it lives in decaying leaves, beneath loosened bark on dead trees and under sticks and fallen logs. It is frequently associated with another woodland snail (*Zonitoides arboreus*) of similar size and superficial appearance. *R. electrina* is common in the woodlands of eastern Kansas, where the annual rainfall is generally more than 35 inches, but it declines in frequency of occurrence toward the more arid Plains Border province, and is unknown in the Plains province, even where timber is locally available." (A. B. Leonard, 1950, p. 37).

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, UMMZ 184467 (40); loc. 2, UMMZ 197516 (12); loc. 3, UMMZ 197525 (2).

Remarks.—The specimens (UMMZ 181187) recorded by van der Schalie 1953, p. 82) as *Retinella* cf. *rhoadsi* are *Nesovitrea electrina.*

Genus *Hawaiia* Gude, 1911

Hawaiia minuscula (Binney), 1840

(Pl. XIV, Figs. 4, 7, 10)

Hawaiia minuscula (Binney), Pilsbry, 1946, p. 420, Figs. 228*a, b;* 229 in part, Nos. 1–3. A. E. Leonard, 1943, p. 238, Pl. 1, Figs. 5–6. Franzen and Leonard, 1943, p. 412, Pl. 31, Figs. 20–21. A. B. Leonard, 1950, p. 36, Pl. 5, Fig. *A;* 1952*a*, p. 20, Pl. 4, Figs. *E, F.;* Pl. 1, Figs. *F, N, JJ.* Frye and Leonard, 1952, pp. 151, 158, 164, 170, 179, Pl. 14, Fig. *m;* Pl. 15, Fig. *j;* Pl. 16, Fig. *n;* Pl. 17, Fig. *m;* Pl. 18, Fig. *b.* Leonard and Goble, 1952, p. 1042, Pl. 101, Figs. 20–21. D. W. Taylor, 1954*b*, p. 76, Pl. 20, Fig. 21–23; 1956, p. 123, Fig. 5.

Geologic Range.—Late Miocene to Recent. The known Tertiary occurrences are as follows: Late Miocene, Barstow formation, Barstow Hills, San Bernardino County, California; middle Pliocene, Teewinot formation, Jackson Hole, Teton County, Wyoming (USGS locality 19105); late Pliocene Red Corral local fauna, Oldham County, Texas (USGS locality 21040); late Pliocene Saw Rock Canyon local fauna, Seward County, Kansas (UMMZ 173592, 177570); late Pliocene Rexroad local fauna, Meade County, Kansas, (UMMZ 177609, 181058, 183048, 183064, 183081); late Pliocene Bender local fauna, Meade and Seward counties, Kansas (UMMZ 177512, 183024, 184133, 184143, 184158); late Pliocene Sand Point local fauna, Owyhee County, Idaho (USGS locality 19128).

Distribution.—North America from Alaska and Maine to Costa Rica. "It is generally spread over every eastern and midwestern state, and in Florida as far south as Miami and Cape Sable, though not seen from the keys. It becomes rather local in the Rocky Mountain states, and has not been seen from Washington, Oregon, Idaho, Nevada and Utah, and only towards the south in California, where some of the records are probably owing to importation with plants." (Pilsbry, 1946, pp. 421–23).

Habitat.—The wide geographic range of this common snail is correlated with its adaptability to various habitats. In northeastern Kansas, Franzen and Leonard (1943) found that it "is a common snail in the Wakarusa valley, where it lives in rocky ledges or among dead leaves and under fallen logs. It thrives in piles of moist drift where it has been cast by flood waters." In Meade and Clark counties, southwestern Kansas, "this species is widely distributed over the area, being nowhere numerous. It withstands arid conditions successfully but is most numerous in wooded places where moisture conditions are better than on the treeless prairies." (A. E. Leonard, 1943, p. 238).

Occurrence.—Butler Spring and Cragin Quarry local faunas; Recent in Meade County, Kansas.

Material.—Butler Spring: loc. 1, UMMZ 177384 (200), USGS 21042–29 (200); loc. 2, UMMZ 197591 (17). Cragin Quarry: loc. 1, UMMZ 184463 (2400), USGS 21274–19 (2400); loc. 2, UMMZ 197515 (1000), USGS 21275–9 (1000); loc. 3, UMMZ 184429 (200), USGS 21276–8 (200); loc. 4, UMMZ 197542 (25).

Subfamily Gastrodontinae

Genus *Zonitoides* Lehmann, 1862

Subgenus *Zonitoides* s.s.

Zonitoides (s.s.) *arboreus* (Say), 1816

(Pl. XIV, Figs. 12, 14, 17)

Zonitoides arboreus (Say), Pilsbry, 1946, p. 480, Figs. 261, 262. Franzen and Leonard, 1943, p. 413, Pl. 31, Fig. 15. A. B. Leonard, 1950, p. 37, Pl. 4, Fig. *B; 1952a,* p. 26, Pl. 3, Figs. *A–B*. Leonard and Goble, 1952, p. 1044, Pl. 102, Figs. 26–27. Frye and Leonard, 1952, pp. 151, 158, 170, Pl. 14, Fig. *p;* Pl. 15, Fig. *e;* Pl. 17, Fig. *v*. D. W. Taylor, 1954*a*, p. 12.
Physa arboreus Say, Rinker, 1949, p. 110.

Geologic Range.—Early Pliocene to Recent. The known Tertiary occurrences are as follows: early Pliocene, Laverne local fauna, Beaver County, Oklahoma; late Pliocene, Meade County, Kansas.

Distribution.—North America from northern Canada to Costa Rica.

Habitat.—"In the eastern states and Mississippi Valley this snail is everywhere abundant, to be found wherever there are trees or shelter of any kind; on or under the bark of logs, under boards, bricks or stones in the grass, or in any like situation offering protection from the sun and a reasonable degree of moisture. In the southern Alleghanies I have found it up to about 5800 feet, and in the Colorado Rockies it has been taken at 10,000 feet." (Pilsbry, 1946, p. 482.). In the Wakarusa River valley of northeastern Kansas Franzen and Leonard (1943, p. 413) found it "very common in woods, even in isolated patches of timber or native shrubbery, where it lives in old wood, under started bark, under decaying logs, and among dead leaves and other forest debris."

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 197574 (51). Cragin Quarry: loc. 1, UMMZ 184464 (40); loc. 2, UMMZ 197517 (14); loc. 3, UMMZ 197526 (1); loc. 4, UMMZ 197543 (1).

Remarks.—Although this species is one of the most abundant and widespread land snails of North America, evidently it is absent from large parts of the High Plains. This gap in its distribution is presumably due to its habitat requirement of woodland, if only patches of timber. The species has not yet been found living in Meade County, southwestern Kansas; the nearest known locality is in Kingman County, south-central Kansas (Franzen and Leonard, 1942, p. 338).

Family Polygyridae
Subfamily Polygyrinae
Genus *Stenotrema* Rafinesque, 1819
Stenotrema leai leai (Binney), 1840
(Pl. VI, Figs. 1, 4, 7)

Stenotrema monodon (Rackett), Pilsbry, 1940, p. 676, Figs. 421*a, b*. A. B. Leonard, 1950, p. 35, Pl. 4, Fig. *D*. van der Schalie, 1953, p. 82.
Stenotrema leai (Binney), Pilsbry, 1948, p. 1099.
Stenotrema monodon aliciae (Pilsbry), A. B. Leonard, 1952*a*, p. 23, Pl. 3, Figs. *F–G* (not of Pilsbry).
Stenotrema leai leai (Binney), Frye and Leonard, 1952, p. 158.
Polygyra monodon Rackett, H. T. U. Smith, 1940, p. 109.

Geologic Range.—Middle Pleistocene (Kansan) to Recent. The first recorded appearance is in the Cudahy fauna, in Kansas and Oklahoma.

Distribution.—New York to Maryland, west to South Dakota and Kansas. "It has been reported from Kansas, but the living species is a distinguishable race, *Stenotrema monodon aliciae*" (A. B. Leonard, 1950, p. 36).

Habitat.—"*S. monodon* is a snail of damp places near the water" (Pilsbry, 1940, p. 678). "*Stenotrema monodon* thrives in rather humid forests, and may be found on low terraces and flood plains of streams, under leaves, logs, and stones" (A. B. Leonard, 1950, p. 36). The locality nearest to Meade County where *Stenotrema leai* (s.s.) is living today is in Cherry County, Nebraska, on the flood plain of the Niobrara River (Taylor, 1960). Here perennial vegetation was sparse, but scattered debris and the moist, low ground gave a suitable habitat.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring: loc. 1, UMMZ 177385 (46), USGS 21042–30 (22). Cragin Quarry: loc. 1, UMMZ 184455 (475), USGS

21274–20 (100); loc. 2, UMMZ 197518 (158), USGS 21275–10 (64); loc. 3, UMMZ 197527 (1); loc. 4, UMMZ 197544 (29).

Remarks.—The shell figured by A. B. Leonard (1959, p. 89, Pl. 4, Figs. 25–27) as *Stenotrema leai aliciae* has the more open umbilicus of typical *S. leai,* as defined by Pilsbry (1940). Many of the Kansas records published by Leonard may therefore also be *S. leai,* and closer to Meade County than the Nebraska record mentioned above.

Phylum VERTEBRATA
Class Osteichthyes

C. Lavett Smith (1958, p. 179) reported the fishes associated with the Butler Spring local fauna. He has identified the specimens reported here from the Cragin Quarry local fauna.

Family Lepisosteidae
Genus *Lepisosteus* Lacépède, 1803
Lepisosteus sp.

Geologic Range.—Cretaceous to Recent.

Distribution.—"Gars are found in larger streams and lakes from the upper Missouri valley of Montana and North Dakota through the drainage of the Red River of the North in North Dakota and Minnesota and the Great Lakes drainage exclusive of Lake Superior, to the St. Lawrence River. They range southward to Lake Nicaragua in central America." (Smith, 1958, p. 179.)

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, No. 34855, part of an upper jaw and 16 scales.

Family Catostomidae
Genus *Catostomus* Le Sueur, 1817
Catostomus commersoni (Lacépède), 1803

Catostomus commersoni (Lacépède), Smith, 1958, p. 177.

Geologic Range.—Middle Pleistocene (Illinoian) to Recent.

Distribution.—The white sucker "is now found from the upper Mackenzie River basin to the Labrador Peninsula and southward to the Saluda River in South Carolina. In the Mississippi River drainage it occurs south to the Tennessee River System and in the upland of northern Arkansas and northeastern Oklahoma. It is absent south of north-central Kansas but does occur in the headwaters of the Arkansas, Canadian and Pecos Rivers." (Smith, 1958, p. 177).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, No. 34856, parts of two pharyngeal arches, and one incomplete vomer.

Family Cyprinidae
Indeterminate Cyprinid

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 39447, two fragmentary pharyngeal bones of a minnow.

Family Ictaluridae
Genus *Ictalurus* Rafinesque, 1820
Ictalurus cf. *I. punctatus* (Rafinesque), 1818

Geologic Range.—Middle Pleistocene (Illinoian) to Recent.

Distribution.—"The channel catfish occurs in lakes and rivers from the northern end of Lake Huron and the St. Lawrence drainage of Quebec to Cumberland Lake in Saskatchewan and south to the Rio Panuco Basin in northeastern Mexico." (Smith, 1958, p. 179).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, No. 34858, parts of two right cleithra, fragments of two pectoral spines and part of a posttemporal.

Icatalurus sp.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 39446, parts of two pectoral spines of a small bullhead.

Family Percidae
Genus *Perca* Linnaeus, 1758
Perca flavescens (Mitchill), 1814

Perca flavescens (Mitchill), Smith, 1958, p. 179.

Geologic Range.—Middle Pleistocene (Illinoian) to Recent.

Distribution.—"The present distribution of the yellow perch is from Lesser Slave Lake of the Mackenzie Basin east to the Hudson Bay drainage and south to the northern parts of Missouri, Illinois, Indiana, Ohio and western Pennsylvania. On the Atlantic slope of the Appalachians, it ranges from New Brunswick to South Carolina." (Smith, 1958, p. 178).

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, No. 34860, part of a right preopercle and a supracleithrum.

Class AMPHIBIA
Order CAUDATA
Family Ambystomatidae
Genus *Ambystoma* Tschudi, 1838
Ambystoma tigrinum (Green), 1825

Ambystoma tigrinum (Green), Tihen, 1955, p. 239.

Geologic Range.—Late Nebraskan or early Aftonian to Recent.

Distribution.—"From Albany and Long Island, New York, southward to northern Florida, westward to Texas, northward to Minnesota and Point Pelee, Ontario" (Bishop, 1943, p. 159).

Habitat.—"The Tiger salamander, as an adult, is essentially a burrowing species and spends most of its life below the surface of the ground. The breeding waters, to which it resorts in the spring, are found in semidesert regions, pine barrens, and forests of plains and mountains, its ability to survive under such diverse situations probably being due to the burrowing habit . . . . In the high lakes of Colorado and other western states this species is often neotenic and reaches a size comparable to that of the transformed adults." (Bishop, 1943, pp. 159, 170).

Occurrence.—Cragin Quarry and Butler Spring local faunas; Recent in Meade County, Kansas.

Material.—Cragin Quarry loc. 1, No. 33376, isolated vertebrae; Butler Spring loc. 2, Nos. 34702 and 34703, vertebrae, limb and skull elements.

Remarks.—The tiger salamander remains from the Cragin Quarry local fauna are those of the normal adult, while those from the Butler Spring local fauna are of neotenic individuals. Tihen (1958, p. 5) stated concerning the tiger salamander that inhabited southwestern Kansas during the Pleistocene: "Within a limited area of southwestern Kansas, it appears that the changing environments of the glacial and interglacial stages during the Pleistocene were accompanied by corresponding changes in the mode of living of populations of *tigrinum* inhabiting that area. Populations from deposits associable with major glacial advances were apparently neotenic, while those associable with the interglacial stages underwent normal metamorphosis (cf. Tihen, 1955)."

Class REPTILIA

E. H. Taylor (1943) reported a semibox turtle from the Butler Spring local fauna. Other turtle remains are being studied by T. M. Oelrich. He has furnished the identification of the two species listed. Richard Etheridge (1958) reported the lizards from the Cragin Quarry local fauna. No lizard remains were recovered from the Butler Spring local fauna. The snake remains from both local faunas are being studied by B. H. Brattstrom. For a detailed map showing the distribution of the recent species of reptiles see Conant (1958).

Order CHELONIA
Family Chelydridae
Genus *Chelydra* Schweigger, 1812
Chelydra serpentina (Linnaeus), 1758

Geologic Range.—Middle Pleistocene (Illinoian) to Recent.

Distribution.—The common snapping turtle is now found from southern New Brunswick south to northern Florida and west along the coast to the San Antonio River in Texas. It ranges west to Del Rio, Texas, and northward just east of the Rocky Mountains to the extreme southeastern corner of Alberta (see Conant, 1958, p. 313, Map 3).

Occurrence.—Butler Spring local fauna; Recent in Meade County, Kansas.

Material.—Butler Spring loc. 1, No. 38637, piece of carapace.

Family Testudinidae

Genus *Terrapene* Merrem, 1820

Terrapene llanensis Oelrich, 1953

Terrapene llanensis Oelrich, 1953, p. 35.

Geologic Range.—Sangamon.

Distribution.—Slaton local fauna of western Texas and the Cragin Quarry and Jinglebob local faunas of southwestern Kansas.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 38637, part of carapace and plastron.

Remarks.—*Terrapene llanensis* and other fossil forms were synonymized with *T. canaliculata* Hay by Milstead (1956); and all these with the living *T. carolina* by Holman (1958). *T. llanensis* is retained as a distinct species herein, however. The difference in size between it and *T. canaliculata* is correlated with stratigraphic differences. *T. llanensis,* which is known from several Sangamon localities, is smaller than the Wisconsin *T. canaliculata* of Texas. Furthermore, that the relations of *T. llanensis* may be as close, or closer, to *T. mexicana* (Gray) or other large Mexican *Terrapene* than to the southeastern *T. carolina* has been suggested by Richard Etheridge (personal communication, January, 1959). The relationship of *T. llanensis* to the Mexican forms has not been considered by previous workers.

Part of a carapace, No. 39442, of *T. llanensis* was found in collecting mollusks of the Slaton local fauna, Lubbock County, Texas. This assemblage has been considered of either late Illinoian or Sangamon age (Herrington and Taylor, 1958), but its contrast with the Butler Spring local fauna suggests that the Sangamon is the more likely.

The *Terrapene* of Wisconsin age from Friesenhahn Cave, Bexar County, Texas, and from the Lewisville site, Denton County, Texas (Crook and Harris, 1958) have been examined by Hibbard. The size range of these younger box turtles is much greater than that of specimens from the Sangamon deposits in the Plains region.

Genus *Emydoidea* Gray, 1870

Emydoidea Gray, Loveridge and Williams, 1957, p. 189.

Emydoidea twentei (Taylor), 1943

Emys twentei E. H. Taylor, 1943, p. 250.

Geologic Range.—Illinoian.

Distribution.—Known only from Meade County, Kansas.

Occurrence.—Butler Spring loc. 4, KU 6478, holotype, most of carapace.

Genus *Geochelone* Fitzinger, 1835

Geochelone sp.

Geologic Range.—The genus is known in North America from the late Eocene to the late Wisconsin.

Distribution.—This land turtle is confined to subtropical and tropical regions.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, part of plastron and carapace, deposited in the University of Kansas Museum of Natural History.

Remarks.—At the time Hibbard collected the invertebrate fossils at the Cragin Quarry site, reported by H. T. U. Smith (1940, p. 109), part of a medium-sized *Geochelone* was recovered. The type of *G. equicomes* (Hay) was later examined, but it was impossible to arrive at a species identification of the Cragin Quarry specimen due to the fragmentary nature of the type. In the summer of 1956 additional fragments of a medium-sized *Geochelone* were recovered from the deposit.

The presence of this turtle is significant in the interpretation of the paleoecology of the Cragin Quarry local fauna. The living members of the genus *Geochelone* are confined to subtropical or tropical regions. There is no evidence from the Cenozoic fossil record in North America that the medium-sized or large *Geochelone* entered burrows for hibernation or to escape summer heat, as do *Terrapene* and *Gopherus*. Furthermore, there were no caves in the Plains region that could be used by these large turtles. It is possible that the small late Pleistocene *Geochelone wilsoni* (Milstead), a common member of the Friesenhahn Cave fauna, may have used that cave for shelter.

Order SQUAMATA

Family Iguanidae

Genus *Crotaphytus* Holbrook, 1842

Crotaphytus collaris (Say), 1823

Crotaphytus collaris (Say), Etheridge, 1958, p. 95.

Geologic Range.—Sangamon to Recent.

Distribution.—The eastern collared lizard is now found from east-central Missouri, northeastern Arkansas, Oklahoma, south-central Texas to southeastern New Mexico, north to extreme southeastern Colorado, eastward across southwestern Kansas and north almost to the Nebraska line in central Kansas, hence southeastward into Missouri (see Conant, 1958, Map 42, p. 319).

Habitat.—Rock outcrops, associated with patches of bare ground (Etheridge, 1958, p. 100).

Occurrence.—Cragin Quarry local fauna; Recent in Meade County, Kansas.

Material.—Cragin Quarry loc. 1, Nos. 33828, 33831, 33833, 34129–34139, parts of dentaries, maxillaries, vertebrae, and scapulocoracoids.

Genus *Phrynosoma* Wiegmann, 1828

Phrynosoma cornutum (Harlan), 1825

Phrynosoma cornutum (Harlan), Etheridge, 1958, p. 98.

Geologic Range.—Upper Pliocene to Recent.

Distribution.—The Texas horned lizard now ranges from Kansas southward to northern Mexico and west to southeastern Arizona.

Habitat.—Open areas with little or no vegetation.

Occurrence.—Cragin Quarry local fauna; Recent in Meade County, Kansas.

Material.—Cragin Quarry loc. 2, No. 34126, a right squamosal.

Phrynosoma modestum Girard, 1852

Phrynosoma modestum Girard, Etheridge, 1958, p. 97.

Geologic Range.—Sangamon to Recent.

Distribution.—The round-tailed horned lizard is now found from northwest Texas to southeastern Arizona and southward into Mexico (see Conant, 1958, Map 53, p. 321).

Habitat.—Upland areas that are bare or support sparse vegetation.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 33827, 34140–34146, parts of dentaries, maxillaries, squamosals, and a parietal.

Genus *Holbrookia* Girard, 1851

Holbrookia texana (Troschel), 1850

Holbrookia cf. *texana* Troschel, Etheridge, 1958, p. 98.

Geologic Range.—Sangamon to Recent.

Distribution.—The greater earless lizard now occurs from central Texas north to the Red River, west to southeastern New Mexico, and south into northern Mexico (see Conant, 1958, Map 39, p. 319).

Habitat.—Along valley walls with rock outcrops and open areas with sparse vegetation.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 31678, 33375, 33832, 34165–34176, parts of dentaries, maxillaries, frontals, and two pelves.

Remarks.—The original fossils assigned to this genus were tentatively referred to *Holbrookia texana,* since they differed from *H. maculata* only in their somewhat larger size. Additional material now available includes frontals, scapulocoracoids, dorsal and pelvic vertebrae, maxillaries, and a single articular. The articular is sufficiently distinct from that of *H. maculata* to permit the more positive identification of the fossil as *H. texana.* The new material also more certainly establishes the greater size of the Cragin Quarry *Holbrookia* (personal communication from Richard Etheridge, January 30, 1959).

Family Teiidae

Genus *Cnemidophorus* Wagler, 1830

Cnemidophorus sexlineatus (Linnaeus), 1766

Cnemidophorus sexlineatus (Linnaeus), Etheridge, 1958, p. 99.

Geologic Range.—Late Pliocene to Recent.

Distribution.—The six-lined racerunner is now found from Maryland to Florida, west to eastern Wyoming and south to Texas (see Conant, 1958, Map 72, p. 324).

Habitat.—Sandy areas, with moderate cover or bare strips of sand or sandy ground.

Occurrence.—Cragin Quarry local fauna; Recent in Meade County, Kansas.

Material.—Cragin Quarry loc. 1, Nos. 34151–34152, parts of two dentaries of the lower jaw.

Family Scincidae

Genus *Eumeces* Wiegmann, 1834

Eumeces obsoletus (Baird and Girard), 1852

Eumeces obsoletus (Baird and Girard), Etheridge, 1958, p. 99.

Geologic Range.—Sangamon to Recent.

Distribution.—The Great Plains skink now ranges from southern Nebraska southwestward to northern Mexico and west to southeastern Arizona (see Conant, 1958, Map 66, p. 323).

Habitat.—Rock outcrops, rocky areas; in the Plains region along valley slopes with bare areas, or dry stream beds, using burrows made by mammals for shelter.

Occurrence.—Cragin Quarry local fauna; Recent in Meade County, Kansas.

Material.—Cragin Quarry loc. 1, Nos. 33835, 34155–34164, parts of dentaries, maxillaries, and a vertebra.

Class MAMMALIA
Order INSECTIVORA
Family Soricidae
Genus *Notiosorex* Coues, 1877
Notiosorex crawfordi (Coues), 1877
(Fig. 10H–I)

Sorex (Notiosorex) crawfordi Baird, n. subg. et sp., Coues, 1877, p. 651.
Notiosorex crawfordi Baird, Merriam, 1895, p. 32.
Notiosorex crawfordi (Coues), Miller and Kellogg, 1955, p. 43.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna, Meade County, Kansas. The only other record of this species as a fossil is from the Rancho La Brea tar pits, Los Angeles, California (Compton, 1937).

Distribution.—Extreme northwestern Oklahoma (Cimarron County, Glass, 1953) southwest to central New Mexico, then northwest to near the northern boundary of New Mexico and Arizona and southeastern Nevada, southeastern and extreme southern California, north along the west coast to Carpinteria, California (von Bloeker, 1944); south to the tip of peninsula of Baja California; along the west coast of Mexico south to Michoacán (Baker and Alcorn, 1953); east along the northern boundary of Mexico to Nueces County, Texas, hence to northwestern Cimarron County, Oklahoma. Relict populations occur in the Ouachita Mountains of northeastern Oklahoma (Clark, 1953) and the Boston "Mountains" of northwestern Arkansas (Sealander, 1952).

Habitat.—The desert shrew is confined chiefly to the semiarid and arid regions of southwestern North America. It has been taken chiefly in low desert shrub areas. Hoffmeister and Goodpaster (1954) found this shrew living at an elevation between 4500 and 5000 feet in a desert grassland that occurred on dry alluvial fans along the east side of the Huachuca Mountains in Arizona. The specimens taken of the relict populations of the Interior Highlands were found in the dry areas of that region.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1 (KU loc. 6, Meade County, Kansas), Nos. 35557–35561, parts of three left and four right lower jaws.

Remarks.—The anteroposterior lengths (in millimeters) of four of the fossil dentitions are: No. 35557, P_4–M_3, 4.50 (Fig. 10H); No. 35558, M_1–M_3, 3.80; No. 35559, C–M_3, 5.0; and No. 35560, P_4–M_3, 4.50.

Fragmentary incisors are present in specimens Nos. 35558 and 35559. There is no evidence of pigmentation in the teeth.

The above specimens were compared with a series of Recent lower jaws of the desert shrew, *Notiosorex c. crawfordi,* from the Huachuca Mountains, Cochise County, Arizona (see Hoffmeister and Goodpaster, 1954). The fossil specimens agree in size and dental characters with those of the Recent species, except in the development of the entoconid on M_1, and on M_2 in the fossil series. The entoconid is well developed on both M_1 and M_2 of the fossil specimens, regardless of the stage of wear. Five of the Recent specimens from Arizona had greatly reduced entoconids. Four Recent specimens, two from Arizona, one each from Texas and New Mexico, had the entoconids as well developed as in the fossil specimens.

The lower jaws of *Notiosorex* are easily distinguished from those of *Sorex, Microsorex, Blarina,* and *Cryptotis* by the groove that separates the lower condyle from the angular process of the ramus (Fig. 10I). The lower condyle in *Notiosorex* is more lingual than in the above genera, but the lower condyle of *Hesperosorex* and *Megasorex* is also separated by a slight groove (Hibbard, 1958*a*, p. 329).

The specimens of *Notiosorex crawfordi* in the Cragin Quarry local fauna (of Sangamon age) furnish not only the oldest, but also the most northern known record of the species. The Recent specimen from Cimarron County, Oklahoma (Glass, 1953), was found approximately 150 miles west by south of the Cragin Quarry site in Meade County, Kansas. The northward movement, in recent years, of such mammals as *Didelphis, Baiomys, Sigmodon,* and *Dasypus* suggests that it would not be unlikely for this shrew to occur in the southwest corner of Kansas.

Sealander (1952) and Clark (1953) both suggested that the occurrence of the desert shrew in Arkansas (Boston "Mountains") and eastern Oklahoma (Ouachita Mountains) may be part of a relict fauna which spread there during a former drier climate. The Arkansas population is separated from the northeastern Oklahoma population now by the Arkansas Valley. The semiarid climate that prevailed in this valley during part of the Sangamon could have provided an ecological pathway for *Notiosorex crawfordi* to the Interior Highlands. These eastern populations may, therefore, date from that time.

Order CHIROPTERA

Family Vespertilionidae

Genus *Lasiurus* Gray, 1831

Lasiurus cinereus (Beauvois), 1796

(Fig. 10A)

Lasiurus cinereus (Palisot de Beauvois), Miller and Kellogg, 1955, p. 106.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The only known fossil occurrence is in the Cragin Quarry local fauna.

Distribution.—Boreal North America from the Atlantic to the Pacific, breeding as far south as Pratt, Kansas, but migrating southward at least to Central Chihuahua (Miller and Kellogg, 1955, p. 106).

Habitat.—This large tree-dwelling bat inhabits chiefly the broad-leaf forests, but it also occurs along wooded streams, in cities with wooded parks, and in western Kansas in groves of large cottonwoods wherever an open water supply is available.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35562–35565, part of a left maxillary, three isolated teeth, an incomplete right lower jaw and parts of two humeri.

Remarks.—Parts of at least two hoary bats were recovered. The anterior part of the left side of the maxillary, No. 35562, is broken just posterior to the infraorbital foramen. Part of the alveolus of the canine and the alveolus of the reduced P^3 is present, also the roots of P^4 and the alveoli of M^1.

Fragments of another skull, No. 35563, consisting of a left canine, a RM^1 and LM^2, and an M^3 in a piece of maxillary, are all of a young adult.

Among the remains is a part of a right lower jaw, No. 35564, bearing the M_2 and the alveolus for the canine, P_3 and P_4, and the alveoli for M_1 and M_3 (Fig. 10A). The humeri, No. 35565, are represented by only the distal ends.

The above specimens were sent to Charles O. Handley, Jr., at the United States National Museum for comparison with a series of skeletons of *Lasiurus* and *Dasypterus*. He wrote November 5, 1958, "I see no reason that they can not be identified as *Lasiurus cinereus*. They cannot be *borealis, ega* or *intermedius*." I am grateful for this comparative study, since I did not have access to a series of Recent skeletons.

FIG. 10. Sangamon (interglacial) mammals. (A) *Lasiurus cinereus*, UMMP 35564, right ramus with M_2. Labial and occlusal views. × 8. (B) *Citellus tridecemlineatus*, UMMP 35582, right maxillary, with P^4. Ventral view. × 4. (C–E) *Paramylodon harlani*, KU 7416, 7415, and 7417. Lateral and occlusal views. × 0.5. (F) *Dasypterus golliheri*, sp. nov., holotype, UMMP 35566, left premaxillary-maxillary, C–P^4. Labial view. × 10. (G) *Cynomys ludovicianus*, UMMP 35580, left P^3–M^3. Occlusal view. × 2. (H–I) *Notiosorex crawfordi*, UMMP 35557, left lower jaw, P_4–M_3. Labial and occlusal views; (I) posterior view of condyle. × 10.

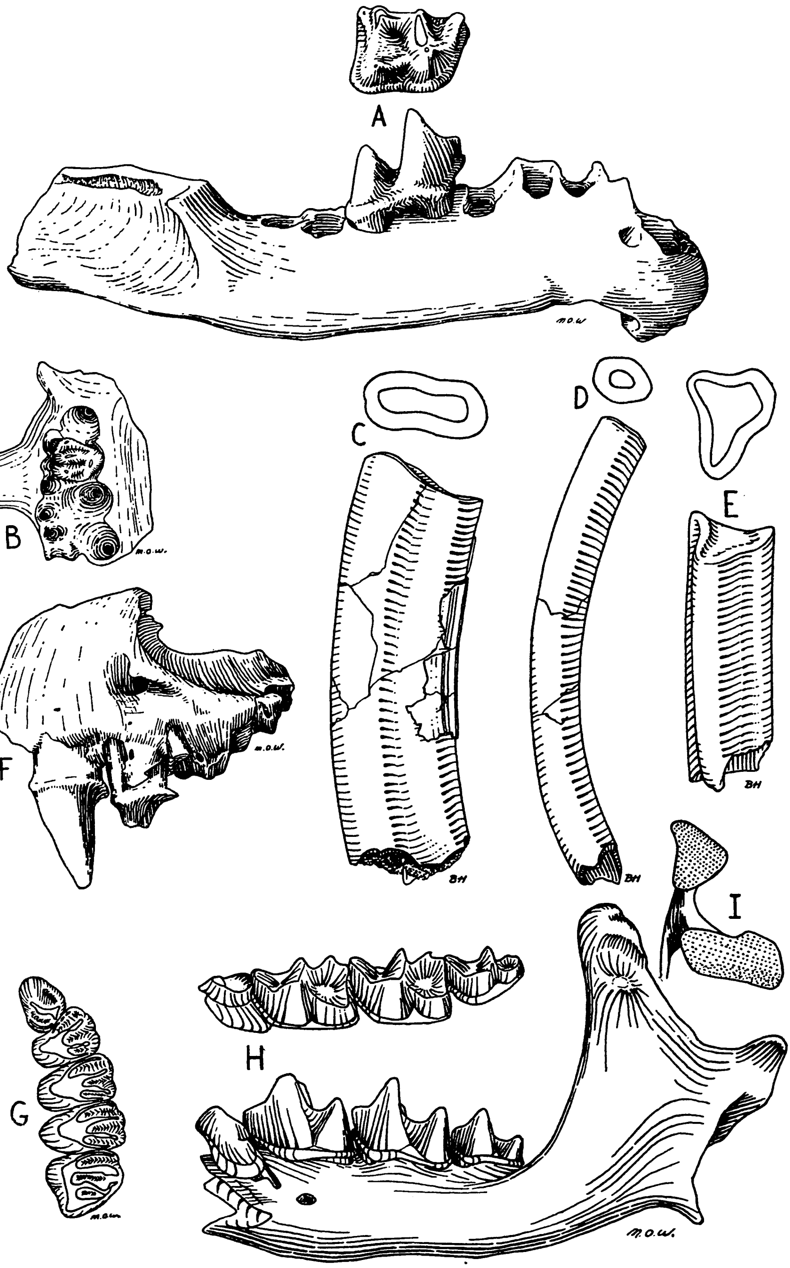

FIGURE 10

Genus *Dasypterus* Peters, 1871

Dasypterus golliheri Hibbard, sp. nov.

(Fig. 10F)

Holotype.—No. 35566, University of Michigan Museum of Paleontology, part of left premaxillary-maxillary with alveolus of I^3, P^4, and alveoli of M^1.

Geologic Range.—Late Pleistocene (Sangamon).

Horizon and type locality.—Below the caliche bed in the Kingsdown formation; Cragin Quarry local fauna, locality 1 (Sangamon age); Big Springs Ranch, SW¼ sec. 17, T. 32 S., R. 28 W., (Kansas University Locality 6), Meade County, Kansas.

Occurrence.—Known only from Cragin Quarry local fauna.

Diagnosis.—A bat smaller than living forms of *Dasypterus,* lacking P^3, and with the position and development of the infraorbital foramen as in *Dasypterus.*

Description of holotype.—No. 35566 is the anterior part of the premaxillary-maxillary which bears the canine and P^4, and is broken just posterior to M^1. The indentation of the anterior part of the palate extends only to a line opposite to the anterior edge of P^4, as in *Dasypterus ega* (Gervais), *D. intermedium* (Allen), and *D. floridanus* Miller. In specimens of *Lasiurus* the anterior indentation of the palate extends more posteriorly. The size of the alveolus of I^3 indicates a large tooth. The canine is the size of that tooth in specimens of *Lasiurus seminolus* (Rhoads). The hypocone (inner heel) of P^4 is 1.0 mm. wide and is the size of that tooth in *Dasypterus ega* and *Lasiurus cinereus* (Beauvois). The transverse width of P^4 is 1.3 mm.

The shape and position of the infraorbital foramen in relation to the roots of P^4 are as in Recent specimens of *Dasypterus.* The infraorbital foramen (Fig. 10F) is located more anteriorly relative to P^4 in *Lasiurus. Dasypterus golliheri* is the first known fossil record of the genus. The species is named for Mr. Jerry D. Golliher of Plains, Kansas, who first showed me the Cragin Quarry site and who has helped through past years with our work in that region.

Habitat.—Tree-dwelling. The yellow bats range from the southern Gulf States southward to South America, and from southern California to Baja California, Mexico. Anthony (1928, p. 64) stated that, "The different Recent species apparently prefer dry, hot country."

Order EDENTATA

Family Megalonychidae

Genus *Megalonyx* Harlan, 1825

Megalonyx sp.

(Fig. 11D)

Geologic Range.—This genus of ground sloths is known from the middle Pliocene, upper Pliocene, and Pleistocene.

Distribution.—The genus is reported from many of the states in the United States.

Habitat.—Unknown.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring Loc. 4, from the sands containing *Emydoidea twentei;* No. 29012, foot bone.

Remarks.—The foot bone is tentatively identified as the right metacarpal IV. The greatest length is 112.4 mm.; greatest depth of the proximal end, 56.5 mm.; and greatest depth of the distal end, 62.8 mm.

Family Mylodontidae

Genus *Paramylodon* Brown, 1903

Paramylodon harlani (Owen), 1840

(Fig. 10C–E)

Mylodon harlani Owen, Stock, 1925, p. 120.
Paramylodon harlani (Owen), Hibbard, 1955*b,* p. 196.

Geologic Range.—Pleistocene.

Distribution.—Alaska to Central America, Washington to Atlantic Coast.

Habitat.—Stock (1925, p. 26–30) discussed the type of habitat of the Mylodontidae that is suggested by their occurrence. He stated: "That *Mylodon* and related genera were inhabitants of the great stretches of open country, the pampas or steppes, in South America seems definitely established by their occurrence and faunal association at several of the most noteworthy localities. . . . The mylodont ground-sloths of North America apparently dwelt in surroundings similar to those in which the animals lived in South America, . . ."

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 7415–7417, parts of four teeth.

Remarks.—Tooth, No. 7415, is either the first lower or first upper (Fig. 10D). The curvature of the crown and the angle at which the occlusal surface of the tooth is worn suggests that it is probably the first upper tooth. The base of the tooth is missing. The remaining length is 124.0 mm. The anteroposterior length of the occlusal surface is 17.0 mm., the greatest width 13.8 mm. Tooth, No. 7416, in general shape is like that of the third lower (Fig. 10C). It has a length of 110.0 mm.; the greatest length of the occlusal surface is 35.0 mm.; the greatest width 16.5 mm. Tooth No. 7417 is the second lower (Fig. 10E), with much of the base of the tooth missing. The last tooth is too fragmentary for placement in the dentitional series.

Order RODENTIA
Family Sciuridae
Genus *Cynomys* Rafinesque, 1817
Cynomys ludovicianus (Ord), 1815
(Fig. 10G)

Cynomys ludovicianus (Ord), Hollister, 1916, p. 14.
Cynomys ludovicianus (Ord), Miller and Kellogg, 1955, p. 188.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna.

Distribution.—From southern Saskatchewan south through the Great Plains region to southeastern Arizona, northern parts of Sonora and Chihuahua, Mexico. For detailed distribution, see Miller and Kellogg, 1955, p. 188, and Burt, 1952, map, p. 81. The eastward range of the species has been restricted by cultivation.

Habitat.—The blacktail prairie dog lives chiefly on broad flats of the open short-grass country with deep soil.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 35580, a left maxillary.

Remarks.—The blacktail prairie dog is represented by a left maxillary with P^3–M^3 (Fig. 10G). The anteroposterior length of the tooth row is 17.0 mm. Dentition is like that of Recent specimens from Meade County.

Genus *Citellus* Oken, 1816
Citellus tridecemlineatus (Mitchill), 1821
(Fig. 10B)

Citellus tridecemlineatus (Mitchill), A. H. Howell, 1938, p. 106.
Citellus tridecemlineatus (Mitchill), Miller and Kellogg, 1955, p. 198.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna.

Distribution.—Bee County, Texas, north by west to extreme east-central Arizona; north to southeastern Alberta, southern Saskatchewan, extreme southern Manitoba, southeast to Lake Michigan; Lower Peninsula of Michigan, hence southwest to Bee County, Texas (see Miller and Kellogg, 1955, and Burt, 1952).

Habitat.—Open grasslands within its range.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35581, 35582, incomplete right and left maxillaries.

Remarks.—The thirteen-lined ground squirrel is represented by a fragment of the left maxillary, No. 35581, containing M^2 and M^3; and part of the right maxillary, No. 35582, containing P^4 (Fig. 10B). The teeth are those of young animals. In character the infraorbital process for the attachment of the masseter muscle is like that in *Citellus tridecemlineatus*. This feature, as well as the shape of the cusps of the unworn teeth, indicates the fossils represent *C. tridecemlineatus* and not *C. spilosoma* (Bennett). Both species are members of the Recent fauna of Meade County, and their teeth are nearly the same size.

Citellus sp.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 2, No. 34705, part of left maxillary with three teeth.

Remarks.—The maxillary contains P^4, M^1, and M^3. It is intermediate in size between those of *Citellus richardsonii* (Sabine) and *Citellus armatus* (Kennicott). The metaloph on P^4 is continuous, a character of the subgenus *Citellus* (Howell, 1938). The infraorbital foramen is as in the *Citellus richardsonii* group, but the ventral surface of the maxillary anterior to the infraorbital process lacks the well-developed masseteric scar present on *Citellus richardsonii*. More material is needed for specific identification.

Family Geomyidae

Genus *Geomys* Rafinesque, 1817

Geomys bursarius (Shaw), 1800

(Fig. 11G)

Geomys lutescens Merriam, Hibbard, 1937, p. 234.
Geomys bursarius (Shaw), Miller and Kellogg, 1955, p. 334.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna.

Distribution.—Extreme northwestern Minnesota, southeastern to northern Illinois and northwestern Indiana; most of Missouri, southwestern Arkansas, Louisiana, except the eastern edge, south to southeastern Texas, northwest to east-central New Mexico, northwestern Texas and Oklahoma, eastern Colorado, extreme eastern Wyoming, southern and eastern South Dakota and southeastern North Dakota (see Miller and Kellogg, 1955).

Habitat.—Found chiefly in sandy soils.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35608 and 35609, part of a left lower jaw and isolated teeth; KU 3959, a skull.

Remarks.—The left lower jaw, No. 35608, with P_4–M_2 (Fig. 11G) is indistinguishable from that of the pocket gopher, *Geomys bursarius.*

In the summer of 1936, a gopher skull was collected at the Cragin Quarry site in association with *Camelops* cf. *kansanus* Leidy. Hibbard (1937, p. 234) reported this specimen as *Geomys lutescens,* but since that

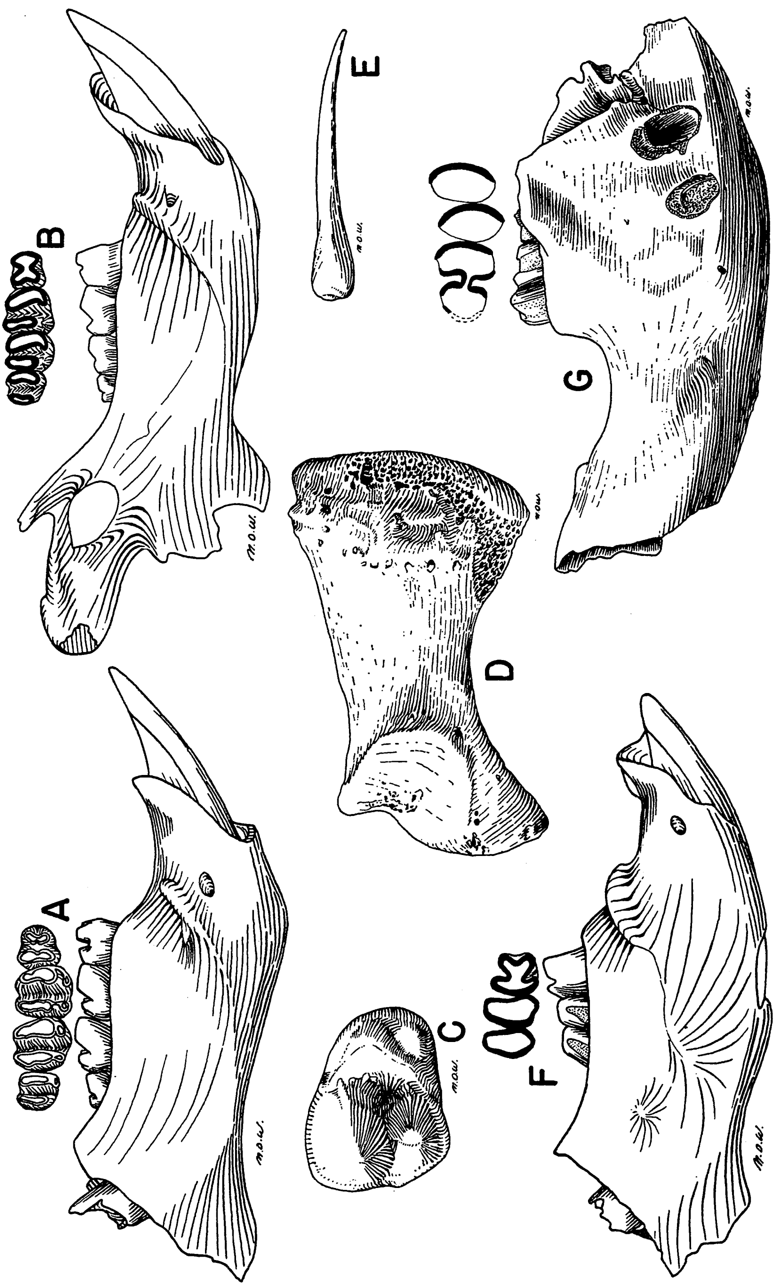

FIGURE 11

date *Geomys lutescens* and *Geomys breviceps* and their subspecies have been asigned to the species *Geomys bursarius*. The subspecies are based on color and variation in local geographic populations. A large series of perfect skulls and lower jaws is necessary for subspecific assignment.

cf. *Geomys*

(Fig. 11E)

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 2, No. 35736, baculum.

Remarks.—The baculum of a geomyid was recovered with the Butler Spring local fauna in association with the *Citellus* maxillary, No. 34705; the lower jaws of *Microtus pennsylvanicus* (Ord), No. 34701; and remains of *Ambystoma tigrinum* Green (Tihen, 1955). The baculum was identified by W. H. Burt as probably belonging to a member of the genus *Geomys* (Fig. 11E).

Family Heteromyidae
Genus *Perognathus* Wied-Neuwied, 1839
Perognathus hispidus Baird, 1858

(Fig. 11A)

Perognathus hispidus Baird, Osgood, 1900, p. 42.
Perognathus hispidus Baird, Miller and Kellogg, 1955, p. 370.

Geologic Range.—Late Pleistocene (Sangamon) to Recent.

Distribution.—From central Arizona southeast to Pachuca, Hidalgo, Mexico, northeast to western Louisiana, hence northwest to the southwestern corner of North Dakota, south through the Plains Region to northeastern New Mexico, and then southwest to central Arizona (Miller and Kellogg, 1955; and Burt, 1952).

Habitat.—Chiefly a grassland form, living in both the short grass and long grass prairies.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35574–35579, fragmentary lower and upper jaws.

FIG. 11. Late Pleistocene mammals. (A) *Perognathus hispidus,* UMMP 35574, right lower jaw, P_4–M_3. Labial and occlusal views. × 6. (B) *Perognathus* sp., UMMP 35571, right lower jaw, P_4–M_3. Labial and occlusal views. × 8. (C) *Aenocyon dirus* (Leidy) KU 7434, right M^1. Occlusal view. × 1. (D) *Megalonyx* sp., UMMP 29012, metacarpal IV. Lateral view. × 1. (E) *Geomys?* sp., UMMP 35736, baculum. Lateral view. × 4. (F) *Dipodomys* cf. *D. ordii,* UMMP 35602, part of right lower jaw, P_4–M_2. Labial and occlusal views. × 6. (G) *Geomys bursarius,* UMMP 35608, part of left lower jaw. Labial and occlusal views. × 4.

Remarks.—The hispid pocket mouse is known from parts of six right and seven left lower jaws. Two of the right jaws, Nos. 35574 (Fig. 11A) and 35575, contain P_4–M_3. The anteroposterior lengths of P_4–M_3 are 4.2 and 4.0 mm. Part of the right maxillary, No. 35579, contains P^4, M^1, and M^3. The dentition is indistinguishable from that of *Perognathus hispidus paradoxus* Merriam which now lives in Meade County.

Perognathus sp.

(Fig. 11B)

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35568–35572, parts of five maxillaries and 51 lower jaws.

Remarks.—The maxillaries and lower jaws are those of a small pocket mouse the size of *Perognathus flavescens* Merriam. No characters were found that would separate the lower jaws of *P. flavescens, P. merriami* Allen, and *P. flavus* Baird. The upper dentitions are not complete and they are specifically unidentifiable. The number of right lower jaws with teeth represent at least 27 individuals.

Genus *Dipodomys* Gray, 1841

Dipodomys cf. *Dipodomys ordii* Woodhouse, 1853

(Fig. 11F)

Dipodomys ordii Woodhouse, Setzer, 1949, p. 511.
Dipodomys ordii Woodhouse, Miller and Kellogg, 1955, p. 396.

Geologic Range.—Late Pleistocene to Recent.

Distribution.—Extreme southeastern Alberta and southwestern Saskatchewan, hence southeastward to central Kansas and south to central Mexico, northwestward in Arizona and Nevada, and north to the southern edge of southeastern Washington (see Setzer, 1949, p. 510, Fig. 23, for detailed distribution of subspecies).

Habitat.—Sandy soils and sand dunes in the semiarid or arid regions.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35602–35606, parts of four lower jaws and a maxillary.

Remarks.—Parts of two right and two left lower jaws represent young individuals; part of a left maxillary with P^4, No. 35606, is that of an adult kangaroo rat. The P^4 is more triangular in shape than those of Recent species of comparable stage of wear. More specimens are needed to determine the significance of this triangular character of the P^4. In other features the fossils are similar to the kangaroo rat (*D. o. richardsoni*) now living in Meade County.

Family Castoridae
Genus *Castoroides* Foster, 1838
Castoroides cf. *C. ohioensis* Foster, 1838
(Fig. 13G)

Castoroides ohioensis Foster, Cahn, 1932, p. 229.
Castoroides ohioensis Foster, Cahn, 1936, p. 66.

Geologic Range.—Pleistocene (late Kansan to late Wisconsin). The oldest known occurrence of *Castoroides* cf. *C. ohioensis* is late Kansan, in the Crooked Creek formation of southwestern Kansas.

Distribution.—New York south to Florida, west to Minnesota, western Nebraska and south to Dallas, Texas. One specimen is reported from Alaska.

Habitat.—The fossil record indicates that the giant beavers lived in marshes, bog areas, around lakes, and along large rivers.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 5, No. 29022, fragments of skull and teeth.

Remarks.—The specimen was badly damaged by cattle; only the LM^3 (Fig. 13G) is in good condition. The greatest anteroposterior length of the occlusal surface is 17.0 mm.; the occlusal width 13.0 mm. The length of the tooth is 34.5 mm. Plates that appear to be a part of P^4 have a width of 18.0 mm.

A RM^3, No. 29072, from the silt and impure ash, of late Kansan age, at the Arkalon Gravel Pit area, Seward County, Kansas, has an anteroposterior occlusal length of 16.0 mm. and an occlusal width of 12.0 mm.

Family Cricetidae
Genus *Onychomys* Baird, 1858
Onychomys cf. *O. leucogaster* (Wied-Neuwied), 1841
(Fig. 13I)

Onychomys leucogaster (Wied-Neuwied), Hollister, 1915, p. 434.
Onychomys leucogaster (Wied-Neuwied), Miller and Kellogg, 1955, p. 513.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna, Meade County, Kansas.

Distribution.—From southern Alberta, east to eastern Manitoba, south through western Minnesota, extreme western Iowa, west to the 97th Meridian, south to the mouth of the Rio Grande River and slightly south into Mexico, westward to central Arizona and north to central Oregon and south central Washington (for detailed distribution see Miller and Kellogg, 1955, pp. 513–17).

Habitat.—In the southwest arid and semiarid regions; farther east upland areas in the prairie regions.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35646 and 38557, parts of two lower jaws and two maxillaries.

Remarks.—Partial right and left lower jaws, No. 35646, both with M_1, are referred to the grasshopper mouse living in Meade County, Kansas. The lower jaws are smaller than *Onychomys jinglebobensis* Hibbard, but similar to those of the Recent species. The capsular process for the reception of the incisor is not as enlarged as that of *O. jinglebobensis* or of Recent specimens of *O. leucogaster.*

The maxillaries represent two different individuals. One, with M^1 and M^2 is that of a young animal; the other with M^1 is that of an old adult.

Genus *Reithrodontomys* Giglioli, 1874

Reithrodontomys cf. *R. megalotis* Baird, 1858

(Fig. 12)

Reithrodontomys megalotis (Baird), Hooper, 1952, p. 43.
Reithrodontomys megalotis (Baird), Miller and Kellogg, 1955, p. 450.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna, Meade County, Kansas.

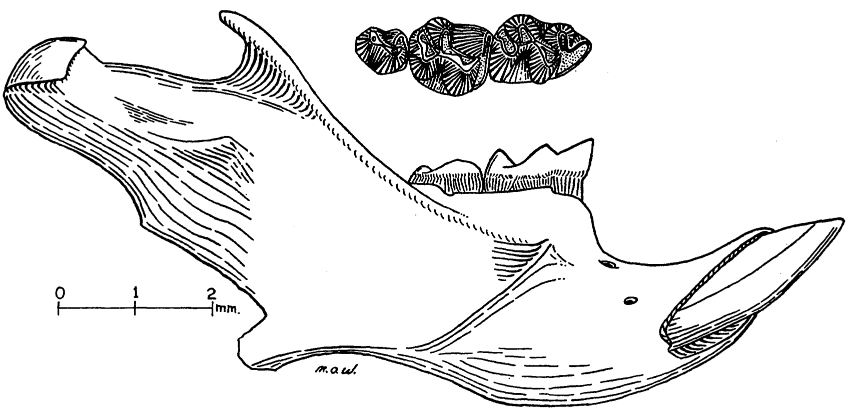

FIG. 12. *Reithrodontomys* cf. *R. megalotis,* UMMP 35610, right lower jaw with M_1–M_3. Labial and occlusal views. × 10.

Distribution.—British Columbia south to southern Mexico; California, east to extreme west Texas, eastern New Mexico, from southeastern Colorado east to the Mississippi River, just entering southwestern Wisconsin (see Burt, 1952).

Habitat.—Tall grass and weeds, confined to the more moist areas in the western part of their range.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35610–35635, parts of 42 lower jaws and 25 maxillaries.

Remarks.—Harvest mouse remains are common in the deposit. Parts of 21 right lower jaws, 8 right maxillaries, 21 left lower jaws, and 15 left maxillaries with teeth were recovered. In comparison with dentitions of Recent species of *Reithrodontomys montanus, R. megalotis,* and with the remains of *Reithrodontomys* cf. *montanus* (Baird) from the Jinglebob local fauna of Meade County, the teeth from Cragin Quarry are very similar to those of *Reithrodontomys megalotis* (western harvest mouse).

Nineteen lower jaws have M_1 and M_3 present. The anterposterior length of the molar series varies from 2.9 mm. to 3.3 mm.; with an average of 3.17 mm. The specimen with the shortest molar series is that of an old adult. Three of the maxillaries contain M^1–M^3. The anteroposterior lengths are 3.0, 3.2, and 3.2 mm.

The specimens at hand are distinct from *R. m. aztecus* from Meade County, in that the anteroconid of M_1 is not divided by an anterior groove. The ectostylid (see Hooper, 1952, p. 21) is present on some of the lower molars, but not as well developed as the ectostylid on M_1 of *R. m. aztecus.* Some teeth of *R. m. aztecus* also have an ectolophid associated with the ectostylid. The ectostylid is nearly always present on M_1 of *R. m. aztecus* and sometimes on M_2.

A small mesostylid is present on several of the fossil M_1's. Large series of *R. megalotis aztecus* and *R. m. dychei* were examined but no M_1 was found that had a mesostylid. The teeth of *R. montanus* examined lacked the ectostylid and mesostylid. The majority of the fossil M^1's have a very small anterostyle which connects to the anterolingual conule of M^1, but it does not close the re-entrant valley between the anterolingual conule and the protocone as it does in many Recent specimens of *R. megalotis aztecus.* This style seldom develops on M^1 of *R. montanus* and when present it is not as large as that of *R. megalotis.*

The lower jaws from Cragin Quarry are larger than those of *Reithrodontomys montanus albescens* (Cary). A few of the lower M_1's lack stylids and also a few M^1's lack styles. Better material is needed to determine whether *R. montanus* was present in the fauna.

Genus *Peromyscus* Gloger, 1841

Peromyscus progressus Hibbard, sp. nov.

(Fig. 13A, H)

Holotype.—No. 35637, University of Michigan Museum of Paleontology, part of right lower jaw with M_1–M_3. Paratypes: Nos. 35639, left ramus, M_1 and M_2; 35640, right ramus, M_1 and M_2; 35642, right ramus, incisor, M_1–M_3; 35643, left ramus, incisor, M_1 and M_2. Referred specimens, Nos. 35638, 38553–38555, 39532–39534, fragments of lower jaws containing M_1.

Geologic Range.—Late Pleistocene (Sangamon).

Horizon and type locality.—Below the caliche bed in the Kingsdown formation; Cragin Quarry local fauna, locality 1 (Sangamon age); Big Springs Ranch, SW¼ sec. 17, T. 32 S., R. 28 W., Kansas University locality 6, Meade County, Kansas.

Occurrence.—Known only from the Cragin Quarry local fauna.

Diagnosis.—A *Peromyscus* larger than *Peromyscus cragini* Hibbard and *P. berendsensis* Starrett and smaller than *P. cochrani* Hibbard. It is intermediate in size between *P. maniculatus* (Wagner) and *P. leucopus* (Rafinesque) that now live in Meade County. The dental characters are less advanced than those of Recent *P. maniculatus* and *P. leucopus.* Stylids and lophids may be present or absent. Internal and external re-entrant valleys betwen the cusps are broader than in *P. maniculatus* and most specimens of *P. leucopus* (Fig. 13H). The teeth are narrower for their length than the teeth of *P. maniculatus* and *P. leucopus.*

Description of holotype.—The holotype, No. 35637, is part of a right jaw broken in front of the mental foramen and just posterior to the capsular process for the reception of the base of the incisor. The molar teeth are present and in an advanced stage of wear. There is no evidence of a median groove on the face of the anteroconid of M_1 (Fig. 13A). The ectostylid and ectolophid of M_1 are present but not as well developed as in some Recent specimens of *Peromyscus leucopus.* The mesolophid of M_1 is not as wide as the ectolophid. The ectostylid and mesostylid are of equal size but neither fills the re-entrant valley in which it occurs. The mesostylid and mesolophid of M_2 are nearly as large as those of M_1. A very small rudimentary ectostylid occurs in the external valley between the protoconid and hypoconid of M_2. M_1–M_3 are relatively narrow for their length and appear more rectangular than the teeth of *Peromyscus cochrani, P. maniculatus,* and *P. leucopus.*

The depth of the jaw of *Peromyscus progressus* below M_1 and M_3 is less than that of *P. cochrani* and *P. leucopus* but greater than that of *P. maniculatus.* The fossils have been compared with Recent specimens of *Peromyscus maniculatus* and *leucopus* from Meade County, Kansas. The anteroposterior length of M_1–M_3 is 3.9 mm.

Remarks.—Specimen No. 35639 is part of a left jaw with M_1 and M_2. No stylids or lophids are present on the teeth. There is a very small upward growth of the cingulum in the external re-entrant valleys of M_1 and M_2 where the ectostylid would occur if present. The re-entrant valleys

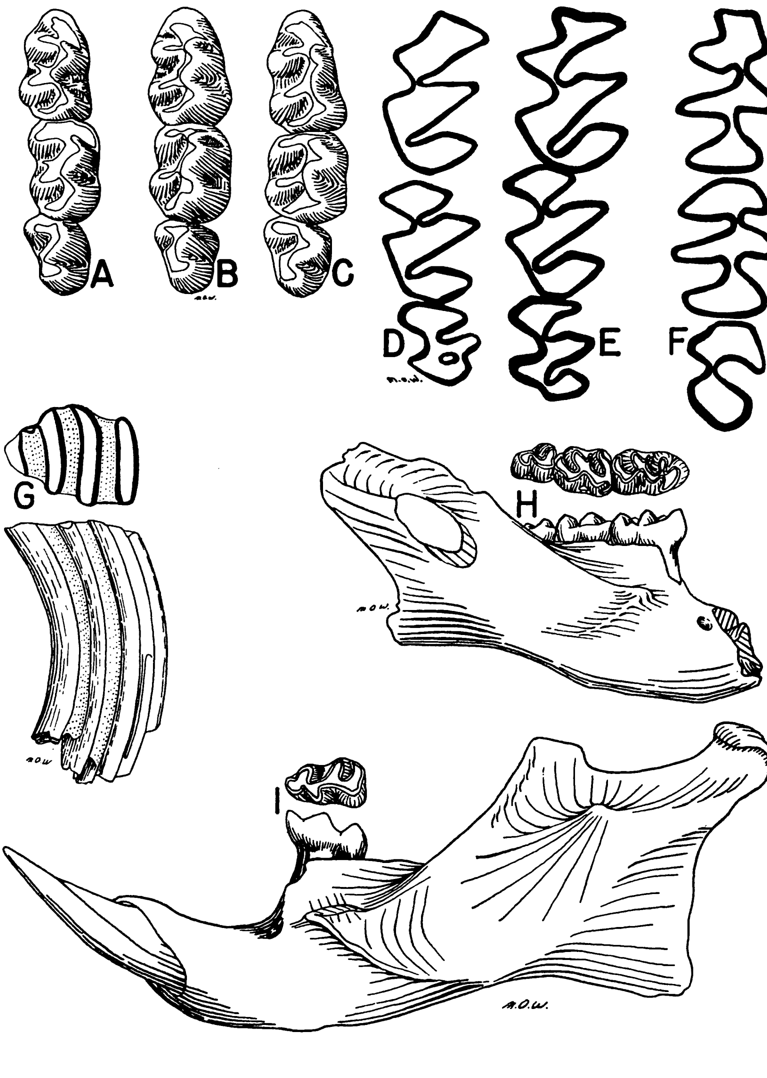

FIG. 13. Late Pleistocene mammals. (A) *Peromyscus progressus,* sp. nov., holotype, UMMP 35637, right M_1–M_3. Occlusal view. × 10. (B–C) *Peromyscus leucopus:* (B) UMMZ 92264, right M_1–M_3. (C) UMMZ 92263, right M_1–M_3. Occlusal views. × 10. (D–F) *Neotoma micropus:* (D) UMMP 35591, LM^1–M^3; (E) UMMP 35607, LM^1–M^3; (F) UMMP 35601, RM_1–M_3. Occlusal views. × 6. (G) *Castoroides ohioensis,* UMMP 29022, right M^3. × 1. (H) *Peromyscus progressus,* sp. nov., holotype, UMMP 35637, right lower jaw with M_1–M_3. Labial and occlusal views. × 6. (I) *Onychomys* cf. *O. leucogaster,* UMMP 35646, left lower jaw with M_1. Labial and occlusal views. × 6.

of the teeth appear broader than those of the holotype because of the lack of stylids and lophids. The anteroposterior length of M_1 and M_2 is 2.7 mm.

A very rudimentary ectostylid occurs on M_1 and M_2 in the right ramus, No. 35640. The anteroposterior length of M_1 and M_2 is 2.75 mm.

Specimen No. 35642, is part of a right lower jaw, with incisor, M_1–M_3. The dental wear indicates greater age than the holotype. The teeth are free of both stylids and lophids. The external and internal re-entrant valleys are open. The size and shape of the jaw are as in the holotype. The anteroposterior length of the M_1–M_3 series is 3.75 mm.

The anterior end of the left lower jaw, No. 35643, with the incisor, M_1 and M_2 is that of a young adult mouse. The teeth are the size of the holotype and are free of stylids and lophids. The anteroposterior length of M_1 and M_2 is 2.8 mm.

Paratype No. 35638 is part of a left lower jaw with M_1 of an adult mouse with a more advanced stage of wear than that of the holotype. The ectostylid–ectolophid and mesostylid–mesolophid are present. The ectolophid is poorly developed.

The referred specimens consist of the anterior part of two right and four left lower jaws with M_1. These molars are the size of the M_1 of the holotype and the re-entrant valleys are as broad. The dental pattern varies from M_1, No. 38554, with no stylids or lophids to M_1, No. 39534, with stylids and lophids as well developed as in the holotype. Teeth, Nos. 38555 and 39533, have only rudimentary ectostylids, while No. 38553 has both a rudimentary ectostylid and mesostylid. No. 39532 has a well-developed mesostylid and a mesolophid.

No maxillaries were found in occlusion with the lower dentitions. In the material recovered are parts of six right and two left maxillaries that are probably those of *Peromyscus progressus*. These are tentatively referred to this form because of the size of teeth, the wide re-entrant angles, and the variable development of styles and lophs.

A right maxillary, No. 35641, contains M^1–M^3; their anteroposterior length is 3.75 mm. A small style is developed in the anterior valley between the anterior cingulum and the paracone of M^1. No other style or loph occurs on M^1, M^2, and M^3. The re-entrant valleys between the major cusps of the teeth are broader than those of Recent specimens of *Peromyscus leucopus* taken in Meade County, Kansas.

The left maxillary, No. 35645, with M^1–M^3 has a large style between the anterior cingulum and the paracone that closes the re-entrant valley. M^1 and M^2 have a mesostyle and mesoloph. The inner valleys are open. The anteroposterior length of M^1–M^3 is 3.70 mm.

Five of the other maxillaries, No. 38556, contain only M^1. Three of these teeth lack styles and lophs. One has a rudimentary mesoloph and a small enterostyle and the other a small enterostyle and an enteroloph. The sixth maxillary (No. 38556) of this series bears M^1 and M^2. M^1 has a well-developed style between the anterior cingulum and paracone. Both M^1 and M^2 have a mesostyle and a mesoloph.

In previous papers Hibbard has referred specimens of *Peromyscus* that lacked the stylids and lophids on the lower teeth and styles and lophs on the upper teeth, to the subgenus *Haplomylomys*. From a study of the associated material it was impossible to separate the series of jaws assigned to *Peromyscus progressus* on size or characters other than the development of accessory cusplets or their absence. The series of jaws can be divided into three groups (1) those with teeth that possess well-developed stylids and lophids (Nos. 35637, 35638, 39532, and 39534); (2) those with teeth that possess only stylids (Nos. 35643, 38553, 38555, and 39533); and (3) those with teeth that have open external and internal valleys without either stylids or lophids (Nos. 35639, 35640, 35642, and 38554).

The lower jaws assigned to *Peromyscus progressus* appear to represent part of a population of a single species.

The presence or absence of accessory tooth structures and the degree to which they develop have been shown by Hooper (1957) to be most variable in species of *Peromyscus*. Recent specimens of *P. leucopus* from Meade County State Park include one individual (UMMZ 92263) that completely lacks all accessory cusps (stylids, lophids, styles, and lophs). The external and internal valleys of both the upper and lower teeth are broad and open (Fig. 13C). The M_2 of No. 92263 is not as rectangular in appearance as the M_2 of No. 92264 which possesses the accessory structures (Fig. 13B). Absence of these accessory cusplets is rare and interpreted as an atavistic trait.

Peromyscus cochrani and *P. progressus* appear to be related to *Peromyscus leucopus*. If so, the present grade of dental development observed in the Recent *leucopus* was attained during the Wisconsin.

Peromyscus sp.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 38551, part of right ramus with M_1 and M_2; No. 38552, fragments of a right and left ramus with M_1; No. 39535, part of a right ramus with incisor and M_1; and No. 39536, fragments of two maxillaries with M^1.

Remarks.—The above teeth are smaller than those of *Peromyscus progressus*. Better material is needed for specific identification.

Genus *Neotoma* Say and Ord, 1825
Neotoma micropus Baird, 1855
(Fig. 13D–F)

Neotoma micropus Baird, Goldman, 1910, p. 26.
Neotoma micropus Baird, Miller and Kellogg, 1955, p. 534.

Geologic Range.—Late Pleistocene (Sangamon) to Recent. The earliest known occurrence is in the Cragin Quarry local fauna.

Distribution.—The Southern Plains packrat occurs in southwestern Kansas, western Oklahoma, New Mexico except the northern part, and West Texas south into Mexico along the Rio Grande River drainage (see Miller and Kellogg, 1955).

Habitat.—Along rock outcrops, in trees, brush thickets, old piles of debris and abandoned buildings, and larger mammal dens.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, Nos. 35583–35601 and 35607, parts of at least 18 individuals; lower jaws, maxillaries and isolated teeth.

Remarks.—Parts of two lower jaws (Nos. 35600 and 35601), with M_1 to M_3, of an adult packrat appear to belong to the same individual (Fig. 13F). The re-entrant valley between the protoconid and hypoconid of M_1–M_3 is broader than observed in specimens of *Neotoma micropus* and the majority of the specimens of *N. floridana*. In the posterior external re-entrant valley of M_1 and M_2 and in the external re-entrant valley of M_3 of the lower jaws there is a well-developed ectostylid. Ectostylids occur on some of the teeth of *N. micropus,* and *N. floridana*. The occlusal lengths of M_1–M_3 of the two jaws are 9.1 and 9.2 mm.

A left maxillary, No. 35607, containing M^1–M^3, has an occlusal length of 8.7 mm. The anterointernal angle (fold) of M^1 is slightly deeper than in most specimens of *N. floridana* and approximates most closely that of *N. micropus* (Fig. 13E).

The anterior loop of M^1 consists of two confluent alternating triangles. The anterior part is external or labial. The posterior part (triangle) is lingual. In *Neotoma floridana* the enamel along the side (base) of the lingual part of the loop is flattened, while this part of the tooth is rounded in *N. micropus*. The anterior loop of M^1 in the fossil specimens (18 right M^1s and 14 left M^1s) is as in Recent *Neotoma micropus* (Fig. 13D). It is on the basis of this character that I have assigned the fossil specimens to *N. micropus*.

Genus *Pedomys* Baird, 1858
Pedomys sp.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 35650, isolated left M_3.

Remarks.—A single tooth (LM_3) is referred to *Pedomys,* since it consists of a posterior loop and three closed triangles. The tooth is the size of that of *Pedomys ochrogaster* now living in Meade County, Kansas.

Genus *Microtus* Schrank, 1798
Microtus pennsylvanicus (Ord), 1815
(Fig. 14A–C)

Microtus pennsylvanicus (Ord), Bailey, 1900, p. 16.
Microtus pennsylvanicus (Ord), Hibbard, 1943, p. 190.
Microtus pennsylvanicus (Ord), Miller and Kellogg, 1955, p. 583.

Geologic Range.—Late Pleistocene (Illinoian) to Recent.

Distribution.—Boreal region of North America, southeast to northern New Mexico, southern Nebraska, northern Missouri, northern Kentucky, and southeast to southern South Carolina.

Habitat.—Grassy areas throughout range. In the southern limits of the range these voles are confined to the more moist areas with good grass cover.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring loc. 1, KU 6494, a right jaw with M_1 and M_2; No. 34740, part of right jaw with I, M_1 and M_2, and fragmentary palate without teeth; loc. 2, No. 34701, one right and one left jaw.

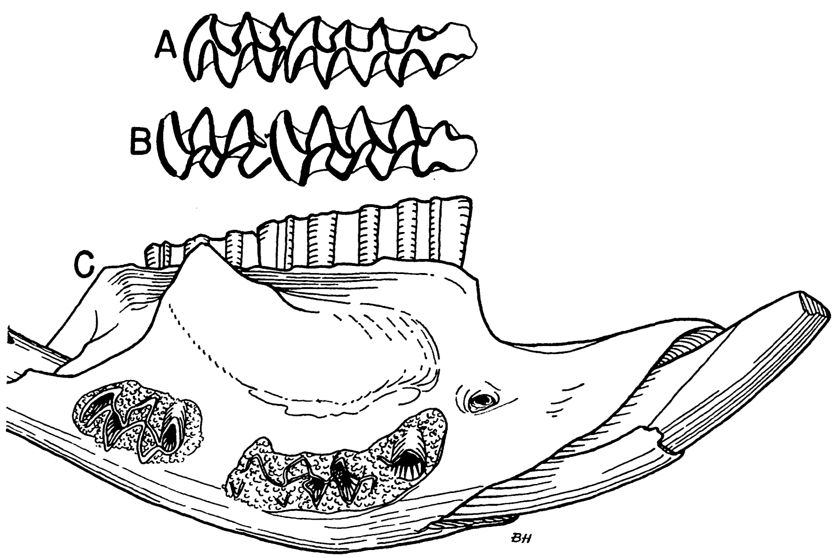

FIG. 14. *Microtus pennsylvanicus.* (A) UMMP 34701, left M_1 and M_2. Occlusal view. (B–C) UMMP 34740, right lower jaw with M_1 and M_2. Occlusal and labial views. All × 8.

Remarks.—The lower jaws, No. 34701, of the meadow vole were taken in association with the remains of a giant neotenic tiger salamander, *Ambystoma tigrinum* (Tihen, 1955, pp. 240–41) at locality 2. The right jaw lacks the incisor and molar teeth. The incisor, M_1 and M_2 are present in the left jaw. M_1 has five closed triangles. The sixth triangle opens broadly into the anterior loop (Fig. 14A). The anteroposterior occlusal length of M_1 and M_2 is 5.0 mm.

The right jaw (No. 34740) with the incisor, M_1 and M_2 (Figs. 14B-C) was taken higher in the section, in association with the fish remains and the abundant molluscan shells. This jaw is slightly larger than No. 34701. The M_1 also possesses five closed triangles, the sixth triangle opens broadly into the anterior loop. The anteroposterior length of M_1 and M_2 is 5.5 mm.

Order CARNIVORA

Family Canidae

Genus *Aenocyon* Merriam, 1918

Aenocyon dirus (Leidy), 1858

(Fig. 11C)

Canis dirus Leidy, Merriam, 1912, p. 218.
Aenocyon dirus (Leidy), Merriam, 1918, p. 532.
Aenocyon dirus (Leidy), Hibbard, 1949*a*, p. 84.

Geologic Range.—Late Pleistocene.

Distribution.—California east to the Atlantic Coast, Wisconsin south to Mexico. Southern limits of range unknown.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1; KU 7434, a right M^1; KU 7488, part of a right ulna; KU 7597, a left metacarpal II.

Remarks.—The upper molar is that of a young wolf (Fig. 11C). The tooth agrees in size and cusp development with specimens from the Rancho La Brea deposits. The protoconule is better developed in some of the Rancho La Brea specimens. The anteroposterior length of the tooth is 20.0 mm. The width is 25.5 mm.

The ulna and metacarpal are the size of those bones in the mounted skeleton, No. 3479, of the dire wolf from the Rancho La Brea deposits.

Genus *Canis* Linnaeus, 1758

Canis cf. *C. latrans* Say, 1823

Geologic Range.—Late Pleistocene.

Distribution.—Alaska to southern Mexico, east to eastern Texas, central Arkansas, southern Illinois, western Ohio, and northeast in Canada to the St. Lawrence River (see Burt, 1952, p. 50).

Habitat.—Chiefly in open country.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring loc. 5, No. 29021, part of a left lower jaw, with P_4 and M_1; Cragin Quarry loc. 1, KU 5968, part of a left M^1.

Remarks.—The lower jaw, No. 29021, is that of an adult coyote. The anterior and posterior parts of the jaw are missing. The posterior part of the canine alveolus is present. Alveoli of P_1, M_2 and M_3 are present. The roots of P_2 and P_3 remain in the jaw. The length from the anterior border of the alveolus of P_1 to the posterior border of the alveolus of M_3 is 79.0 mm. The depth of the jaw between P_4 and M_1 is 21.5 mm.

The labial side of M^1, KU 5968, is missing. The tooth is that of an adult coyote and is the same size as that of the coyote now occurring in Meade County, Kansas.

Genus *Vulpes* Oken, 1816

Vulpes velox (Say), 1823

(Fig. 15)

Vulpes velox (Say), Bailey, 1931, p. 300.
Vulpes velox (Say), Miller and Kellogg, 1955, p. 687.

Geologic Range.—Late Pleistocene (Sangamon) to Recent.

Distribution.—Southeastern British Columbia, southern Alberta and southwestern Saskatchewan, south through the plains country to northeastern New Mexico, west Texas, and western Oklahoma.

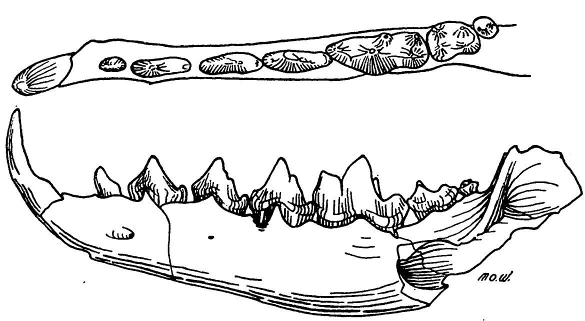

FIG. 15. *Vulpes velox*. UMMP 33802, left lower jaw, C–M_3. Occlusal and labial views. × 1.

Habitat.—Open grassland, with den on valley slope.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 7435, a right P^4, and, No. 33802, right and left lower jaws.

Remarks.—The jaws represent a young adult kit fox (swift) and are indistinguishable from those of *Vulpes velox velox* (Say), now living in Meade County, Kansas. The back part of the lower jaws are lacking (Fig. 15), also the RM_3 and three of the incisors. The anteroposterior length of the premolar-molar series is 51.5 mm.

The RP^4, KU 7435, is from an old adult and is the size of the P^4 of an adult male of the Recent kit fox.

Family Mustelidae
Genus *Spilogale* Gray, 1865
Spilogale cf. *S. interrupta* (Rafinesque), 1820

Spilogale interrupta (Rafinesque), A. H. Howell, 1906, p. 18.
Spilogale interrupta (Rafinesque), Miller and Kellogg, 1955, p. 750.

Geologic Range.—Late Pleistocene (Sangamon) to Recent.

Distribution.—Southern Minnesota and eastern South Dakota, south to southwestern Oklahoma and the northern part of eastern Texas.

Habitat.—The distribution of the genus *Spilogale* (the little spotted skunk) in the United States is approximately that of the wood rats (packrats) which are one of its favorite prey. The little spotted skunk is found chiefly around rock outcrops, old buildings, and abandoned packrat houses.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 38578, parts of left and right lower jaws, and RM^3.

Remarks.—Part of a left lower jaw contains the base of the canine and P_2. The right lower jaw fragment contains P_3 and an associated P_4. All of the teeth are the size of those of *Spilogale interrupta,* now living in Meade County. The lower teeth are most similar in size to those of a male specimen, while the RM^3 is more like that of a female.

Family Felidae
Genus *Panthera* Oken, 1816
Panthera atrox (Leidy), 1853
(Fig. 16F–G)

Felis atrox Leidy, Merriam and Stock, 1932, p. 164.
Felis cf. *imperialis* Leidy, Hibbard, 1939, p. 465.
Panthera atrox (Leidy), Simpson, 1941, p. 16.

Geologic Range.—Illinoian(?) to late Wisconsin.

Distribution.—Scattered records from Natchez, Mississippi westward, south to the valley of Mexico, and north to Alaska (see map by Simpson, 1941, p. 21).

Habitat.—The habitat of this extinct giant jaguar in southwestern Kansas appears to have been similar to the one suggested for this large cat

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FIG. 16. Sangamon (interglacial) mammals. (A) *Tanupolama* sp., KU 7414, phalange. Anterior view. × 0.5. (B) *Camelops kansanus,* KU 7412, posterior phalange. Anterior view. × 0.5. (C) *Platygonus* cf. *compressus,* UMMP 38591, left M^2 and M^3. Occlusal view. × 1. (D–E) *Capromeryx furcifer:* (D) UMMP 38635, part of metapodial. Anterior view. × 1. (E) UMMP 38633, right tibia. Medial view. ×0.5. (F–G) *Panthera atrox,* UMMP 38383, right astragalus. Dorsal (tibial) and ventral (calcaneal) views. × 1.

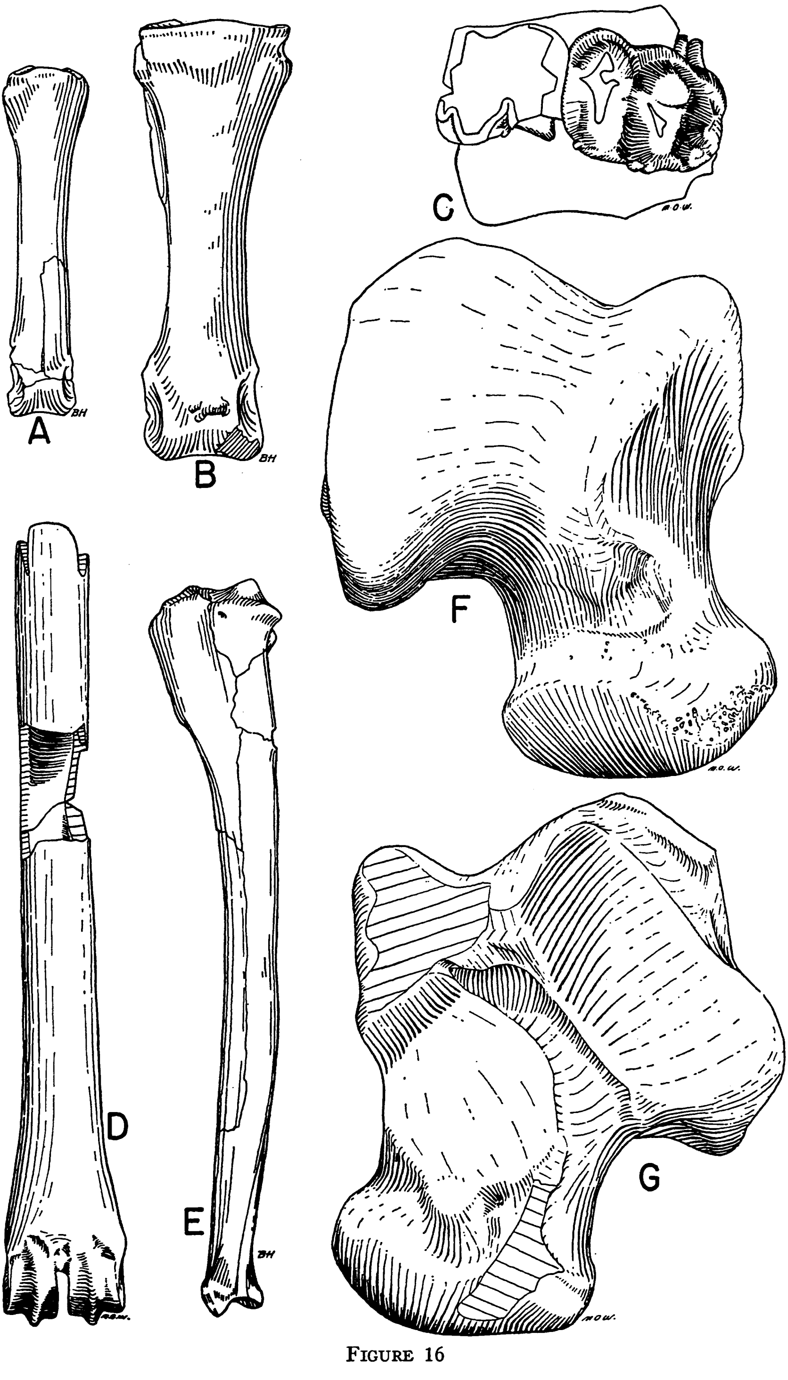

FIGURE 16

by Merriam and Stock (1932, p. 26), from their study of California material: "An open plain or a rolling country, probably grass-covered and supporting here and there a growth of trees and shrubs, presented in the vicinity of Rancho La Brea during Pleistocene time an environment in which one might reasonably expect to find such carnivores as the great cat."

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 4625, a left M_1; KU 4629, left metacarpal V; KU 7603, right ectocuneiform; No. 38383, a right astragalus.

Remarks.—The astragalus (Fig. 16F–G) has been compared with astragali of *Panthera atrox* from the Rancho La Brea tar pits. It agrees both in shape and size. The greatest length of the right astragalus, No. 38383, is 73.0 mm.; greatest width, 62.0 mm.; least distance across neck, 23.5 mm.; greatest diameter of head, 38.5 mm.

Genus *Felis* Linnaeus, 1758

Felis concolor Linnaeus, 1758

Felis cf. *oregonensis* Rafinesque, Hibbard, 1939, p. 466.
Felis concolor Linnaeus, Goldman, 1946, in Young and Goldman, Pt. 2, p. 177.

Geologic Range.—Late Pleistocene (Sangamon) to Recent.

Distribution.—Northern British Columbia to Patagonia, from the Pacific to the Atlantic.

Habitat.—This graceful cat lives in all types of habitats from swamplands to forests and rugged mountain country. It is wide ranging and feeds chiefly on deer.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 4625, part of a right M_1.

Remarks.—The right M_1, KU 4625, of a puma (mountain lion) agrees in size with that of *Felis concolor oregonensis,* but it is not possible to assign the tooth to a given subspecies.

Simpson (1941, pp. 13–15) gives a good discussion of the occurrences of the North American fossil pumas.

Order PROBOSCIDEA

Family Elephantidae

Genus *Mammuthus* Burnett, 1830

Mammuthus columbi (Falconer), 1857

(Pl. XV)

Parelephas columbi (Falconer), Osborn, 1942, p. 1071.
Mammuthus columbi (Falconer), Hibbard, 1955*b,* p. 196.

Geologic Range.—Middle Pleistocene to near the end of the Wisconsin.

Distribution.—From Oregon east to Montana, southeast to Iowa, east to Ohio, Pennsylvania and Maryland, south to Florida and the valley of Mexico.

Habitat.—Fossil evidence indicates that the Columbian mammoth (elephant) belonged to a southern fauna. This mammoth required a habitat with permanent water in the streams, and vegetation of shrubs, trees, and tall grasses for food.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 33768, part of M^3.

Remarks.—A number of fragmentary tooth plates were recovered from the quarry. The best specimen is part of an upper third molar. Both the anterior and posterior parts of the tooth are missing. Nine and one-half ridge plates are present. There are 6 ridge plates in 100.0 mm. (Pl. XV).

Mammuthus sp.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring localities 4 and 5, Nos. 26973 and 33498, two foot bones.

Remarks.—The lack of comparative material prevents identification as metacarpal or metatarsal elements. The bones are well preserved and were taken from the sand deposit in association with the holotype of *Emydoidea twentei* (Taylor) and the skull fragments of *Castoroides*. Specimen No. 26973 is the larger, with an anteroposterior length of 174.0 mm.; the greatest depth of the distal end is 130.0 mm.; and the depth of the proximal end, 108.0 mm.

Order LAGOMORPHA

Family Leporidae

Genus *Lepus* Linnaeus, 1785

Lepus sp.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 35647, four upper premolars or molars.

Remarks.—Many isolated rabbit teeth were recovered; the majority from immature rabbits. It is impossible to identify them even generically.

Genus *Sylvilagus* Gray, 1867

Sylvilagus sp.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 35648, parts of seven upper incisors.

Order ARTIODACTYLA

Family Tayassuidae

Genus *Platygonus* Le Conte, 1848

Platygonus cf. *P. compressus* Le Conte, 1848

(Fig. 16C)

Platygonus compressus Le Conte, Simpson, 1949, p. 21.

Geologic Range.—Middle Pleistocene to late Wisconsin.

Distribution.—California to New York, Michigan south to Florida and Texas.

Habitat.—From eastern wooded stream valleys to western grasslands.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, No. 38591, part of a left maxillary with M^2 and M^3.

Remarks.—The M^3 is slightly larger than most teeth assigned to *Platygonus compressus* (Fig. 16C). It has an anteroposterior length of 20.2 mm., with a greatest width across the anterior loph, of 18.0 mm. The tooth is similar in shape to the first M^3 in the third row figured by Simpson (1949, Fig. 10). The cingulum is well developed along the external edge of the tooth. Better material is needed for definite specific determination.

Family Camelidae

Genus *Tanupolama* Stock, 1928

Tanupolama sp.

(Fig. 16A)

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 7414, 7601, part of a phalange and an astragalus; and No. 38592, part of a metapodial.

Remarks.—This small llama-like camel is represented by scant and fragmentary elements. The best specimen is a phalange (KU 7414) with a maximum length of 91.0 mm.; width of the distal end, 23.5 mm. (Fig. 16A).

Genus *Camelops* Leidy, 1854

Camelops kansanus Leidy, 1854

(Figs. 16B; 17E)

Camelops kansanus Leidy, J. C. Merriam, 1913, pp. 317–18.
Camelops huerfanensis (Cragin), Hay, 1917, p. 47.
Camelops cf. *C. kansanus* (Leidy), Hibbard, 1937, p. 234.
Camelops kansanus Leidy, Hibbard, 1939, p. 468.

Geologic Range.—Middle Pleistocene to late Wisconsin.

Distribution.—West of the Mississippi River to the Pacific Coast, southern limits of range unknown.

FIG. 17. Sangamon (interglacial) mammals. (A–C) *Capromeryx furcifer:* (A) Part of left frontal with base of horn cores. Lateral view. × 1. (B) KU 7419, right P_2–M_3. Occlusal view. × 1. (C) KU 7418, left P_4–M_3. Labial and occlusal views. × 1. (D) *Equus conversidens,* UMMP 38775, RM^1. Lingual and occlusal views. × 1. (E) *Camelops kansanus,* UMMP 38596, left M^2. Lingual and occlusal views. × 1.

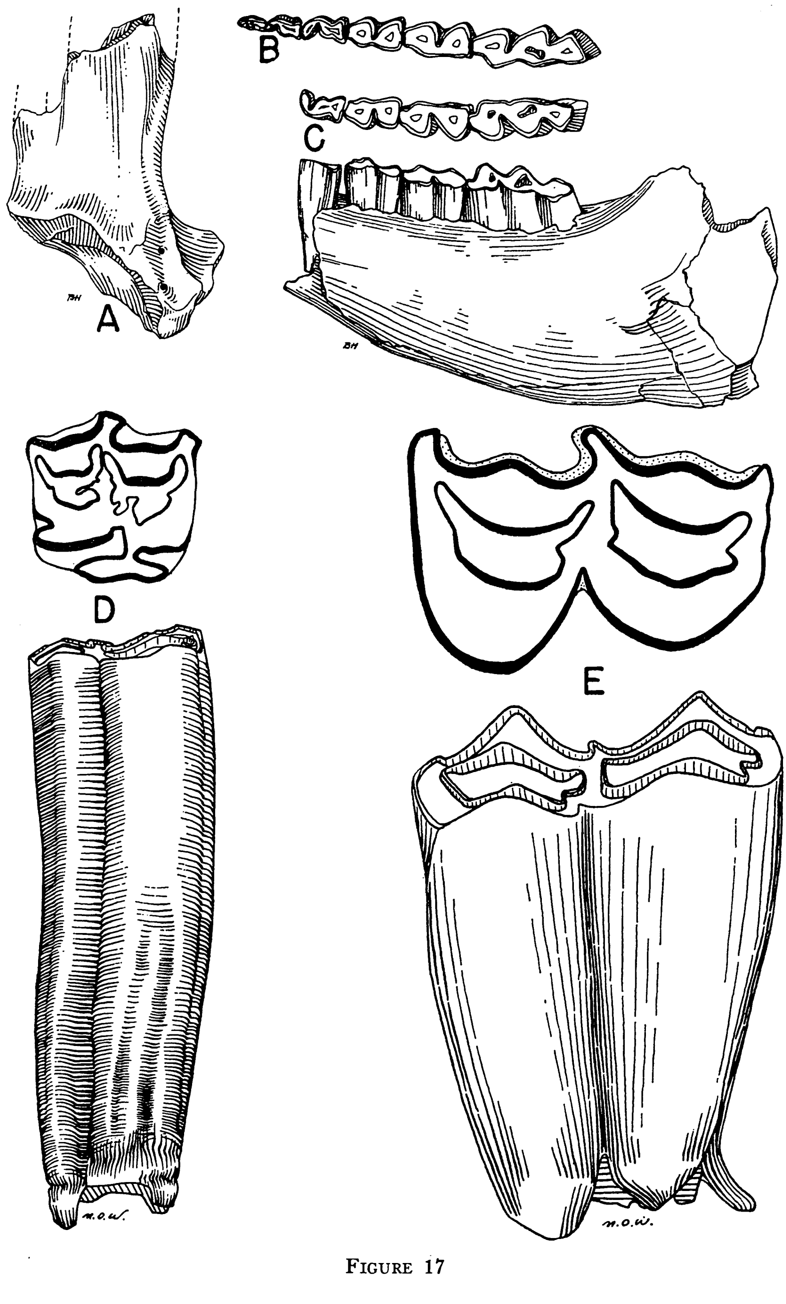

FIGURE 17

Habitat.—Open country, shrub and grassland.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1; KU 3960, left M_2; KU 4626, left lower jaw, P_4–M_3; KU 4628, right lower jaw, P_4–M_3; KU 7407, six lower molars; KU 7408, left P^4; KU 7409, seven isolated incisors; KU 7410, calcaneum; KU 7411, astragalus; KU 7412, two first phalanges; KU 7413, second phalange; KU 7480, 7482, 7483 and 7603, twenty-one carpal and tarsal elements; KU 7481, two patellas; KU 7595, thirteen isolated teeth; KU 7600, second phalange; and No. 38593, metapodial; No. 38594, upper molar; No. 38595, two upper molars; No. 38596, right and left M^2–M^3; No. 38597, distal end of tibia; No. 38598, astragalus.

Remarks.—I have not examined the mammals described from the Cragin Quarry and reportd by O. P. Hay (1917). University of Kansas and University of Michigan material from the Cragin Quarry represents at least two individuals, an old adult and a young adult. For measurements of the lower dentition, see Hibbard, 1939, p. 469.

The metatarsal, No. 38593, has the most distal process missing. The length of the metatarsal along the anterior face is 365.0 mm. The calcaneum, KU 7410, has a length of 165.0 mm. The two phalanges, KU 7412, are from a front and hind foot. The first phalange of the front foot has a length of 128.5 mm.; width of proximal end, 46.5 mm. The length of the first phalange of the hind foot is 126.5 mm. (Fig. 16B). The proximal end is broken but it was slightly narrower than the front phalange.

Camelops sp.

Occurrence.—Butler Spring local fauna.

Material.—Butler Spring, basal sands, Nos. 35738 and 38398, a calcaneum and astragalus.

Remarks.—The two camel bones were taken from the sand that yielded the remains of *Emydoidea twentei* and *Castoroides*. Both of the bones are from adult camels and are smaller than the same elements from *Camelops kansanus* taken at Cragin Quarry locality 1. The length of the calcaneum, No. 35738, is 143.0 mm.

Family Antilocapridae
Genus *Capromeryx* Matthew, 1902
Capromeryx furcifer Matthew, 1902

(Figs. 16D–E; 17 A–C)

Capromeryx furcifer Matthew, 1902, p. 318.
Capromeryx minimus Meade, 1942, p. 89.
Breameryx minimus (Meade), Hibbard, 1955, p. 196.
Breameryx minimus (Meade), Hibbard, 1958*b*, p. 22.

Geologic Range.—Late Pleistocene (Illinoian? and Sangamon).

Distribution.—Specimens referable to this species are known from Kansas, Nebraska, and Texas.

Habitat.—The fossil records indicate that this small pronghorn lived in open upland grassland.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 7418–7422, parts of 5 lower dentitions; KU 7423, an astragalus; Nos. 38632–38636, part of a frontal with horn cores, tibia, humerus, distal end of a metapodial, carpal and toe bones.

Remarks.—Specimen, KU 7419, is a right lower premolar–molar series (Fig. 17B). The anteroposterior occlusal length of P_2–P_4 is 14.0 mm.; of P_3–M_3 is 41.2 mm.; of M_1–M_3 is 30.5 mm.; and P_2–M_3 is 45.0 mm.

The lower dentition is that of an adult individual. There are two lingual inflections on P_2, P_3, and P_4 (see Fig. 17B). Two lingual inflections occur on the P_4 (Fig. 17C) of specimen KU 7418. The lower dentition, KU 7419, is approximately the size of the holotype of *Capromeryx minimus* from the Slaton local fauna, Texas, and so far as known the Cragin Quarry specimen and the holotype are of the same geologic age (Herrington and Taylor, 1958, p. 6).

Specimen, KU 7419, is more advanced in stage of wear than the holotype of *Capromeryx furcifer,* since it has only the enamel fossette remaining on the middle lobe of M_3.

The holotype of *Capromeryx furcifer* from the Hay Springs local fauna, Nebraska, differs chiefly from the holotype of *C. minimus* by its slightly larger size and the presence of the expanded basal part of the third lobe of M_3. The base of the third lobe of M_3 is expanded in specimens KU 7420 and 7422, though not so much as in *C. furcifer.* The base of the other third molars is either not exposed or is broken. The other associated lower dentitions of *C. furcifer* from Kansas help to show variation in tooth measurements (see Table IX).

The skeletal elements associated with the dentitions at the Cragin Quarry simply indicate a small antilocaprid. The right astragalus, KU 7428, has a length of 22.0 mm. and a width of 14.0 mm. The tibia, No. 38633, is that of an adult animal (Fig. 15E). The length of the bone is 195.0 mm. The humerus, No. 38634, is from an immature individual, and the head of the bone is lacking. A fragmentary metapodial, No. 38635, has a width at the distal articulation of 15.7 mm. (Fig. 16D).

A part of the left frontal, No. 38632, bearing the base of the small anterior horn core and the larger posterior horn core is considered to be that of a female or of an immature male, because of the small size of the cores (Fig. 17A). The long diameter of the core base is 20.0 mm. (see Skinner 1942, pp. 190–91, for a key to cranial measurements). The long diameter of the anterior horn core is approximately 5.5 mm; that of the posterior horn core is 14.0 mm. and its transverse width, 13.2 mm. (see Fig. 17A).

The variations in the development of the horn cores observed in the specimens of *Capromeryx furcifer* from Texas, Kansas, and Nebraska are considered due to both sexual and age differences. Skinner (1942), who made a critical study of the Recent specimens of *Antilocapra americana* (Ord), showed that there is considerable size and individual variation in that species. The variation noted by Skinner for the Recent pronghorn

TABLE IX

MEASUREMENTS (IN MILLIMETERS) OF LOWER DENTITIONS OF *Capromeryx furcifer*

Dimension	Left			Right
	KU 7418	KU 7420	KU 7421	KU 7422
P_4, occlusal length	6.0	....	....	....
P_4, occlusal width	3.4	....	....	....
M_1, occlusal length	7.0	9.0	9.0	9.1
M_1, occlusal width	4.0	5.0	5.1	5.0
M_1, height of crown	....	22.5	....	21.5
M_2, occlusal length	9.0	10.5	10.3	10.5
M_2, occlusal width	4.5	5.5	5.4	5.2
M_2, height of crown	....	31.0	....	28.5
M_3, occlusal length	14.5	14.5	14.9	14.5
M_3, occlusal width	5.0	5.0	5.0	4.1
M_3, height of crown	....	32.0	32.0	29.0
M_1–M_3, occlusal length	30.3	....	34.0	....

appears to be greater than the difference observed between the holotype of *C. furcifer* and the specimens of *Capromeryx minimus* from Texas and Kansas. They are considered to be the same species. The lower jaw, F.A.M. 25689, figured by Frick (1937, p. 525) of *C. furcifer* is smaller than that of the holotype, but it falls within the range of size variation as shown by the specimens from Texas and Kansas.

Capromeryx minor Taylor and *C. mexicana* Furlong are regarded as more advanced than *C. furcifer* in the loss of the posterior lingual inflection of P_3 and P_4. *C. minor* and *C. mexicana* probably represent a single species that lived during the Wisconsin.

Furlong (1946) proposed the genus *Breameryx* with the genotype as *Capromeryx? minor* Taylor from the Rancho La Brea tar pits. He also assigned *Capromeryx mexicana* Furlong, *C. arizonensis* Skinner, *C. gidleyi* Frick and *C. minimus* Meade to this genus. The genus *Breameryx* was erected because it had been assumed by a few students that Matthew's type of *Capromeryx, Capromeryx furcifer,* came from Pliocene deposits in the area of the Hay Springs quarries (Hesse, 1935; Stirton, 1938; and

Furlong, 1946). One of the characters used by Furlong to distinguish the genus *Breameryx* from *Capromeryx* was the presence of a single enamel indentation on the lingual side of the crown of P_3 of *B. minor*. But, from the discussions of Chandler (1916) and Furlong (1946) and from the figured specimens of *Capromeryx minor* and *C. mexicana* (*Breameryx minor* and *B. mexicana* of Furlong), it appears that a single enamel indentation on the lingual side of the crown of P_4 is present only in some specimens. This character can only be considered of specific value.

Meade (1942) noted the presence of two lingual inflections in P_4 of *Capromeryx minimus* from Texas, though the P_3 contained just a single one, like that of *C. minor*. In the case of the specimen he studied, the absence of the second lingual inflection on P_3 may be due to wear or individual variation.

Proof has gradually accumulated that the holotype of *Capromeryx furcifer* came from the Pleistocene deposits that have yielded the Hay Springs local fauna. Frick (1937) and Skinner (1942) have furnished evidence of a lower dentition (F.A.M. 25689) and horn cores (F.A.M. 25687, 25688 and N.S.M. 7–4–1–41) that occurred with the Hay Springs local fauna. The horn cores are like those of *C. minor, C. mexicana,* and *C. minimus*. There is nothing at present to suggest that two species of *Capromeryx* occurred in the Hay Springs local fauna. The Hay Springs local fauna, as indicated by *Microtus pennsylvanicus,* is regarded as not older than Illinoian (Hibbard, 1956).

As Stirton (1938) suggested, the lower jaw, F.A.M. 31749, figured and described by Frick (1937, Fig. 52A) from the Stegomastodon Quarry, Brown County, Nebraska, as *Capromeryx furcifer,* var., probably does not belong to the species *C. furcifer*. It differs chiefly in the presence of wider premolars and molars and in the fact that the posterior internal inflections of P_3 and P_4 are much deeper than those in *C. furcifer*. The age of the specimens from the Stegomastodon Quarry is probably late Nebraskan (see D. W. Taylor, 1954*a;* Herrington and Taylor, 1958, p. 6).

Order PERISSODACTYLA

Family Equidae

Genus *Equus* Linnaeus, 1758

Equus conversidens Owen, 1869

(Fig. 17D)

Equus conversidens Owen, 1869, p. 563, Pl. 61, Fig. 1.
Equus littoralis Hay, 1913, p. 575, Fig. 17.
Onager littoralis (Hay), Quinn, 1957, p. 13.
Equus francisci Hay, 1915, p. 535.
Equus francisci Hay, Hibbard, 1939, p. 467.
Asinus francisci (Hay), Quinn, 1955, p. 52.
Asinus francisci (Hay), Hibbard, 1958*b*, p. 23.

Geologic Range.—Late Pleistocene, probably Illinoian to Wisconsin.

Distribution.—Known from Kansas, Texas, and Mexico.

Habitat.—Probably open grassland and semiarid to arid shrub.

Occurrence.—Cragin Quarry local fauna.

Material.—Cragin Quarry loc. 1, KU 4627, right and left lower jaws, P_2–M_3; KU 7473, right first phalange; KU 7478, right first phalange; KU 7462, two left M_3s; and No. 38775, an M^1 or M^2.

Remarks.—In the summer of 1937, parts of the lower jaws of a small horse, KU 4627, were taken at Cragin Quarry. Measurements of the lower dentition of this horse have been reported (Hibbard, 1939, p. 467). The occlusal length of the premolar–molar series is 133.0 mm. The teeth are those of an old adult. The length of the molar series of the holotype of *Equus francisci* is 66.0 mm., a younger individual. The length of the molar series of the Cragin Quarry specimen is 66.1 mm.

Further collecting at Cragin Quarry has yielded but scant material that can be assigned to *Equus conversidens.* The two right first phalanges recovered in 1945 certainly belong to a small horse. KU 7473, has a length (greatest) of 79.6 mm.; the greatest width at the proximal end is 36.4 mm.; the narrowest transverse width is 22.4 mm.; and the greatest width of the distal end is 30.4 mm. KU 7478 has a length of 77.4 mm.; the greatest width of the proximal end is 35.5 mm.; the narrowest transverse width (approximately at middle of length) is 20.3 mm.; and the greatest width of the distal end is 28.0 mm. Both of the specimens are longer than the first hind phalange of the holotype of *Equus francisci.* How much longer the front phalange should be than the hind phalange is unknown. Phalange KU 7478, appears to be from the hind limb due to its narrow width. The other may also be a hind phalange of a larger individual.

The right molar, No. 38775, is probably an M^1 (Fig. 16D). It has an enamel occlusal length of 23.0 mm.; and a width of 22.5 mm. The length of the protocone is 12.3 mm. The length of the crown of the tooth is 67.0 mm. The base of the tooth is closed and four roots are present. The pli caballin fold is lacking. In addition, there are two small lower third molars (KU 7462) that may have belonged to this horse. Both teeth are from young individuals. The better tooth has an occlusal length of 25.0 mm., and the greatest enamel transverse width is 11.4 mm.

In the collection are three molars and three premolars, KU 7446, KU 7450, No. 38777, and No. 38778 that are as large as the corresponding teeth of *Equus conversidens* Owen, but the occlusal length of the protocones is longer. *E. francisci* and *E. conversidens* appear to be closely related if not identical species; differences between the two holotypes may be accounted for by individual or sexual variation.

Species identification in this group of small Pleistocene horses is further complicated by the name *Equus littoralis* Hay = *Onager littoralis* (Hay) Quinn (1957, p. 13). Quinn (1957, p. 11) gives as one of the chief characters of the Asiatic asses the flatness and elongation of the protocone. Under his discussion of *Onager littoralis* (Hay), he (p. 13) stated that it is the "Smallest of the *Equini,* teeth slightly larger than those of *Nannippus phlegon.* (From Hay, 1913*a,* p. 575; characterized by teeth of small size . . . enamel surrounding the lakes rather strongly folded. The crown somewhat more curved than in *E. leidyi*)." Hay (1913) had stressed the fact that the molars are wider than they are long. He gave the crown length of the holotype of *E. littoralis* as 21.0 mm. and the width as 20.0 mm. As a matter of fact the length of the crown of M^1 of the holotype of *E. francisci* (measurements after Hay, 1915, p. 539) is 19.5 mm., as opposed to a width of 22.0 mm. Hay gave the length of the protocone in both holotype specimens as 11.0 mm. At the time Hay (1915) described *Equus francisci* he did not compare this horse with the previously described *Equus littoralis.* The first two upper molars of the holotype of *E. francisci* are wider than long. M^1 is smaller than the holotype of *E. littoralis.* M^2 is the same size as the holotype but smaller than the paratype of *E. littoralis.*

I have not seen the holotype or paratype of *Equus littoralis,* but I question the statement by Hay (1913, p. 575) that the teeth are more curved than in *E. leidyi.* They may have been slightly more curved than the teeth of *E. leidyi* that he had before him at the time he described *E. littoralis.* In the collection at the University of Michigan is a premolar, probably P^4, of *Equus leidyi* (No. 3105) from Kingsford, Florida, that is as curved as that tooth is in some specimens of *Plesippus.* None of the small premolars or molars recovered from Cragin Quarry are as curved as specimen No. 3105 of *E. leidyi.*

At the time that I (Hibbard, 1955*a,* p. 56) discussed the holotype of *Equus conversidens,* I considered *E. littoralis* Hay a synonym, since the holotype had the folded plications in the fossettes like those of *E. conversidens.* I know of no character that will separate *Equus littoralis* from *E. francisci,* unless it be the slightly more complicated plications in the fossettes, and this character differs due to age and individual variation in the same species.

All evidence at hand clearly indicates that *Equus conversidens, E. littoralis,* and *E. francisci* belong to a single species and to a different subgenus or genus than *Equus* s.s.

I placed *Equus conversidens* Owen under the genus *Asinus* (Hibbard, 1958*b*), because of the close relationship to *E. francisci* and in keeping with the study of Quinn (1955). The lower teeth of *E. francisci* possess a V-shaped valley between the metaconid and metastylid, a character found in *Plesippus, Asinus,* and on the molars of *Hemionus*. The median outer re-entrant valleys of the lower premolars and molars are deep and more like those of *Asinus* than those of the species of North American horses that are considered as closely related to the Asiatic wild asses by Quinn (1957), though in some of the Recent specimens of *Hemionus* the outer valleys of the lower molars extend to, or between, the metaconid and metastylid (see Stehlin and Graziosi, 1935, p. 8, Fig. 5B).

The high infraorbital foramen in the holotype of *Equus conversidens* is a character common to both *Asinus* and *Hemionus*.

Troxell (1915, p. 617) stated in regard to *Equus scotti,* "The width of the muzzle measured across the alveoli of incisors number three is greater than the width across the premaxilla over the canines. This is a horse character, distinguishing it from the ass." It may also be added that it is a character that distinguishes *Hemionus* from the domestic ass as well. On the basis of this character *Equus francisci* would be placed in the *Hemionus* group.

At the time I reported *Equus* (*Asinus*) *calobatus* Troxell from Kansas (Hibbard, 1953), I mentioned the presence, in lower teeth from the Rock Creek locality, of a V-shaped groove between the metaconid and metastylid, a character in common for the zebras and African asses. I have since examined the skull and lower jaws of *Hemionus hemionus hemionus* (AMNH 57207). In the lower teeth of this specimen the premolars have a rather broad U-shaped valley, while the molars have V-shaped valleys but not as sharply V-shaped as those of the Recent zebra and domestic ass.

Professor F. E. Zeuner kindly wrote to me July 13, 1953, concerning the metatarsals of *Equus calobatus* that I reported from Kansas, "I have made some measurements on your figures and compared them with *Hemionus* and *Asinus* respectively. This seems to me to suggest that *E. calobatus* has distinct *E.* (*Hemionus*) tendencies." After examination of the metapodials of *H. h. hemionus* I agree with Zeuner.

Since there are a number of characters in common among the different groups of Recent horses, it is almost impossible to assign isolated elements to these various subgenera or genera. It would probably be more logical to assign *Equus conversidens* to *Hemionus* than to *Asinus*. I hesitate to assign it to either because (1) there is a small late Pleistocene horse the size of *E. conversidens* with a flattened and elongated protocone; (2) there is a question whether the third phalange of the fossil horses assigned to *Onager* by Quinn (1957) has this phalange developed as in the Recent Asiatic wild asses (see Fig. 18D–F); and (3) if it does, to what fossil horse does the *Asinus*-like third phalange belong (see Fig. 18A–C)?

I have not followed Quinn (1957) in the use of *Onager* Brisson, 1762. Brisson's use was only as a common name, or used as stated by Ellerman and Morris-Scott (1951, p. 341) for "*Equus asinus* Linnaeus." *Microhippus* Matschie (1924), as listed by Ellerman and Morris-Scott (p. 341), is preoccupied by *Microhippus* von Reichenau (1915), who used it for *Equus przewalskii* Poliakov. For the Asiatic wild asses I (1955*a*) followed Stehlin and Graziosi (1935) in their use of *Hemionus.*

The horses in North America after Aftonian time were numerous and represent distinct groups. Some of the species were late arrivals from Asia. It is not possible at the present time to assign all described species to recognized genera or subgenera, and the application of subgeneric or generic names of Recent horses to certain Pleistocene groups is, without doubt, incorrect and misleading.

Equus scotti Gidley, 1901

Equus scotti Gidley, 1901, p. 134.
Equus scotti Gidley, Hay, 1914, p. 179.
Equus complicatus Leidy, Hay, 1917, p. 43.
Equus niobrarensis Hay, Hibbard, 1939, p. 467.

Geologic Range.—Late Kansan to Wisconsin.

Distribution.—Specimens known from Kansas, Oklahoma, and Texas.

Habitat.—Troxell (1915, p. 617) makes the statement that "*E. scotti* was a ponderous animal, a form not suited to rapid movements but one probably living in a region surrounded by luxuriant vegetation with plenty of food and water and close in its habits to the mammoth and ground-sloth with which it may have been associated." Because of its large size, *Equus scotti* was probably confined to the grassy areas of the valleys, while the smaller horses lived in the grassy upland areas.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring, from basal sands, No. 38399, P_3 or P_4; No. 38400, second phalange. Cragin Quarry loc. 1, KU 400, LP^2; KU 7445, LP^4; KU 7453, two lower left molars (M_1 or M_2); KU 7457, two lower premolars and a molar; KU 7456, LP_4 and a right molar; KU 7460, RM_3 and LM_3; KU 7465, LP^2.

Remarks.—Parts of at least two individuals of the large horse were recovered. The teeth represent a young adult and an old adult. One of the left lower molars, KU 7453, has a crown length of 104.0 mm. The anteroposterior occlusal length is 31.2 mm., the transverse occlusal width 18.0 mm. The left P_4, KU 7456, has a crown length of 88.0 mm. The anteroposterior occlusal length is 30.0 mm., the transverse occlusal width is 20.5 mm.

Equus sp.

Occurrence.—Butler Spring and Cragin Quarry local faunas.

Material.—Butler Spring, from basal sands, No. 29974, astragalus;

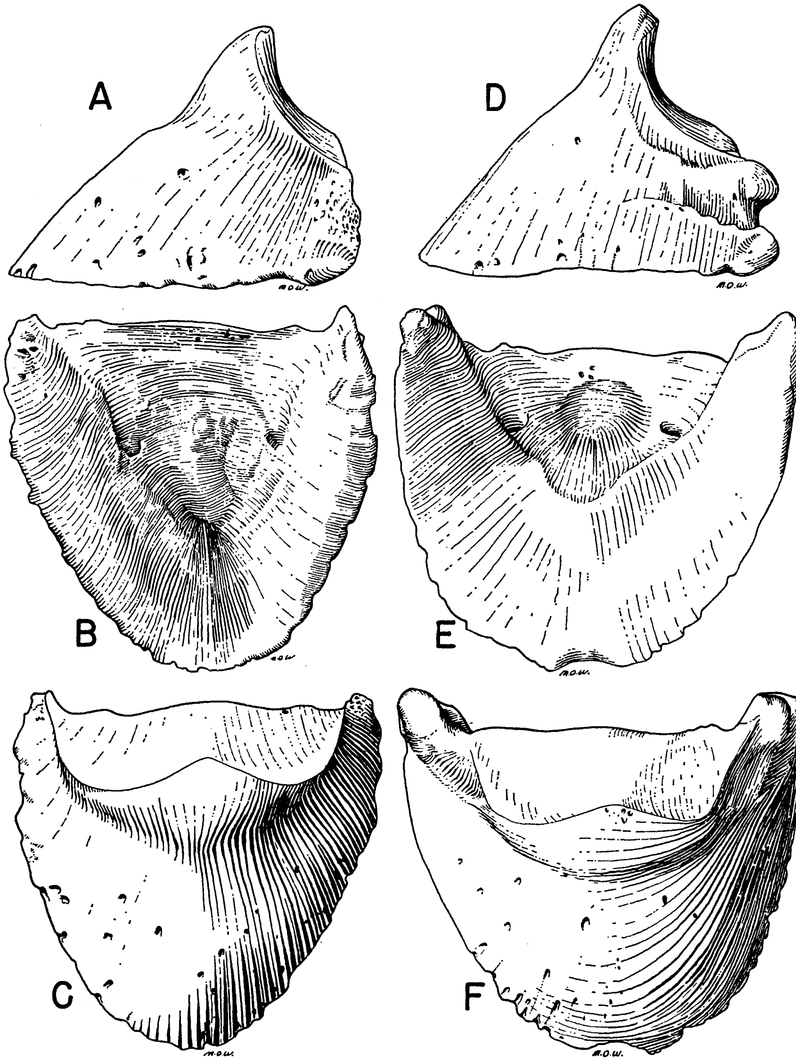

FIG. 18. Third phalanges of a Pleistocene and Recent horse. (A–C) *Equus* sp., UMMP 38776, third phalange. Side, ventral and dorsal views. (D–F) *Equus h. hemionus,* AMNH 57207, hind third phalange. Side, ventral and dorsal views. All $\times$ 1.

No. 38402, third phalange; Cragin Quarry loc. 1, KU 7439–7444, three P^2s and three M^3s; KU 7447–7449, upper premolars and molars; KU 7458–59, two M_3s; KU 7461, RM_3; KU 7463–64, two P^2s; KU 7467, lower molar or premolar; a few individual teeth under KU 7591–93, lot numbers for isolated lower and upper teeth; KU 7437, astragalus; KU 7468–72, five first phalanges; KU 7474–76, three second phalanges; No. 38776, third phalange; No. 38778–79, three upper premolars; and No. 38780, first phalange.

Remarks.—Many of the teeth are from a medium-sized horse, which is smaller than *Equus scotti* and larger than *Equus conversidens*. Teeth of this size from the Cragin Quarry local fauna were referred by Hay (1917) to *Equus leidyi* Hay. Though teeth of *E. leidyi* have been reported in the earlier literature for Kansas, I have seen none correctly identified from Kansas. *E. leidyi* has the external median valley of the lower molars developed as in *Plesippus* and caballines. The dental pattern of *E. leidyi* is very similar to that of *Plesippus* (see Simpson, 1929, Figs. 11*c* and *d*, p. 584). It is probably an eastern species of zebrine horse.

Only two sizes of the first phalange were recovered from Cragin Quarry. The two small and slender ones were referred to *Equus conversidens;* seven others belong to an intermediate-sized horse. Of these, three seem to be the first front phalange and three others the first hind phalange. The seventh specimen is badly eroded. The three second phalanges found at Cragin Quarry locality 1 agree in size with the intermediate-sized first phalange.

From Cragin Quarry was also recovered a small hoof bone, No. 38776 (Fig. 18A–C), that appears to be a hind third phalange. In comparison with both the one of *Hemionus hemionus hemionus* (AMNH 57207) and that of *Asinus domesticus* (No. R1533), this small third phalange is more like that of *Asinus* than *Hemionus* (see Fig. 18D–F) in that it is pointed and has an excavation on the ventral surface where the *tendo perforans* attaches (see Camp and Smith, 1942). On the ventral surface of both the front and hind phalange of *Hemionus,* where the tendon attaches, there is a slight dome-shaped enlargement of the bone.

Another third phalange, No. 38402, of the same shape and size was taken with the Butler Spring local fauna. These two small hoof bones fit the second hind phalange of the intermediate horse, but this does not in any way assure association, since the hoof bone from the Cragin Quarry also fits perfectly the associated hind limb of *Equus calobatus* Troxell, No. 29071, from Seward County, Kansas, which lacks the third phalange.

Measurements of the phalange, No. 38402, are: greatest proximal width, approximately 50.0 mm.; greatest width of articular surface, 39.0 mm.; greatest dorsal-ventral height, 33.0 mm.; median length, 46.8 mm.

The astragalus, No. 29974, from the Butler Spring local fauna is smaller than the astragalus of *Equus calobatus,* No. 29071.

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PLATES

PLATE I

(All figures × 20)

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Pisidium compressum Prime; Butler Spring locality 1 78

FIG. 1. Inner view of immature right valve, UMMZ 197548*d*.

FIG. 2. Inner view of mature right valve, UMMZ 197548*c*.

FIG. 5. Inner view of mature right valve, UMMZ 197548*b*.

Pisidium casertanum (Poli) 77

FIG. 3. Butler Spring locality 1. Inner view of mature left valve, UMMZ 197547*a*.

FIG. 4. Cragin Quarry locality 1. Inner view of mature right valve, UMMZ 184468*b*.

Pisidium nitidum Jenyns; Butler Spring locality 1 78

FIG. 6. Inner view of mature right valve, UMMZ 197549*b*.

PLATE I

PLATE II

PLATE II

(All figures × 20)

	PAGE
Pisidium compressum Prime; Butler Spring locality 1	78
FIG. 1. Inner view of immature left valve, UMMZ 197548*e*.	
FIG. 5. Inner view of mature left valve, UMMZ 197548*f*.	
FIG. 6. Inner view of mature left valve, UMMZ 197548*a*.	
Pisidium casertanum (Poli); Cragin Quarry locality 1	77
FIG. 2. Inner view of mature left valve. UMMZ 184468*a*.	
Pisidium nitidum Jenyns; Butler Spring locality 1	78
FIG. 3. Inner view of immature right valve, UMMZ 197549*d*.	
FIG. 4. Inner view of mature left valve, UMMZ 197549*a*.	
FIG. 7. Inner view of mature left valve, UMMZ 197549*c*.	

PLATE III

(All figures × 20)

PAGE

Pisidium compressum Prime; Butler Spring locality 1 78

FIG. 1. Outer view of immature right valve, UMMZ 197548*d*. Note ridge on beak.

FIG. 5. Outer view of immature left valve, UMMZ 197548*e*. Note ridge on beak.

FIG. 7. Outer view of mature left valve, UMMZ 197548*a*.

Pisidium casertanum (Poli) 77

FIG. 2. Cragin Quarry locality 1. Outer view of mature left valve, UMMZ 184468*a*.

FIG. 6. Cragin Quarry locality 1. Outer view of mature right valve, UMMZ 184468*b*.

FIG. 8. Butler Spring locality 1. Outer view of mature left valve, UMMZ 197547*a*.

Pisidium nitidum Jenyns; Butler Spring locality 1 78

FIG. 3. Outer view of mature right valve, UMMZ 197549*b*.

FIG. 4. Outer view of immature left valve, UMMZ 197549*a*.

PLATE III

PLATE IV

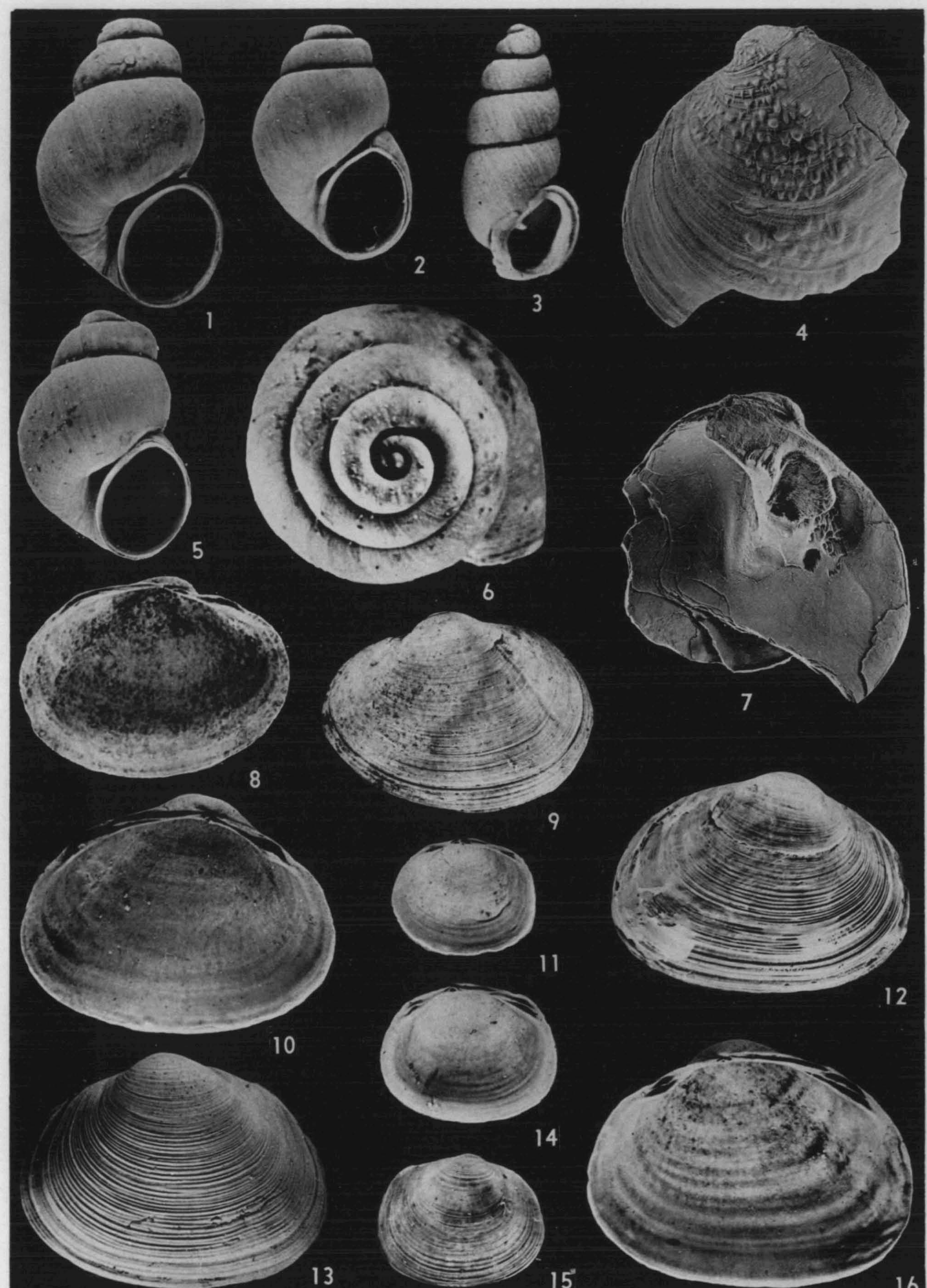

PLATE IV

PAGE

Probythinella lacustris (Baker); Doby Springs locality 4 80

FIG. 1. Apertural view, UMMZ uncat. × 10.

FIG. 2. Apertural view, UMMZ uncat. × 10.

FIG. 5. Apertural view, UMMZ uncat. × 10.

FIG. 6. Apical view of same specimen as in Figure 2. × 20.

Carychium exiguum (Say); Butler Spring locality 1 84

FIG. 3. Apertural view, UMMZ 177380*a*. × 20.

Quadrula quadrula (Rafinesque); Butler Spring locality 3 75

FIGS. 4, 7. Outer (Fig. 4) and inner (Fig. 7) views of left valve, UMMZ 197592. × 1.

Sphaerium transversum (Say); Butler Spring locality 1 76

FIGS. 8–9. Inner and outer views of mature left valve, UMMZ 177368. × 3.

FIG. 11. Inner view of immature right valve, UMMZ 197546*a*. × 5.

Sphaerium striatinum (Lamarck); Butler Spring locality 1 76

FIGS. 10, 13. Inner and outer views of mature left valve, UMMZ 197545*c*. × 3.

FIGS. 12, 16. Inner and outer views of mature right valve, UMMZ 197545*a*. × 3.

FIGS. 14–15. Inner and outer views of immature right valve, UMMZ 197545*b*. × 3.

PLATE V

	PAGE
Armiger crista (Linnaeus); Cragin Quarry locality 3. UMMZ 197520. × 20	101

FIG. 1. Left side.
FIG. 2. Apertural view.

Stagnicola reflexa (Say); Butler Spring locality 1. × 3 88

FIG. 3. Apertural view of immature specimen, UMMZ 177373*b*.
FIG. 9. Apertural view of juvenile specimen, UMMZ 177373*a*.

Anisus pattersoni (Baker); Butler Spring locality 1 95

FIG. 4. Right side, UMMZ 197552*a*. × 10.

Stagnicola caperata (Say); Butler Spring locality 1. × 3 92

FIG. 5. Apertural view, UMMZ 177371*b*.
FIG. 6. Apertural view, UMMZ 177371*a*.
FIG. 7. Apertural view, UMMZ 177371*c*.

Fossaria obrussa (Say); Butler Spring locality 1 94

FIG. 8. Apertural view of adult, UMMZ 177372*a*. × 5.
FIG. 16. Apertural view of juvenile, UMMZ 177372*b*. × 10. Note the sinuous growth line and relatively larger aperture as compared with that of *F. dalli* (Baker), Figures 10–12.

Fossaria dalli (Baker); × 10 93

FIG. 10. Cragin Quarry locality 1. Apertural view, UMMZ 184459*a*.
FIG. 11. Cragin Quarry locality 2. Apertural view, UMMZ 197498*a*.
FIG. 12. Cragin Quarry locality 1. Apertural view, UMMZ 184459*b*.

Stagnicola exilis (Lea), × 3 86

FIG. 13. Cragin Quarry locality 1. Apertural view of immature specimen, UMMZ 184461*a*.

Valvata tricarinata (Say); × 10. Butler Spring locality 1 79

FIG. 14. Apertural view, UMMZ 177369*a*.
FIG. 15. Apertural view, UMMZ 177369*b*.

PLATE V

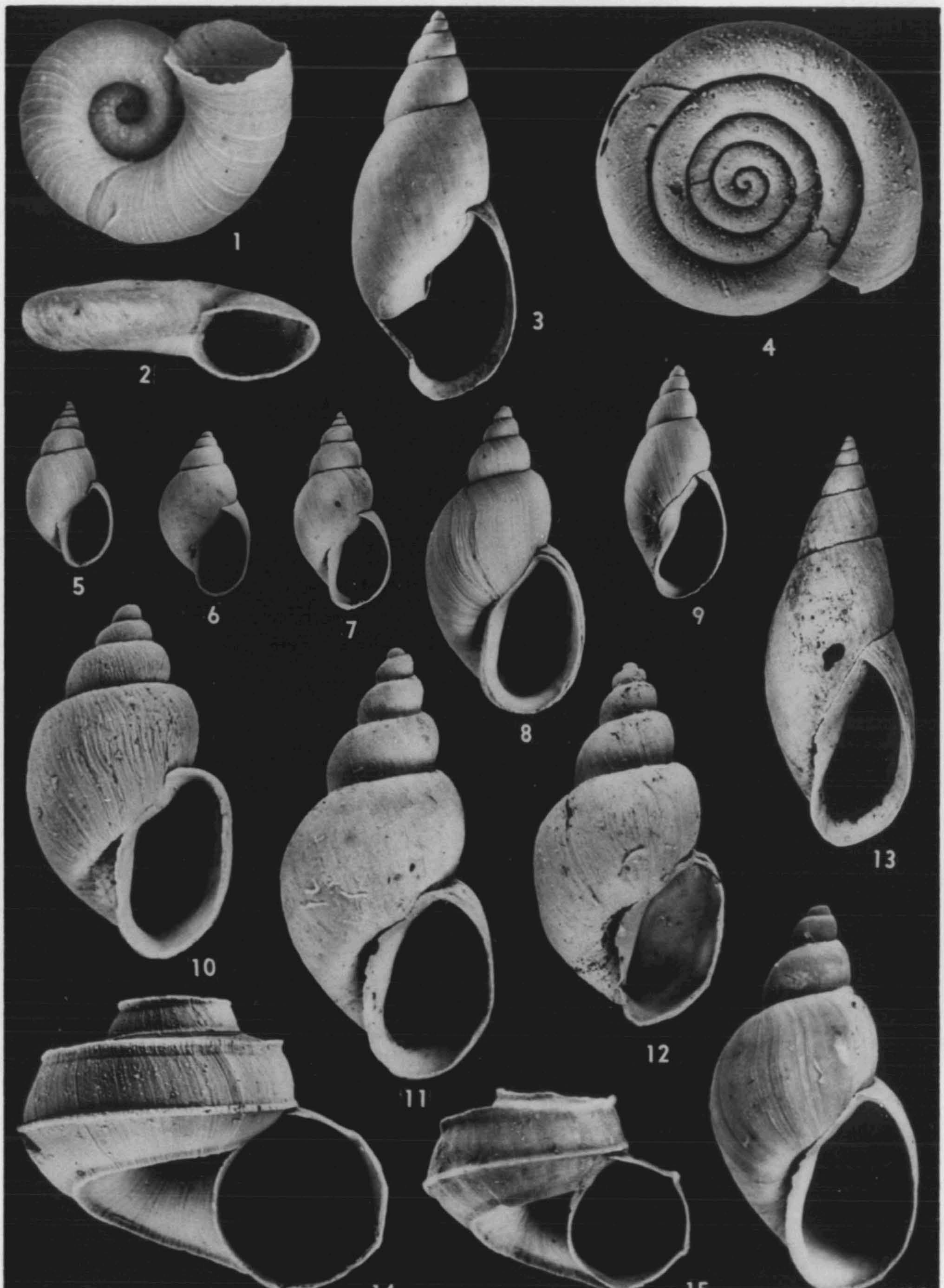

PLATE VI

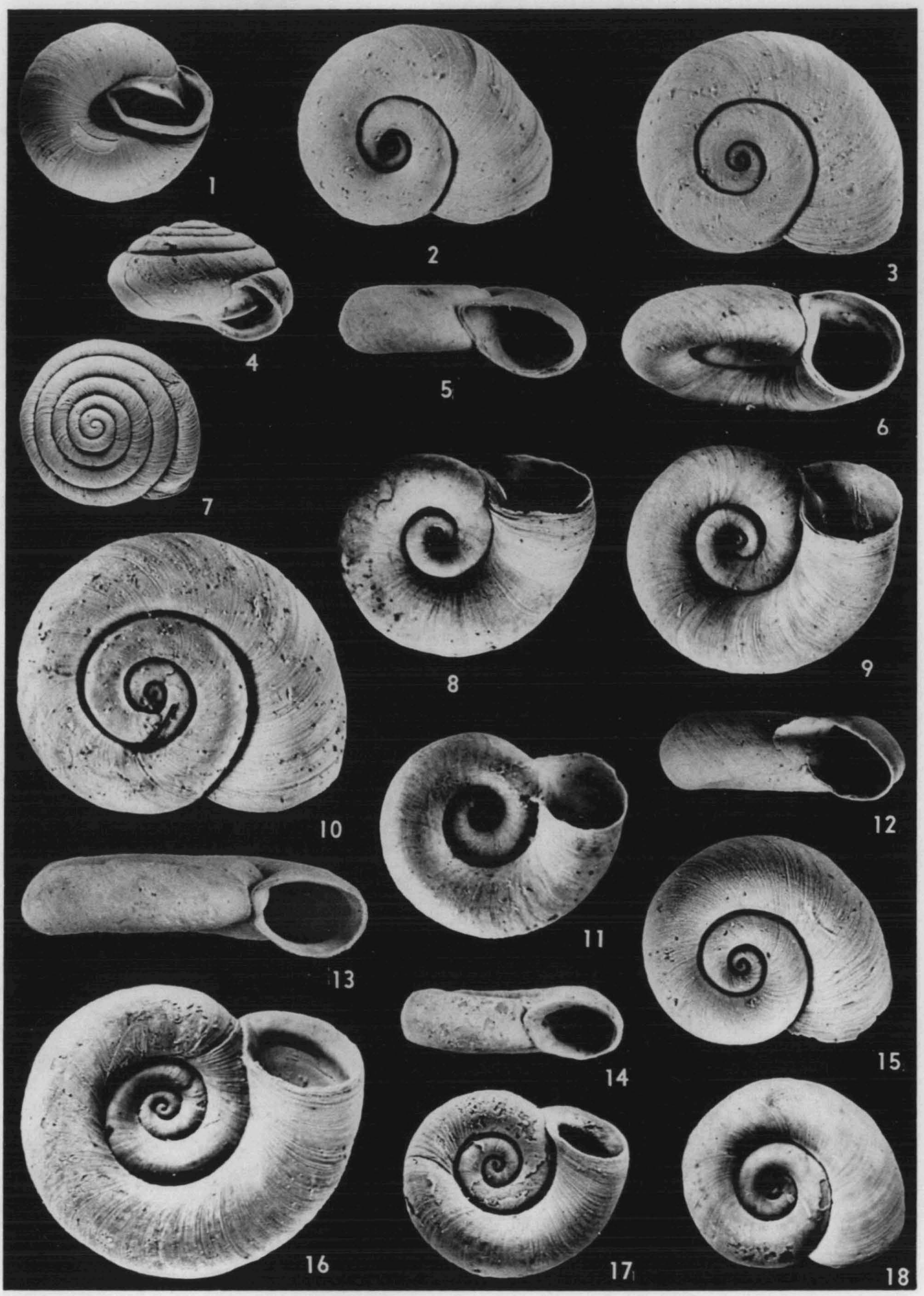

PLATE VI

PAGE

Stenotrema leai leai (Binney) ; Cragin Quarry locality 2 150

FIGS. 1, 4, 7. Basal, apertural, and apical views, respectively, UMMZ 197518*a*. × 3.

Gyraulus parvus (Say) ; Butler Spring locality 1. × 20 100

FIGS. 2, 5, 8. Right side, apertural view, left side, UMMZ 177375*b*.
FIGS. 3, 6, 9. Right side, apertural view, left side, UMMZ 177375*c*.
FIGS. 11, 12, 15. Left side, apertural view, right side, UMMZ 177375*a*.

Gyraulus circumstriatus (Tryon) ; Cragin Quarry locality 1. × 20 96

FIGS. 10, 13, 16. Right side, apertural view, left side, UMMZ 184456*b*.
FIGS. 14, 17, 18. Apertural view, left side, right side, UMMZ 184456*a*.

PLATE VII

(All figures × 20)

PAGE

Promenetus kansasensis (Baker); Butler Spring locality 1 105

FIGS. 1–2. Right and left sides, UMMZ 177377*b*. Shell with acute periphery and moderately coarse riblets which are rather closely spaced and show little change in strength or spacing in ontogeny.

FIG. 3. Right side of unusually large shell, UMMZ 177377*c*. The large size and extremely broad body whorl are similar to these features of Recent *P. exacuous* form *megas*. The last 1½ whorls are very smooth, and like those of *P. exacuous*. Fine riblets are present on the early whorls. Same specimen figured on Plate VIII, Figure 4.

PLATE VII

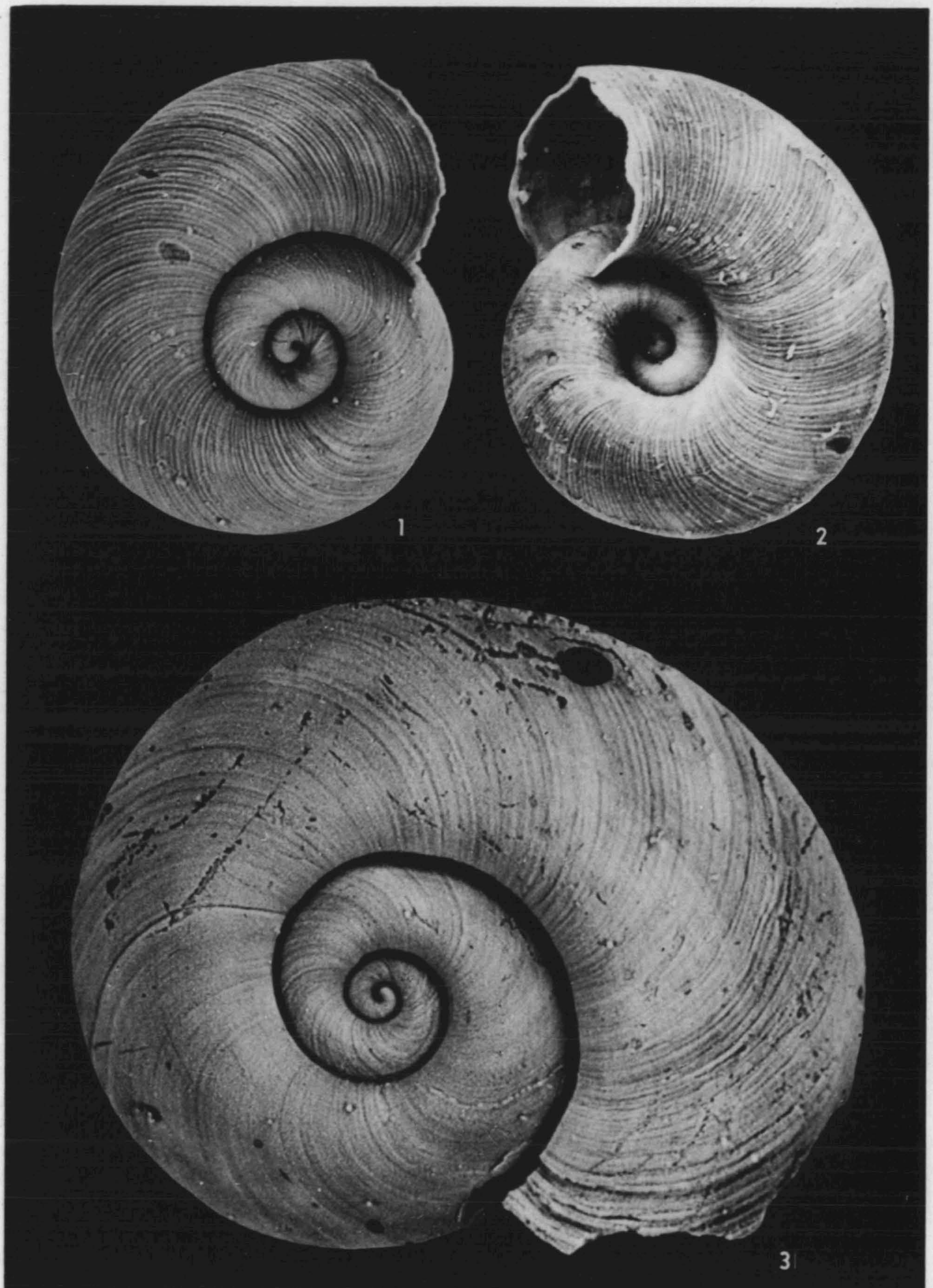

PLATE VIII

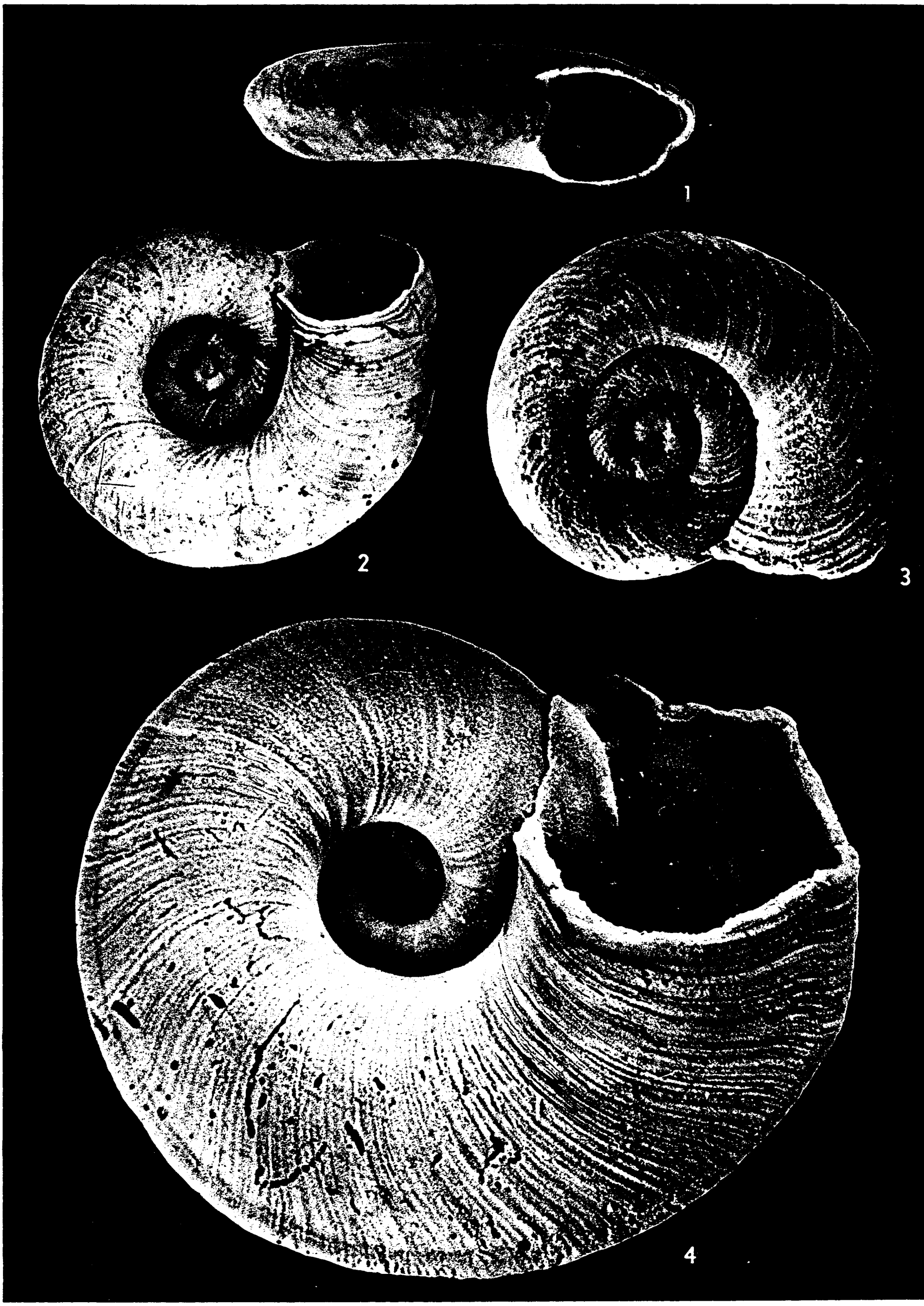

PLATE VIII

(All figures × 20)

PAGE

Promenetus kansasensis (Baker); Butler Spring locality 1 105

FIGS. 1–3. Apertural view, left side, right side, UMMZ 177377*a*. Shell with relatively narrow, rounded whorls and coarse sculpture. The carina is so reduced that the periphery is merely subangular. The coarse riblets are widely spaced, and clearly evident on later as well as early whorls.

FIG. 4. Left side of unusually large shell, UMMZ 177377*c*. The large size and extremely broad body whorl are similar to these features of Recent *P. exacuous* form *megas*. Same specimen figured on Plate VII, Figure 3.

PLATE IX

(All figures × 20)

PAGE

Promenetus kansasensis (Baker); Butler Spring locality 1 105

FIGS. 1–3. Right side, left side, and apertural view, UMMZ 177377*e*. Specimen with acute carina and variable ribbing; sculpture stronger on earlier than on later whorls.

FIGS. 4, 6, 8. Right side, apertural view, and left side, UMMZ 177377*f*. Specimen with obtuse carina and strong, widely spaced riblets.

FIGS. 5, 7, 9. Right side, apertural view, and left side, UMMZ 177377*g*. Specimen with obtuse carina and sculpture of fine, close riblets.

PLATE IX

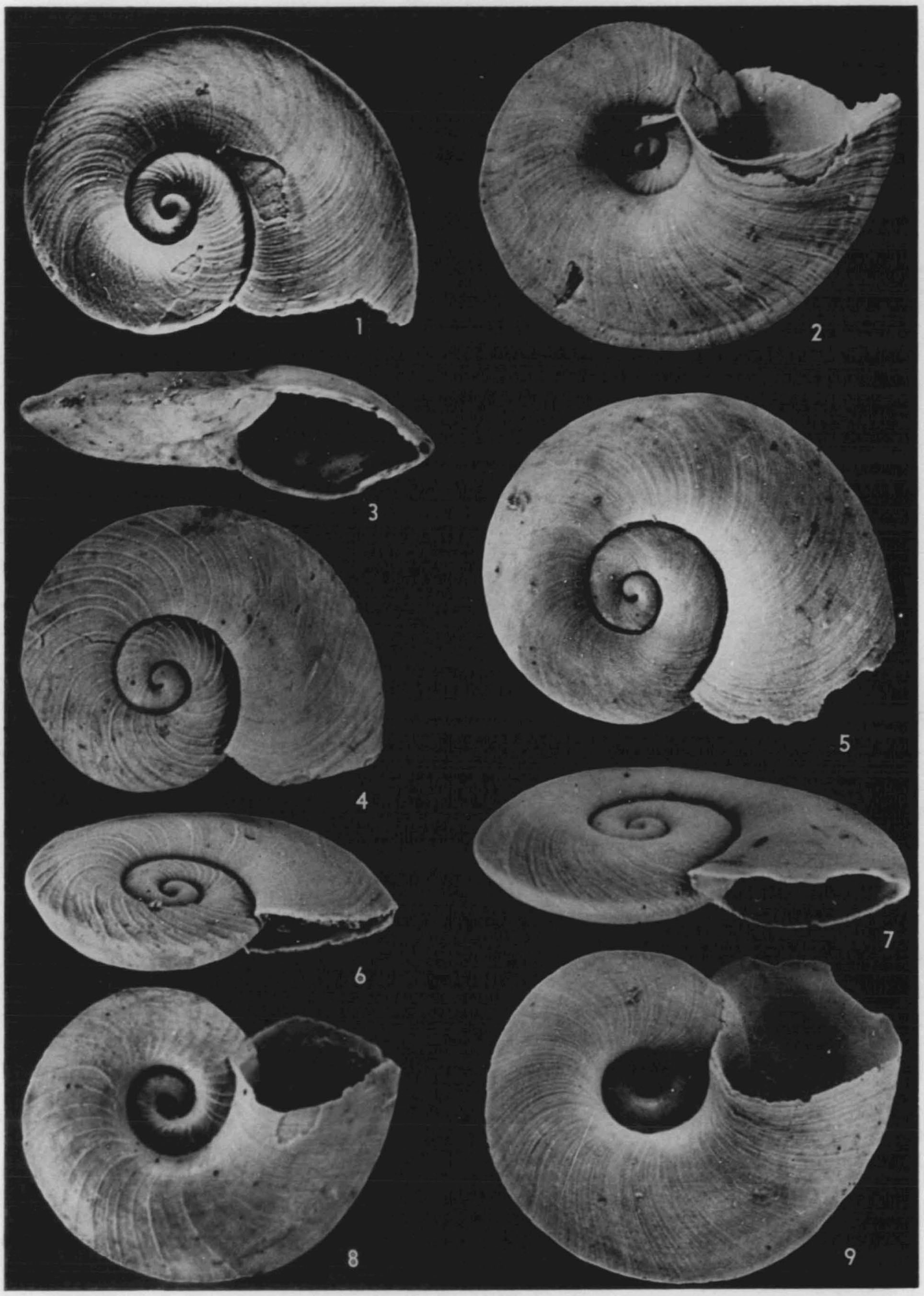

PLATE X

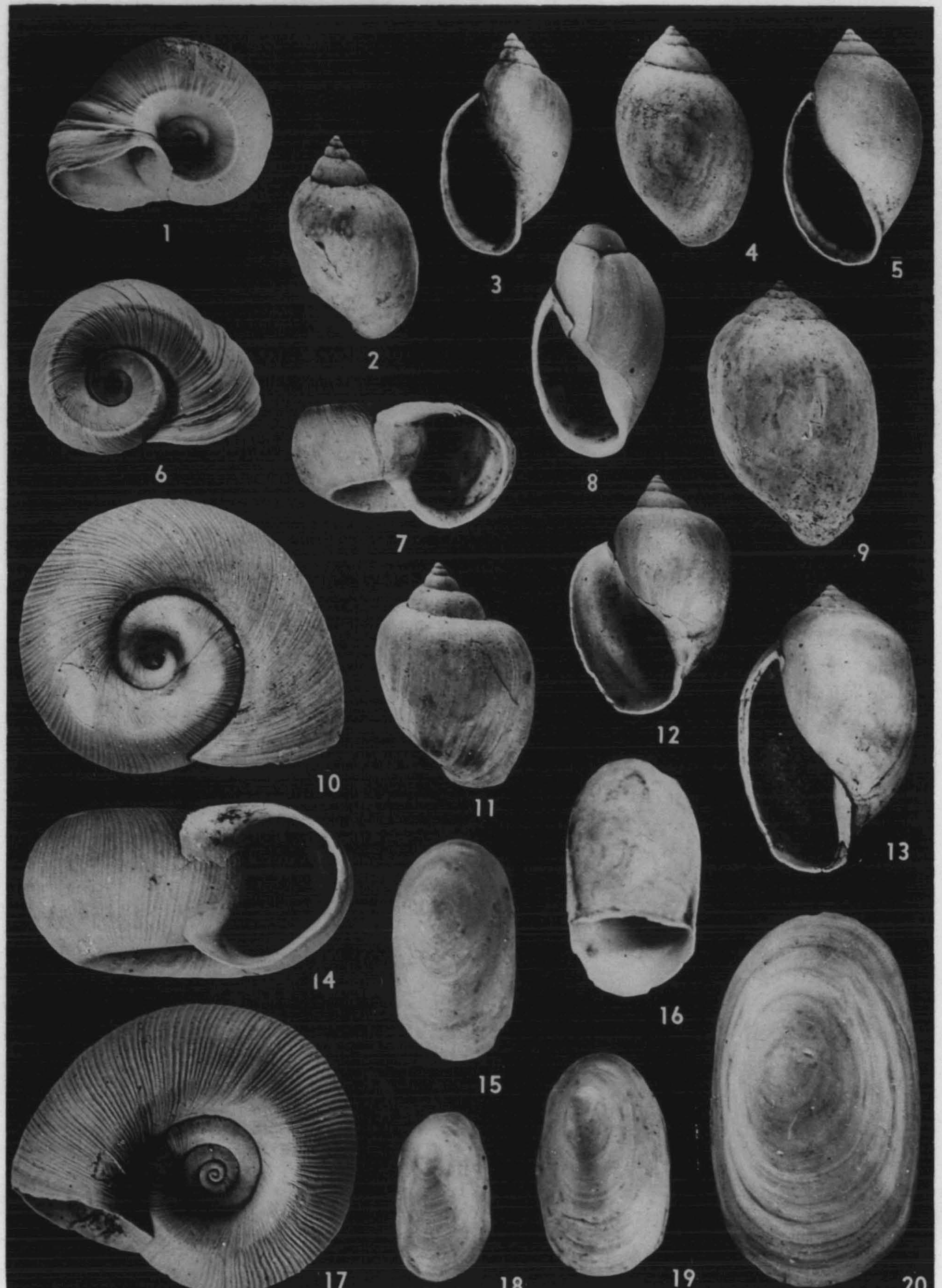

PLATE X

PAGE

Helisoma anceps (Menke); Butler Spring locality 1 103
FIGS. 1, 6, 7. Left side, right side, and apertural view, UMMZ 197553*a*. × 3.

Physa anatina Lea; Butler Spring locality 1. × 3 116
FIGS. 2–3. Abapertural and apertural views. UMMZ 177378*b*.
FIGS. 11–12. Abapertural and apertural views, UMMZ 177378*a*.

Physa gyrina Say, form *hildrethiana* Lea; Butler Spring locality 1. × 3 117
FIGS. 4–5. Abapertural and apertural views, UMMZ 177379*a*.
FIGS. 9, 13. Abapertural and apertural views, UMMZ 177379*b*.

Physa skinneri Taylor; Butler Spring locality 1. × 10 119
FIG. 8. Apertural view, UMMZ 197555*a*.

Helisoma trivolvis (Say); Cragin Quarry locality 1. × 3 104
FIGS. 10, 14, 17. Right side, apertural view, and left side, UMMZ 184469*a*.

Ferrissia meekiana (Stimpson); Cragin Quarry locality 1 113
FIGS. 15–16. Apical and basal views of juvenile septate specimen, UMMZ 184447*c*. × 20.
FIG. 18. Apical view of immature nonseptate specimen, UMMZ 184447*b*. × 10.
FIG. 19. Apical view of mature nonseptate specimen, UMMZ 184447*a*. × 10.

Laevapex kirklandi (Walker); Butler Spring locality 1 114
FIG. 20. Apical view, UMMZ 197557*a*. × 10.

PLATE XI

(Apertural views except where noted)

PAGE

Pupoides albilabris (Adams); Butler Spring locality 1 128
FIG. 1. UMMZ 177383*a*. × 10.

Pupoides inornatus Vanatta; Butler Spring locality 1 129
FIG. 2. UMMZ 197564*a*. × 10.

Vallonia parvula Sterki; Butler Spring locality 1 138
FIGS. 3–4, 9. Apertural, apical, and basal views, UMMZ 197572*a*. × 20.

Pupilla blandi Morse; Butler Spring locality 1 130
FIG. 5. UMMZ 197835*b*. × 10.
FIG. 6. UMMZ 197835*a*. × 10.

Pupilla muscorum (Linnaeus); Butler Spring locality 1 132
FIG. 7. UMMZ 197565*a*. × 10.

Vertigo ovata Say; Butler Spring locality 1 135
FIG. 8. UMMZ 197567*a*. × 20.

Vertigo gouldi (Binney); Butler Spring locality 1 134
FIG. 10. UMMZ 197569. × 20.

Gastrocopta tappaniana (Adams); Cragin Quarry locality 2 127
FIG. 11. UMMZ 197504*a*. × 20.
FIG. 12. UMMZ 197504*b*. × 20.

Gastrocopta armifera (Say); Cragin Quarry locality 2 124
FIG. 13. UMMZ 197501*a*. × 20.

Gastrocopta holzingeri (Sterki); Cragin Quarry locality 2 126
FIG. 14. UMMZ 197503*a*. × 20.

Gastrocopta procera (Gould); Butler Spring locality 1 123
FIG. 15. UMMZ 197563*a*. × 20.

Gastrocopta cristata (Pilsbry and Vanatta); Butler Spring locality 1 122
FIG. 16. UMMZ 197562*a*. × 20.

PLATE XI

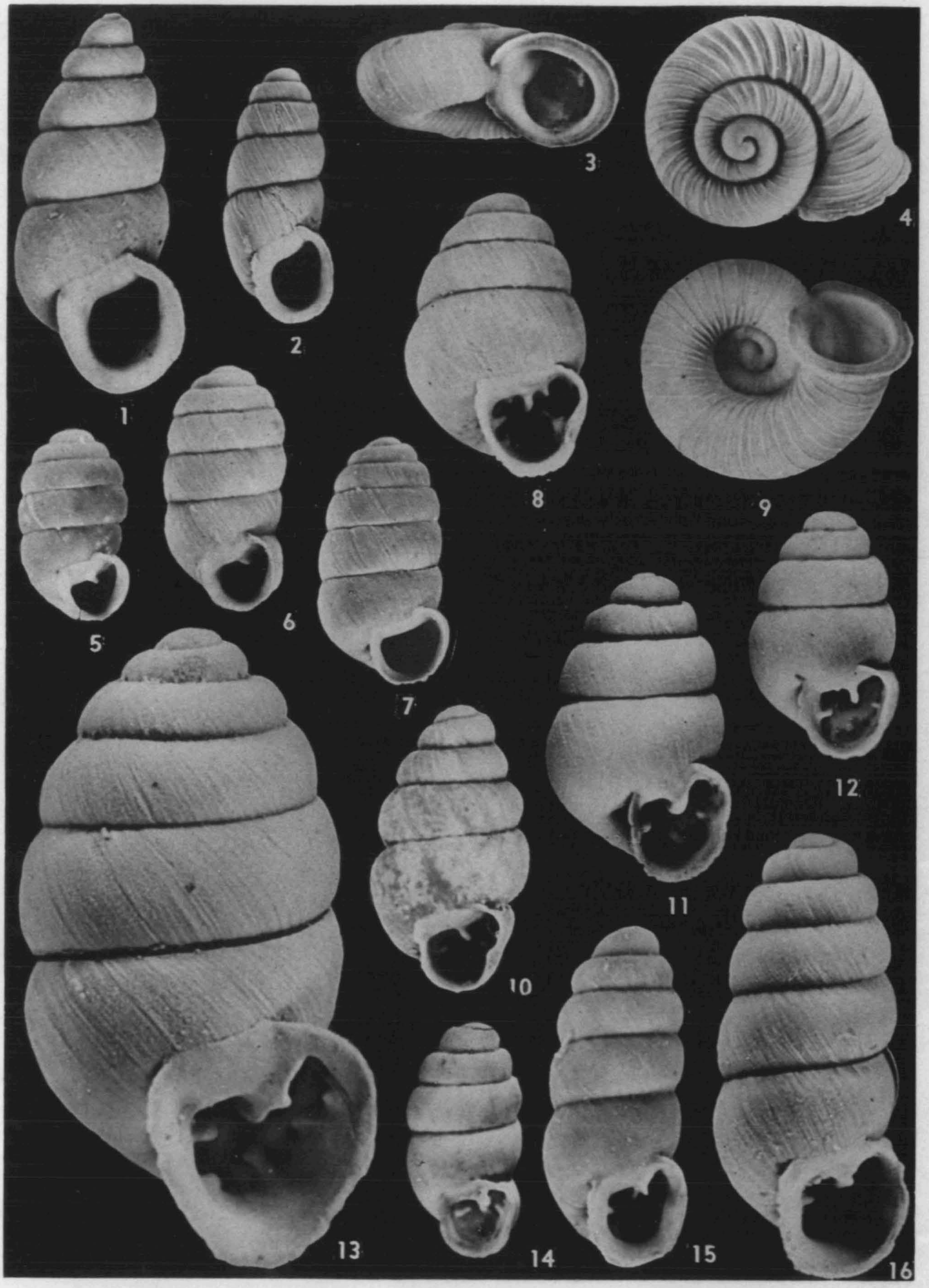

PLATE XII

PLATE XII

(All figures × 20)

PAGE

Vallonia gracilicosta Reinhardt; Butler Spring locality 1 137

FIGS. 1–3. Apertural, basal, and apical views, UMMZ 197570*b*.

FIGS. 4–6. Apertural, apical, and basal views, UMMZ 197570*a*.

Vallonia cyclophorella Sterki; Butler Spring locality 1 136

FIGS. 7–9. Apertural, apical, and basal views, UMMZ 197571*a*.

PLATE XIII

PAGE

Discus cronkhitei (Newcomb); Butler Spring locality 2 143
FIGS. 1–3. Apical, basal, and apertural views, UMMZ 197590*a*. × 5.

Euconulus fulvus (Müller); Cragin Quarry locality 1 146
FIGS. 4, 6, 8. Apertural, basal, and apical views, UMMZ 184458*a*. × 10.

Promenetus umbilicatellus (Cockerell); Cragin Quarry locality 1 110
FIGS 5, 7, 9. Right side, apertural view, and left side, UMMZ 184457*a*. × 20.

Deroceras aenigma Leonard; Cragin Quarry locality 1 146
FIGS 10–11. Right side and dorsal view, UMMZ 184466*a*. × 10.

PLATE XIII

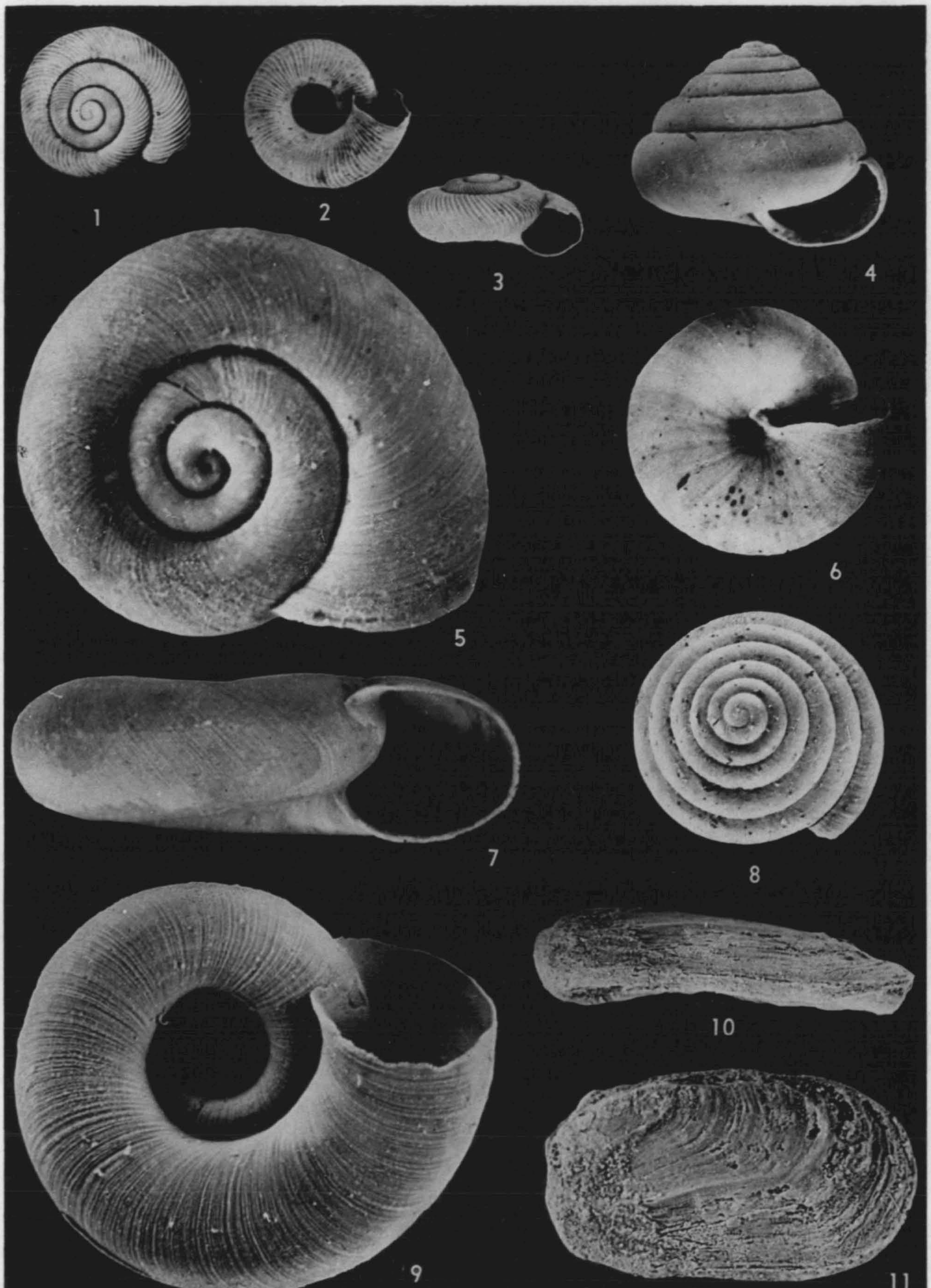

PLATE XIV

PLATE XIV

PAGE

Helicodiscus parallelus (Say); Cragin Quarry locality 3 144
FIGS. 1–3. Basal, apical, and apertural views, UMMZ 184433*a*. × 10.

Hawaiia minuscula (Binney); Cragin Quarry locality 3 148
FIGS. 4, 7, 10. Apical, basal, and apertural views, UMMZ 184429*a*. × 10.

Helicodiscus singleyanus (Pilsbry); Cragin Quarry locality 3 144
FIGS. 5, 8, 11. Apical, basal, and apertural views, UMMZ 184432*a*. × 10.

Promenetus kansasensis (Baker); Butler Spring locality 1 105
FIGS. 6, 9, 16. Right side, apertural view, left side, UMMZ 177377*h*. Specimen with obtuse carina and weak spiral sculpture; axial riblets are slightly coarser on earlier whorls than on later. × 20.

Zonitoides arboreus (Say); Butler Spring locality 1 149
FIGS. 12, 14, 17. Basal, apertural, and apical views, UMMZ 197574*a*. × 5.

Nesovitrea electrina (Gould); Cragin Quarry locality 2 147
FIGS. 13, 15, 18. Basal, apertural, and apical views, UMMZ 197516*a*. × 5.

PLATE XV

PAGE

Mammuthus columbi (Falconer), Cragin Quarry locality 1 182
Left M^3. Natural size.

PLATE XV

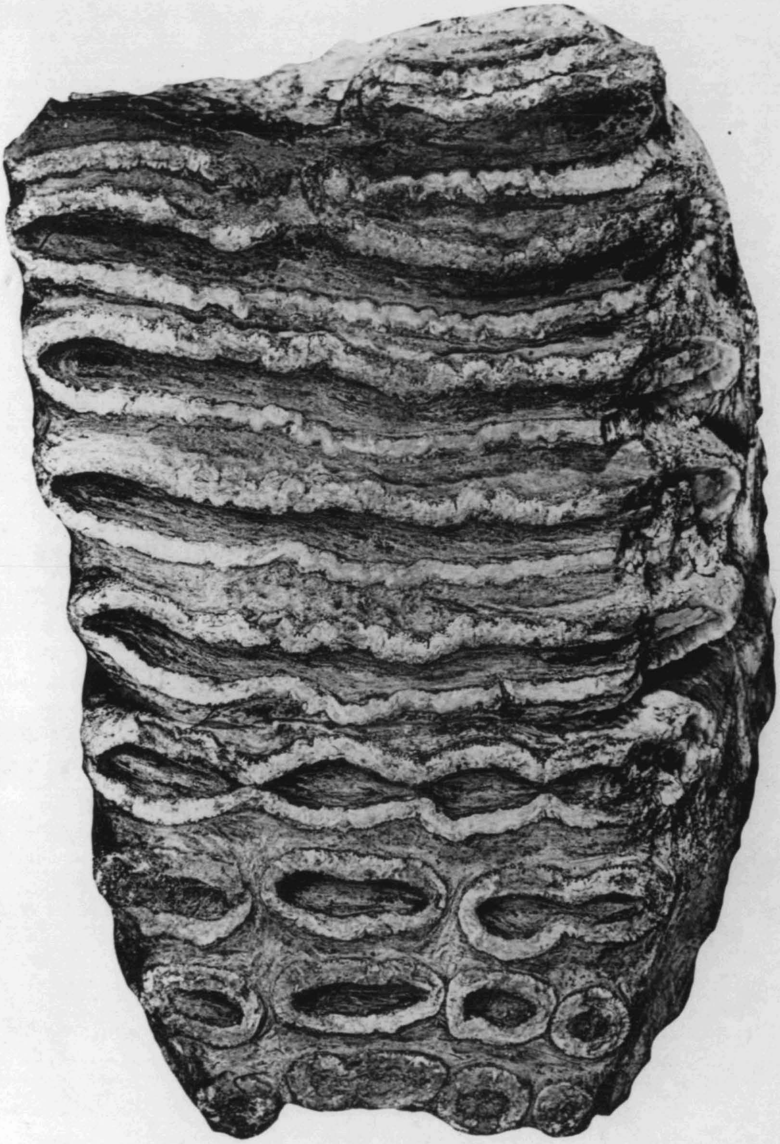

FIG. 1

FIG. 2

PLATE XVI

Cragin Quarry Faunal Localities in Kingsdown Formation

FIG. 1. Cragin Quarry locality 1. University of Michigan Museum of Paleontology field crew collecting fossiliferous silt and clay from the southeastern of the two quarries at locality 1. About 15 tons of matrix were removed and screen-washed, to yield most of the shells and small vertebrates representing the Cragin Quarry local fauna.

FIG. 2. Cragin Quarry localities 2 and 3. Looking east across the south slope of "The Lookout." Locality 3 is just below the caliche capping the hill on the skyline, at left. Locality 2 is in right center in the vicinity of the two people.