LATE PLEISTOCENE AND HOLOCENE VERTEBRATE FOSSIL RECORD OF WISCONSIN

by

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ABSTRACT

Wisconsin's late Pleistocene and Holocene vertebrate fossil record has been investigated sporadically since before the Civil War. Much material collected prior to the 1950's has been lost, and records on what remains generally are poor. More recently collected specimens have better data and permit compilation of faunal lists and formulation of some general paleoecologic conclusions.

Vertebrate fossils have been found in Pleistocene sediment, post-glacial streams, ponds and lakes, and fissures in Paleozoic carbonate rocks. Occurrences in post-glacial stream, pond and lake sediments hold substantial promise for articulated larger mammals within a stratigraphic context, while fissures are excellent prospects for the collection of large population samples of smaller vertebrates.

INTRODUCTION

Late Pleistocene and Holocene vertebrate fossils have been known from Wisconsin since before the Civil War and were first published by Hall and Whitney (1862) who reported large mammal remains from Blue Mounds, west of Madison, as well as other areas of southwestern Wisconsin and adjacent parts of Illinois and Iowa. Other specimens were reported through the early part of the Twentieth Century; these are summarized by Hay (1923) who listed specimens held by museums, universities and individuals. Most of these materials came from the southern and western parts of the state.

Repositories were not always indicated by Hay, but the Milwaukee Public Museum, the University of Wisconsin and the Smithsonian Institutions are known to have possessed many of the specimens. Over the course of the last century the rate of loss has been high. Many causes were responsible for the disappearances: the 1878 fire at old Science Hall in Madison, inadequate curatorial practices, and individual negligence. The result is that a substantial portion of the records listed by Hay (1923) cannot be confirmed, either for taxonomic identification or for locality information. In addition, the quality of locality data accompanying the remaining specimens in the older collections is generally inadequate by current standards.

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The specimens reported by Hay (1923) are mainly of large mammals (proboscideans, artiodactyls and carnivores), though some rodents are recorded from southwestern Wisconsin. A lake trout was collected near Menomonie in Dunn County (Hassakof, 1916). The collecting techniques of the time did not promote the discovery of remains of smaller vertebrates.

During the middle part of the Twentieth Century (1920's to 1960's) late Pleistocene and Holocene vertebrates were collected sporadically within Wisconsin, but very little was published. A modest number of specimens were catalogued into the collections of the Milwaukee Public Museum and the University of Wisconsin during this interval. Typical finds were of isolated bones or teeth of large mammals, included in glacial deposits, and usually encountered in the process of large-scale excavation. Most of this material is still extant, so the identifications can be confirmed, but locality data tends to be poor. We are not aware of any systematic programs anywhere in the state for following up on these discoveries other than a 1954 paper by Palmer describing a Holocene bison occurrence excavated in 1936 at Interstate Park in Polk County.

Over the past decade interest in the faunas of the Wisconsin late Pleistocene and Holocene has increased, and several controlled investigations have been undertaken. One of us (Dallman, 1968, 1969 and unpublished) has excavated several proboscideans and a giant beaver near Madison, gathering detailed stratigraphic and paleoecologic data in the process. Palmer (1974, and unpublished) has been examining caves in southwestern Wisconsin. Several new sites, fissures and cavities in porous Paleozoic limestone of the Driftless Area, have produced substantial numbers of specimens of smaller vertebrates and molluscs. This work was initiated by D.L. Rasmussen, then of the University of Kansas, and has been continued as graduate research projects by S. Theiling and R. Foley of the University of Iowa. The Milwaukee Public Museum opened a third small vertebrate locality near Cave of the Mounds in 1977. Teller-Marshall and Bardack (1978) recently reported on a suite of fishes collected in 1966 by J. Emielity of the Milwaukee Public Museum in a sewer excavation in Milwaukee. J. Stoltman of the Department of Anthropology. University of Wisconsin-Madison, is currently investigating a mastodon site for indications of possible human activity. No clear evidence for men killing or using these animals has been reported yet for Wisconsin.

This recent work is producing specimens with adequate geologic information, associated floral and faunal data for paleoecologic analysis, and radiometric dates. Thus it is now becoming possible to correlate Wisconsin localities with better known surrounding areas, to analyze the changing glacial and post-glacial environments, and, to a limited extent, be able to predict promising areas for further investigations.

VERTEBRATE LOCALITIES

The geologic setting of Wisconsin, with its substantial cover of glacial deposits, has had an effect on the Pleistocene and Holocene fossil record. Most, if not all, of the state has been covered by ice within the past several tens of thousands of years. The most recent ice retreat was not more than 10,000 to 13,000 years ago. The deposits left during this last part of the Wisconsinan age have concealed earlier Pleistocene animal remains in all but the Driftless Area in the southwestern part of the state. Thus post-glacial environments have been generally present for only some 10,000 to 13,000 years.

As can readily be seen on the distribution maps (Figs. 1, 2, and 3), Wisconsin's late Pleistocene and Holocene vertebrate localities are concentrated in the southern part of the state. Sixty-six of 78 localities identified at this time are in the three tiers of counties immediately north of the Illinois state line. Several reasons for this pattern may be advanced: (1) The population centers and areas of longest intensive human habitation are in the south. (2) Milwaukee and Madison, the primary cultural and educational centers (which support active professional scientists), are in this region. (3) The southeastern part of the state was freed from glaciation sooner than the northern part, permitting earlier and perhaps denser vertebrate populations.

Three primary environments have preserved most of the late Pleistocene and Holocene vertebrates of Wisconsin. The least informative is glacial deposits; many fragments of animals (Fig. 4) were caught up in the moving glacial materials (both ice and rock), moved from their original location, abraided, and deposited at the time of glacial retreat. Other fossils are parts of animals that lived on the broad glacial outwash plains and were disarticulated and moved by the strong water action. These specimens have no stratigraphic context, and thus are of relatively little geological utility, although they do provide general distributional records, especially for larger vertebrates. Most of the proboscidean and many of the artiodactyl records are from such glacial deposits.

Post-glacial lake and stream deposits produce specimens preserved approximately where the animals died, and occasionally in articulation. These are the most useful large-vertebrate sites within the state, and include both mammals and fish.

The more important Wisconsin large-mammal sites include three proboscidean localities and one _Bison_ locality. Dallman's (1968) excavation of two partially articulated mastodon specimens near Deerfield in Dane County produced significant paleoecological data. The specimens were buried beneath four feet of peat and two feet of clay along the shore of a post-glacial lake that apparently was open water until at least 9,000 years ago. Radiocarbon dates of 9480 ± 100 years of B.P. and 9630 ± 110 years B.P. (Table 1) were derived directly from the mastodon bones. In an adjacent excavation, in the same lake just 100 yards from the first two, a third mastodon (Fig. 5) lay between two dated strata: sticks carried by the modern species beaver (_Caston canadensis_) and deposited in the old lake bottom were dated at 10,905 ± 105 years B.P.; a spruce log encountered four feet deeper in the same pit gave a date of 13,120 ± 130 years B.P. More than 14 feet of clay underlay the bones. The sediments which held the mastodon remains also contained numerous molluscs and pollen grains, permitting reconstruction of the burial site as lake surrounded by a spruce-dominated boreal forest.

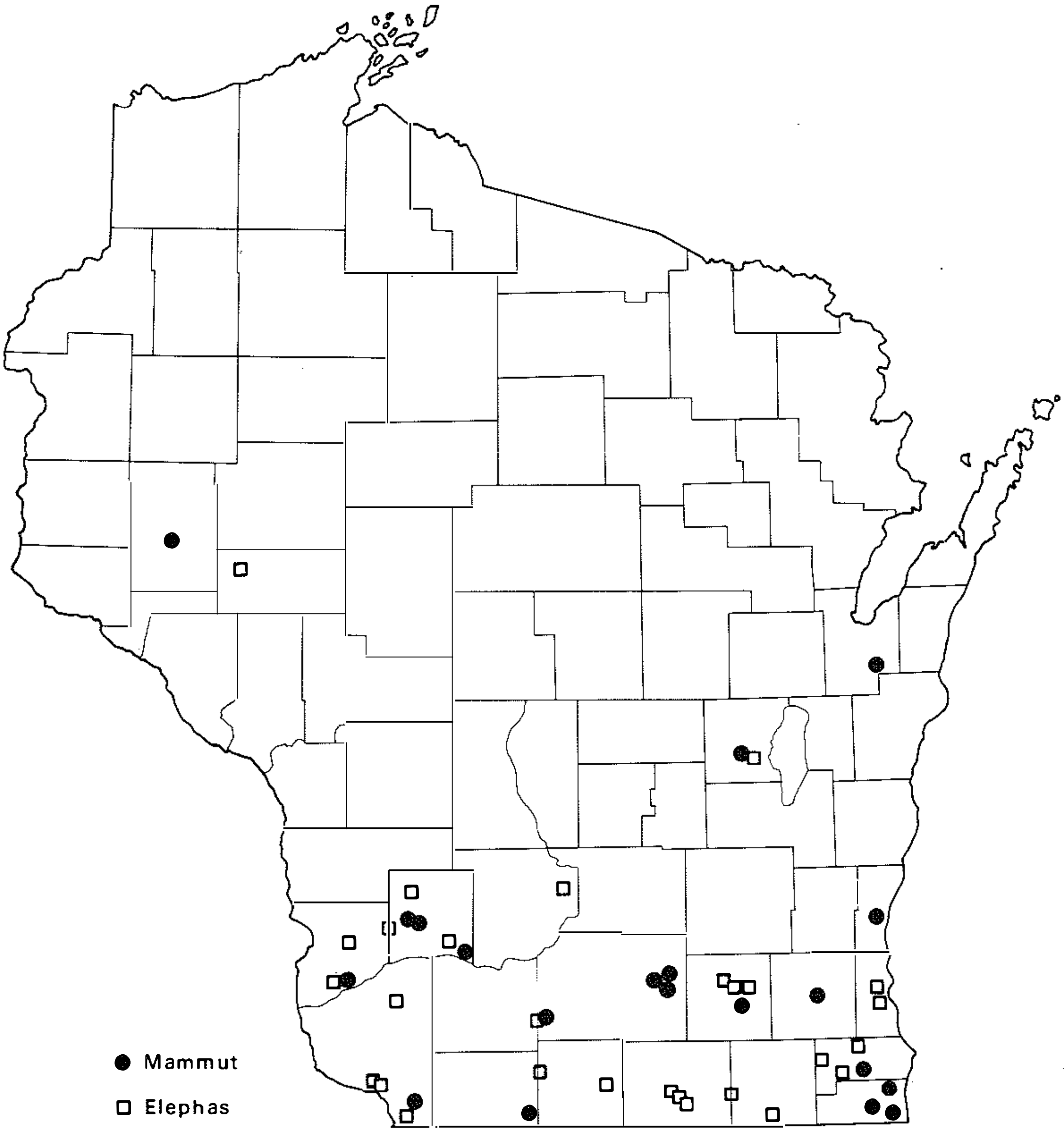

Figure 1. Distribution of proboscidean localities.

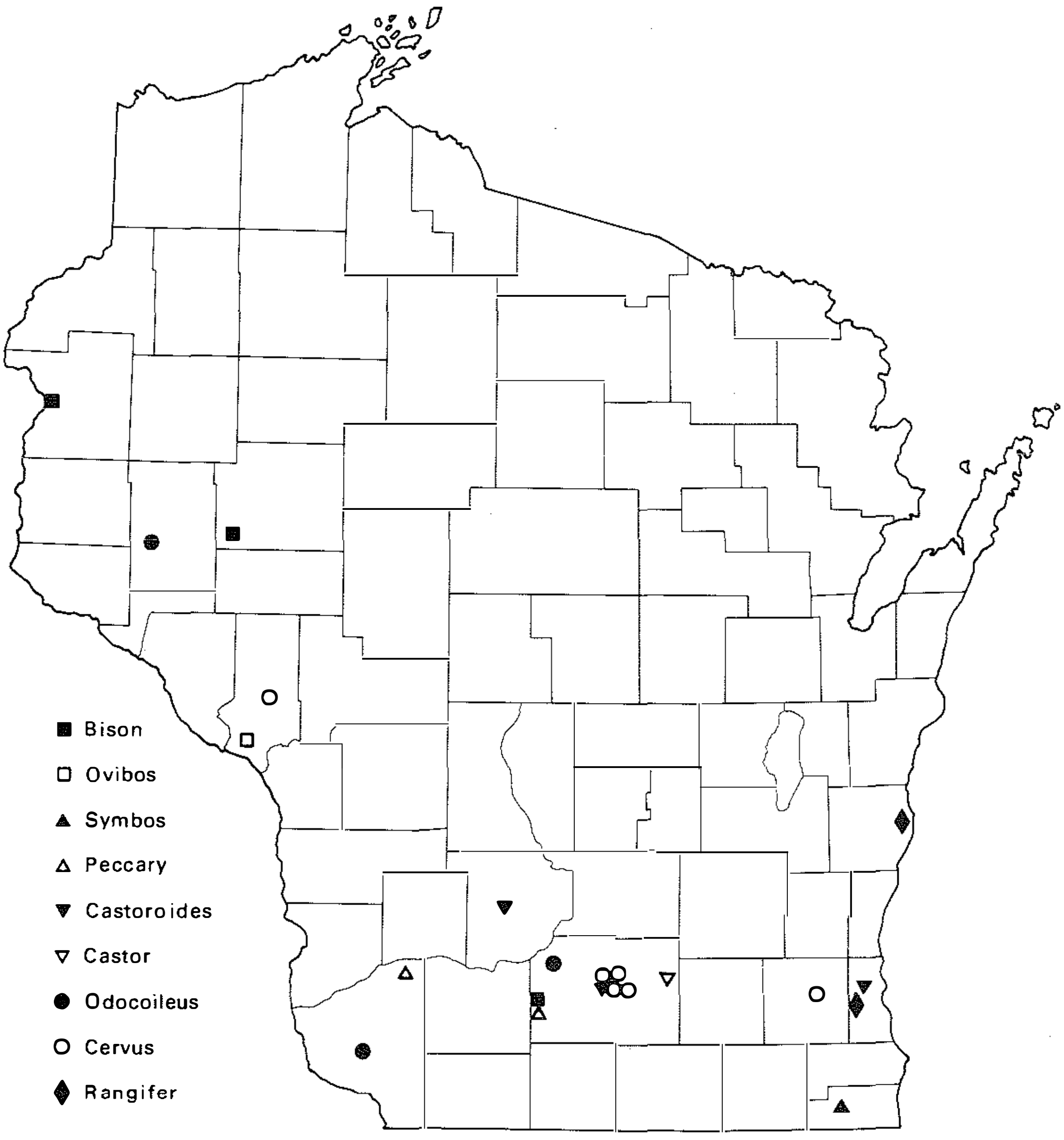

Figure 2. Distribution of large mammal localities.

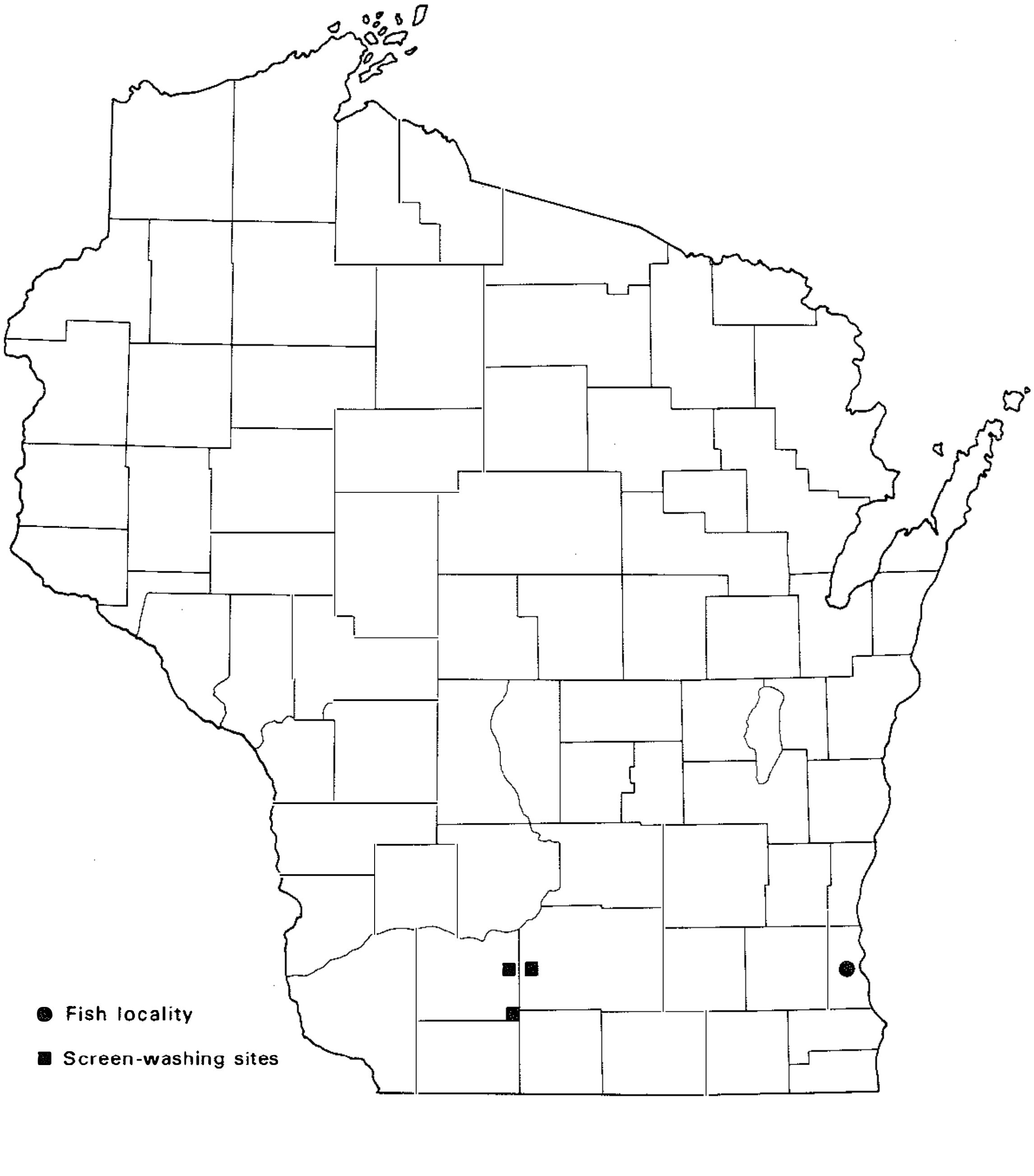

Figure 3. Distribution of small mammal and fish localities.

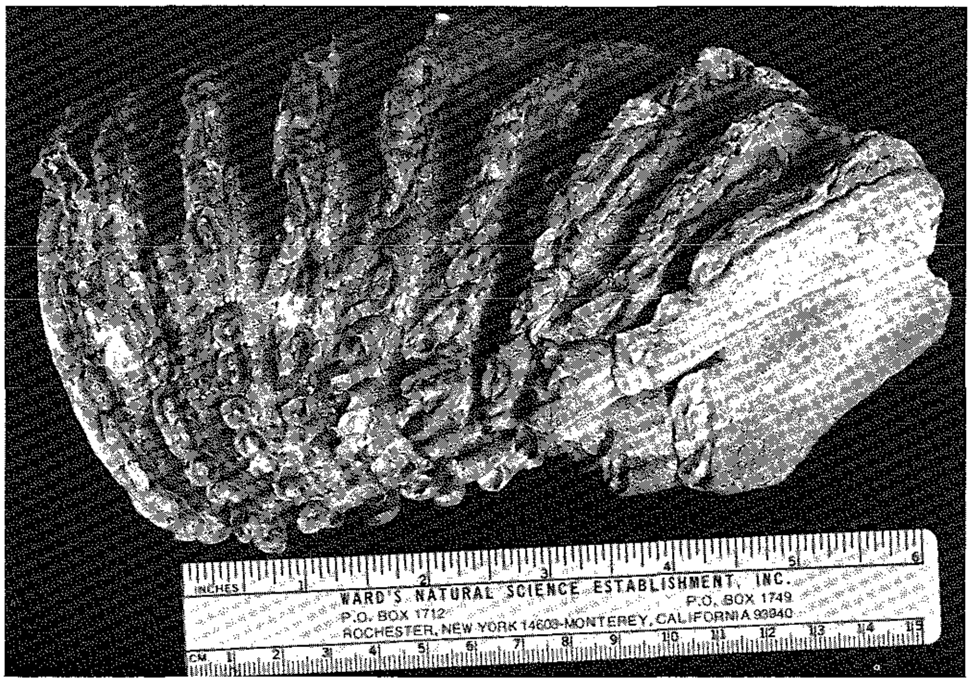

Figure 4. MPM 2, a mastodon molar from Fond du Lac, typical of finds in glacial drift.

Study of the second and third proboscidean localities, near Lake Mills and Jefferson in Jefferson County, is not complete. Each of these sites yielded an incomplete mammoth skeleton occurring under conditions virtually identical to those of the Deerfield mastodons. The bones are in clay rather than in till (the usual matrix for mammoth remains), suggesting that these animals likewise were buried on the fringe of a post-glacial lake. Molluscan remains were not recovered from the matrix surrounding the mammoth remains. Radiocarbon dates (Table 1) and the similar stratigraphic associations suggest that these mammoths were contemporary with the Deerfield mastodons.

A single complete skull with mandibles of the giant beaver, Castoroides ohioensis (Fig. 6). was discovered in 1968 during construction of a fish pond near Hope, 10 miles east of Madison (Dallman, 1969). The skull was not discovered until after its removal so that its original location can only be estimated at 4 to 6 feet below the surface in a marly clay deposit somewhat similar to the deposits encountered in the mastodon excavations. No radiocarbon dates were attempted because of the disturbed situation, but the date is presumed to be approximately 10,000 years B.P. Two other fragmentary mandibles of Castoroides ohioensis are recorded from Wisconsin, one from the Lincoln-Estabrook area, Milwaukee County and another from Plain, Sauk County.

The Interstate Park (Polk County) Bison locality produced approximately 300 Bison occidentalis specimens from a depth of three to four feet in a post-glacial peat bog (Palmer, 1954). Unlike the proboscidean localities, paleo-Indian artifacts were found in direct association with the Bison bones, but no radiocarbon dating was done. The occurrence is one of the relatively larger known samples of post-glacial Bison. The site is no longer available due to development of the park.

A recent study (Teller-Marshall and Bardack, 1978) considered 77 post-glacial fish specimens from a sewer excavation in Milwaukee. An assemblage of eight species was collected 45 to 50 feet below the present ground surface, and 40 to 45 feet above the present level of Lake Michigan. A radiocarbon date on associated wood is 7750 $\pm$ 125 years B.P., making this the oldest known fish locality in the Lake Michigan Basin. Molluscs and plant remains occur along with the fish, but they have not yet been thoroughly studied. The species present, plus the nature of the sediment, indicates deposition in a slowly moving prairie stream, well above the level of glacial Lake Chippewa. The completeness of the specimens at this site attests to the calm conditions at the time of death and during the subsequent rapid burial. This site is also now unavailable for further excavation.

The third fossiliferous depositional environment seems to be limited to the Driftless Area where porous Paleozoic carbonate rock is exposed at the surface without a veneer of obscuring drift. Fissures, sink holes and caves in this carbonate rock apparently have been open through much of the late Pleistocene and on into the Holocene, so many have been natural traps which have preserved stratified sequences of Pleistocene life.

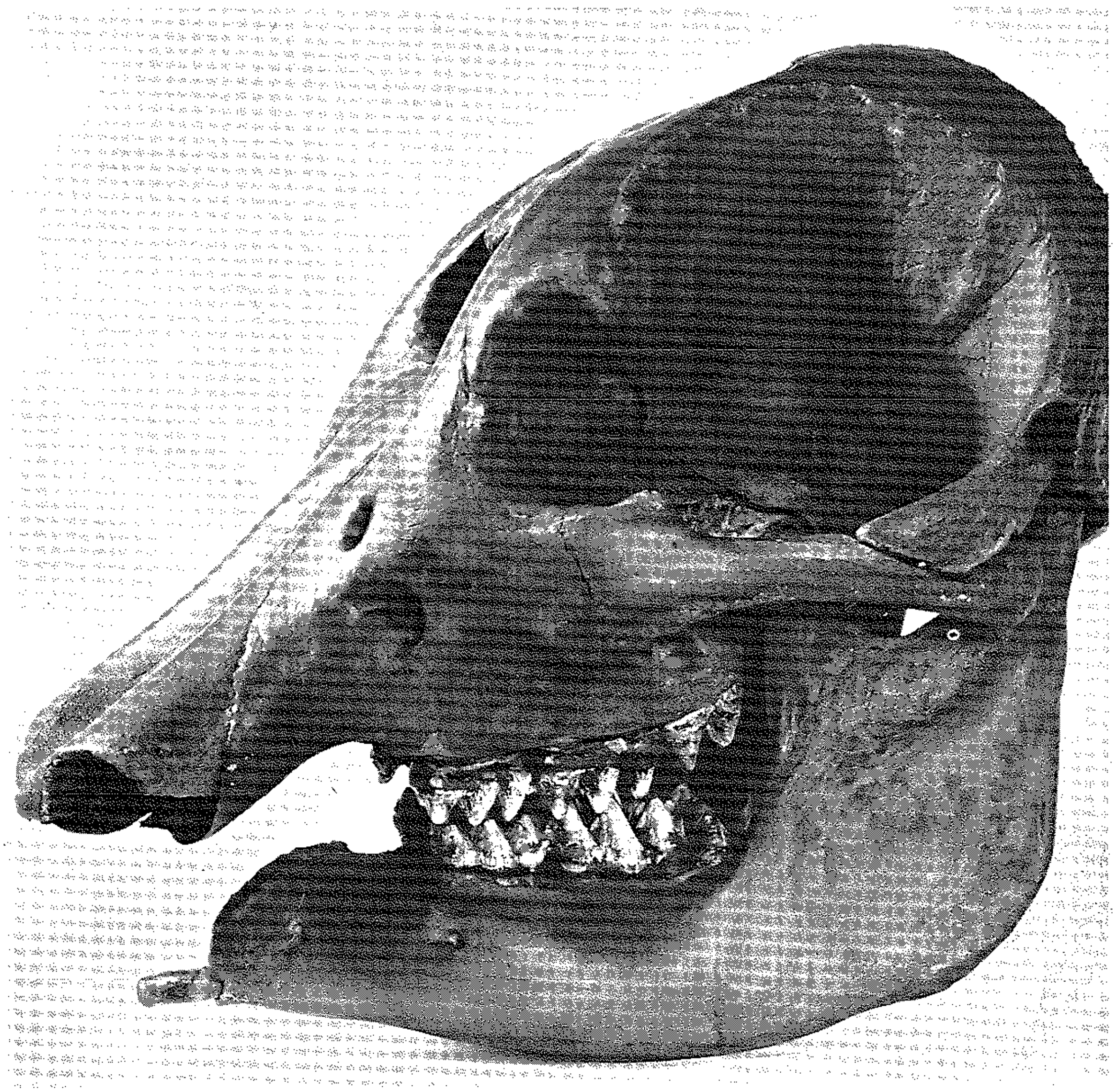

Figure 5. UWZP 20500, a mastodon recovered from Deerfield , Wisconsin, representative of specimens found in or adjacent to post-glacial lakes. Skull 89 cm in length.

Table 1

Ages of Wisconsin Late Pleistocene and Holocene Vertebrate Localities

Site		Date, Years B.P.	Laboratory Reference
Lost River Sink	Level 3	2,720 ± 390	Teledyne Isotopes, I-6622
	Level 4	3,970 ± 240	Teledyne Isotopes, I-6623
Milwaukee Fish		7,750 ± 125	Teledyne Isotopes, I-9545
Deerfield Mastodons		9,480 ± 100	Wisconsin - 265
		9,630 ± 110	Wisconsin - 267
		10,095 ± 105	Wisconsin - 424
		13,120 ± 130	Wisconsin - 431
Lake Mills Mammoth		9,065 ± 90	Wisconsin - 704
Moscow Fissure		17,050 ± 1,500	Teledyne Isotopes, I-10,153

Figure 6. UWZP 20000, skull of the giant beaver discovered in post-glacial sediments near Hope, Wisconsin. Maximum skull length, 28 cm.

So far, three places have produced vertebrate fossils: Moscow Fissure, near Blanchardville; Lost River Sink, near Blue Mounds; and an unnamed fissure near Cave of the Mounds. All of these are in Iowa County, at the eastern edge of the Driftless Area, and all yield abundant small-vertebrate remains (Fig. 7) when the sand and clay fillings of the cavities are wet-sieved through screen-bottomed washing boxes.

These microvertebrate sites have produced a much greater diversity of vertebrates than have any of the large vertebrate sites. Moscow Fissure has produced 20 mammalian species, two of which are rodents presently restricted to tundra areas, as well as snakes, frogs and salamanders. Lost River Sink has yielded 27 mammalian species, plus toads, frogs, snakes and lizards. Cave of the Mounds, which has been worked only in a preliminary fashion, has produced four mammals, a bird and a turtle. These abundant specimens already in hand now permit detailed comparisons of Moscow Fissure and Lost River Sink with similar fissure localities elsewhere in North America. The center for sympatry for Lost River Sink is modern southwestern Wisconsin; the fauna is a modern one, which corresponds well with radiocarbon dates on bone of 2720 ± 390 years B.P. and 3970 ± 1500 years B.P. On the other hand, Moscow Fissure gave a date of 17,050 ± 1500 years B.P. and has a zone of sympatry in the area of the southern part of the Ontario-Manitoba boundary, excluding the two species of tundra rodents. The presence of such old fauna and indications of rodent endemism in this assemblage show that the fissures have great potential for pushing the Wisconsin vertebrate record well back into the Wisconsinan and for revealing the nature of community evolution during the Wisconsinan glacial advances and retreats.

DISCUSSION

The diversity of vertebrates already recovered from the Wisconsin late Pleistocene and Holocene is rather high (Tables 2 and 3), especially when compared with geologically similar Michigan, which has been worked much more consistently than has Wisconsin. However, the total number of specimens, particularly of larger vertebrates, is much higher for Michigan. In both Michigan and Wisconsin much of the diversity comes from the few screen-washing sites, and these, other than Moscow Fissure, tend to be considerably younger geologically than the large-mammal sites. Two Michigan sites (Fenton Lake, 1000-3000 years B.P.; and Sleeping Bear Dunes, 730 ± 250 years B.P.) contain 29 of the 53 reported species (Dorr and Eschman, 1969). In Wisconsin, Moscow Fissure (17,500 ± 1500 years B.P.) and Lost River Sink (2720 ± 390 and 3970 ± 240 years B.P.) contain 39 of 60 reported Wisconsin species. The Milwaukee fish locality (7750 ± 125 years B.P.) is the only locality in the state to show any taxonomic diversity of aquatic vertebrates, as all eight species from there are fish.

There is a marked contrast between the Wisconsin-Michigan records and those from Iowa (Table 2). Certainly both the intensity of collecting efforts and the somewhat less rigorous late Pleistocene environment in Iowa account for much of this difference.

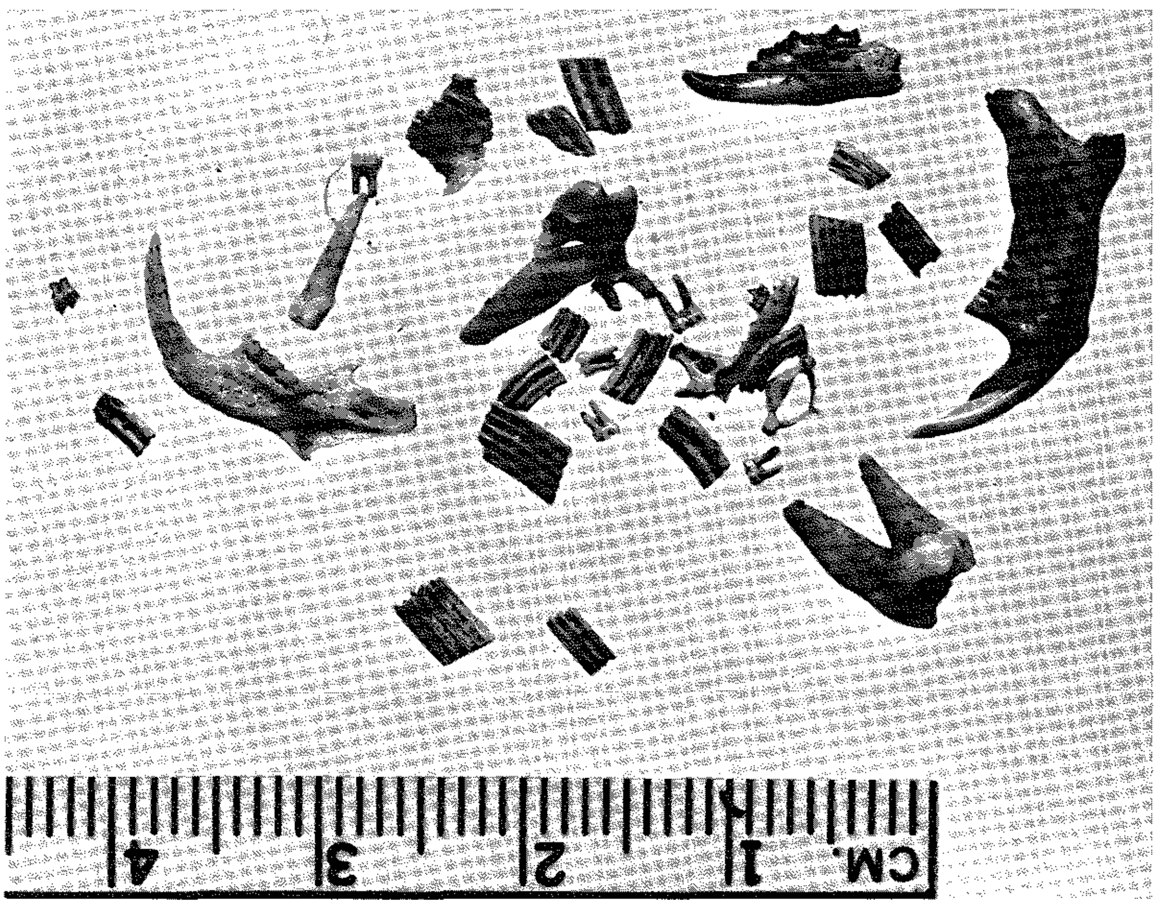

Figure 7. Specimens of small mammals, mostly rodents, from Lost River Sink, representative of collections of vertebrates made from sink holes and fissures in the Driftless Area.

Table 2

Wisconsinan and Holocene Vertebrate Diversity

	Wisconsin		Michigan[1]		Iowa[2]	
	Families	Species	Families	Species	Families	Species
Pisces	6	9	8	11	8	16
Amphibia	2	7	--	--	4	12
Reptilia	3	3	3	4	6	9
Aves	--	--	3	3	6	8
Mammalia						
Insectivora	2	6	1	1	2	8
Edentata	--	--	--	--	1	1
Rodentia	4	16	3	13	7	37
Carnivora	4	5	4	6	5	14
Pinnepedia	--	--	1	1	--	--
Cetacea	--	--	3	3	--	--
Proboscidea	2	2	2	2	1	3
Artiodactyla	3	9	3	9	3	14
Perissodactyla	--	--	--	--	1	1
Chiroptera	1	2	--	--	1	6
Lagomorpha	1	1	--	--	1	2
	28	60	31	53	46	131

[1]Data from Dorr and Eschman, 1969

[2]Data from Leslie P. Fay, personal communication, April 25, 1978

Table 3

Late Wisconsin and Holocene Vertebrates of Wisconsin

ORDER	FAMILY	GENUS AND SPECIES	REFERENCE
Pisces	Umbridae	*Umbra limi*	Teller-Marshall & Bardack 1978
	Esocidae	*Esox* sp.	Teller-Marshall & Bardack 1978
	Catastomidae	Indet.	Teller-Marshall & Bardack 1978
	Ictaluridae	*Ictalurus melas*	Teller-Marshall & Bardack 1978
	Centrarchidae	*Micropterus dolomievi*	Teller-Marshall & Bardack 1978
		Lepomis cyanellus	Teller-Marshall & Bardack 1978
		Lepomis gibbosus	Teller-Marshall & Bardack 1978
		Indet.	Teller-Marshall & Bardack 1978
	Salmonidae	*Cristivomer namaycush*	Hussakof 1916; Hay 1923
		[*Salvelinus namaycush*]	
	Indet.		Theiling 1973
Amphibia			
Anura	Bufonidae	*Bufo* cf. *cognatus*	Theiling 1973
		Bufo americanus	Theiling 1973

ORDER	FAMILY	GENUS AND SPECIES	REFERENCE
		Bufo sp.	Theiling 1973
	Ranidae	*Rana catesbeiana*	Theiling 1973
		Rana pipiens	Theiling 1973
		Rana palustris/sylvatica	Theiling 1973
		Rana sp.	Rasmussen 1971; Theiling 1973
Caudata	Indet.		Rasmussen 1971
Reptilia			
Lacertilia	Anguidae	*Ophisaurus attenuatus*	Theiling 1973
Squamata	Colubridae	Indet.	Theiling 1973
	Crotalidae	Indet.	Theiling 1973
	Indet.		Rasmussen 1971
Aves			
Indet.			Theiling 1973
Mammalia			
Insectivora	Talpidae	*Scalopus aquaticus*	Rasmussen 1971; Theiling 1973
	Soricidae	*Blarina brevicauda*	Rasmussen 1971; Theiling 1973

ORDER	FAMILY	GENUS AND SPECIES	REFERENCE
	Soricidae	*Cryptotis parva*	Rasmussen 1971; Theiling 1973
		Sorex cinereus	Rasmussen 1971; Theiling 1973
		Sorex palustris	Rasmussen 1971
		Microsorex hoyi	Rasmussen 1971
Chiroptera	Vespertilionidae	*Myotis* sp.	Theiling 1973
		Pipistrellus cf. *subflavus*	Theiling 1973
Rodentia	Sciuridae	*Sciurus* sp.	Theiling 1973
		Tamias striatus	Theiling 1973
		Citellus tridecemlineatus	Rasmussen 1971; Theiling 1973
	Cricetidae	*Peromyscus* cf. *maniculatus*	Rasmussen 1971; Theiling 1973
		Peromyscus leucopus	Rasmussen 1971
		Synaptomys cooperi	Theiling 1973
		Synaptomys borealis	Theiling 1973
		Synaptomys sp.	Rasmussen 1971
		Microtus pennsylvanicus	Rasmussen 1971; Theiling 1973
		Microtus ochrogaster	Rasmussen 1971; Theiling 1973

ORDER	FAMILY	GENUS AND SPECIES	REFERENCE
		Pitymys pinetorum	Theiling 1973
		Cleithronomys gapperi	Rasmussen 1971
		Phenacomys cf. *ungava*	Rasmussen 1971
	Geomyidae	*Thomomys talpoides*	Rasmussen 1971
	Castoridae	*Castor canadensis*	Hay 1923
		Castoroides ohioensis	Dallman 1969
Lagomorpha	Leporidae	Indet.	Theiling 1973
		Sylvilagus cf. *floridanus*	Rasmussen 1971
Proboscidea	Mammutidae	*Mummut americanum*	Hay 1914, 1923; Dallman 1968
	Elephantidae	*Elephas primigenius*	Hay 1914, 1923
Artiodactyla	Tayussuidae	*Tayussu*	Hay 1914, 1923
		Platygonus	Palmer 1974
	Cervidae	*Odocoileus*	Hay 1914, 1923
		Cervus canadensis	Hay 1914, 1923
		Rangifer tarandus	Hay 1923; West 1978
	Bovidae	*Bison occidentalis*	Palmer 1954
		Bison bison	Hay 1923
		Ovibos	Unpublished

ORDER	FAMILY	GENUS AND SPECIES	REFERENCE
		Symbos	Unpublished
Carnivora	Ursidae	*Ursus americanus*	Theiling 1973
	Procyonidae	*Procyon lotor*	Theiling 1973
	Mustelidae	*Mephitis mephitis*	Theiling 1973
	Canidae	*Vulpes fulva*	Theiling 1973
		Canis	Allen 1876; Hay 1914

In summary, the late Pleistocene and Holocene vertebrate record of Wisconsin is at this point relatively poorly known. This is due in part to historical accident and in part to the geologic configuration of the state. Those sites and occurrences which have been studied, and those which are under active investigation at present, do, however, give hope for the future. In particular, careful examination of post-glacial lake deposits in southern Wisconsin and late Pleistocene to Holocene caves and fissures in the Driftless Area should be productive. A joint effort of the University of Wisconsin-Madison and the Milwaukee Public Museum is intended to substantially increase our knowledge of the recent part of this state.

ACKNOWLEDGMENTS

We are most grateful for information on unpublished specimens furnished by H. A. Palmer, University of Wisconsin-Platteville, and P. Sander, Kenosha Public Museum. H. Semken and L. P. Fay, University of Iowa, provided lists of Iowa Pleistocene vertebrates and the radiocarbon date for Lost River Sink. The senior author's work on Wisconsin vertebrates is supported by the Friends of the Museum, Inc., Milwaukee.

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Plate 1. Explanation. All figures are SEM micrographs.

1,2 — *Clavohamulus densus* Furnish. 1, posterior view of element coated with calcium phosphate crystals (x70), UW 1677/40; 2, posterior view (x70), UW 1677/39, both from locality 29.

3,12,13 — *Ulrichodina wisconsinensis* Furnish. 3, lateral view (x75), UW 1677/18; 12, posterior view showing flat, rather than depressed, anterobasal extension (x40), UW 1677/17; 13, lateral view showing an atypical projection from the keel like posterior edge (x75), UW 1677/19, all from locality 3.

4,5 — *Ulrichodina prima* Furnish. 4, posterior view (x40), UW 1677/29; 5, lateral view (x50), UW 1677/8, both from locality 25.

6 — *Ulrichodina deflexus* Furnish. Posterior view showing longitudinal posterior groove (x50), UW 1677/7, locality 25.

7-10 — *Paltodus* sp. Lateral views of four different elements showing a sequence of increasing costae development (all x40), UW 1677/11, 12, 24, 25 respectively, all from locality 3.

11 — *Cordylodus angulatus* Pander. Lateral view (x55), UW 1677/4, locality 39.

14,15 — *Oistodus* sp. aff. *O. inaequalis* Pander. 14, lateral view (x50), UW 1677/9, locality 3; 15, lateral view (x70), UW 1677/45, locality 14.

16 — *Oistodus* sp. cf. *O. forceps* Lindström. Lateral view (x85), UW 1677/10, locality 3.

17,25-27 — *Acodus oneotensis* (Furnish). 17, lateral view of *"Oistodus" triangularis* element (x60), UW 1677/64; 25, lateral view of *Acodus oneotensis* element (x70), UW 1677/62; 26, lateral view of *Paltodus bassleri* element (x50), UW 1677/60; 27, lateral view of *Paltodus variabilis* element (x50), UW 1677/61, all from locality 39.

18,19 — *Scolopodus quadraplicatus* Branson & Mehl. 18, posterior view (x25), UW 1677/16; 19, lateral view (x25), UW 1677/15, both from locality 3.

20-23 — *Drepanodus* n. sp. 20, lateral view of homocurvatid element (x50), UW 1677/28, locality 3; 21, lateral view of suberectid element (x70), UW 1677/46, locality 14; 22, lateral view of suberectid element (x50), UW 1677/6, locality 14; 23, lateral view of homocurvatid element (x65), UW 1677/26, locality 3.

24,31-33 — *Acodus stola* (Lindström). 24, lateral view of distacodid element (x60), UW 1677/55, locality 23; 31, lateral view of acodid element (x50), UW 1677/27, locality 3; 32, posterior view of acontiodid element (x70), UW 1677/34, locality 3; 33, lateral view of acontiodid element (x70), UW 1677/33, locality 3.

28 — *Scolopodus* sp. aff. *S. cornutiformis* Branson & Mehl. lateral view (x45), UW 1677/63, locality 5.

29 — *Drepanodus parallelus* Branson & Mehl. Lateral view (x35), UW 1677/37, locality 25.

30 — *Oneotodus simplex* Furnish. Lateral view (x70), UW 1677/52, locality 6.

34,35 — *Scolopodus triplicatus* Ethington & Clark. 34, lateral view (x50), UW 1677/32; 35, lateral view (x50), UW 1677/31, both from locality 3.

36 — *Scandodus furnishi* Lindström. Lateral view (x 45), UW 1677/23, locality 25.

37 — Unidentified distacodontid showing single apatite crystal coating the cusp (x90), UW 1677/42, locality 29.

38 — ?*Drepanodus sculponea* Lindström. Lateral view (x60), UW 1677/65, locality 3.

39 — *Loxodus bransoni* Furnish. Lateral view (x50), UW 1677/2, locality 39.

40,42 — *Drepanodus subarcuatus* Furnish. 40, lateral view (x50), UW 1677/58, locality 2; 42, lateral view (x30), UW 1677/38, locality 25.

41 — *Scolopodus triangularis* Ethington & Clark. Lateral view (x60), UW 1677/56, locality 36.

43 — *Drepanodus conulatus* Lindström. Lateral view (x75), UW 1677/3, locality 3.

44,45 — New genus, new species. 44, lateral view of specimen with single denticle (x85), UW 1677/21; 45, lateral view of specimen with three denticles (x110), UW 1677/22, both from locality 3.

46 — *Acontiodus iowensis* Furnish. Posterior view (x 60), UW 1677/59, locality 20.

47,48 — *Acontiodus bicurvatus* (Stauffer). 47, posterior view (x45), UW 1677/14; 48, lateral view (x45), UW 1677/13, both from locality 3.

49 — *Acontiodus staufferi* Furnish. Posterior view (x 65), UW 1677/47, locality 2.

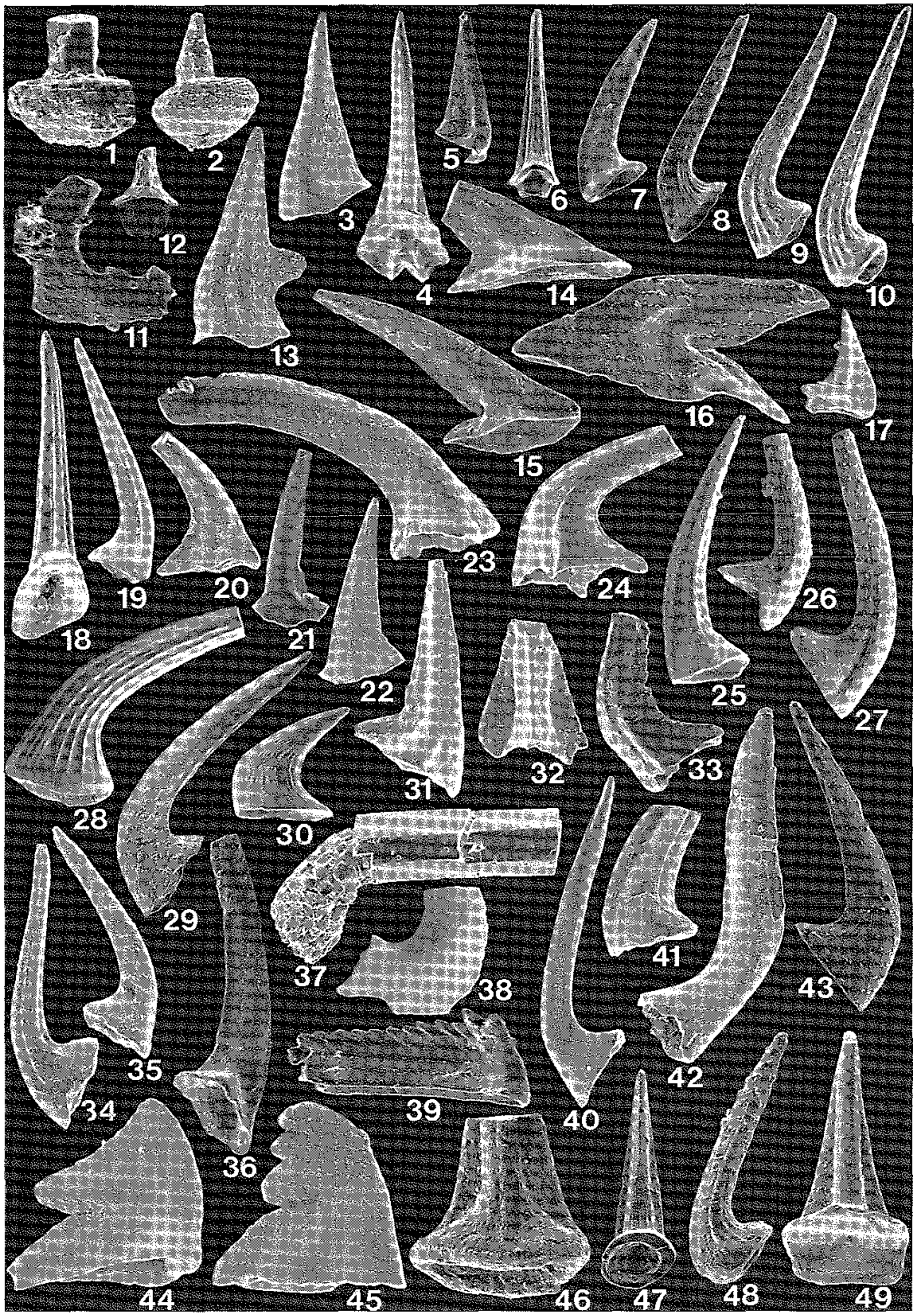

Plate 1. Photomicrographs of described conodonts of Grether and Clark.