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A GUIDE TO FOSSIL SHARKS, SKATES, AND RAYS FROM THE CHESAPEAKE AND DELAWARE CANAL AREA, DELAWARE

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FOREWORD

The authors of this paper are serious avocational students of paleontology. We are pleased to present their work on vertebrate fossils found in Delaware, a subject that has not before been adequately investigated.

Edward M. Lauginiger of Wilmington, Delaware teaches biology at Academy Park High School in Sharon Hill, Pennsylvania. He is especially interested in fossils from the Cretaceous. Eugene F. Hartstein, also of Wilmington, is a chemical engineer with a particular interest in echinoderm and vertebrate fossils. Their combined efforts on this study total 13 years. They have pursued the subject in New Jersey, Maryland, and Texas as well as in Delaware. Both authors are members of the Mid-America Paleontology Society, the Delaware Valley Paleontology Society, and the Delaware Mineralogical Society.

We believe that Messrs. Lauginiger and Hartstein have made a significant technical contribution that will be of interest to both professional and amateur paleontologists.

Robert R. Jordan
State Geologist

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INTRODUCTION

In recent years there has been a renewed interest by both amateur and professional paleontologists in the rich Upper Cretaceous exposures along the Chesapeake and Delaware Canal, Delaware (Fig. 1). Large quantities of fossil material, mostly clams, oysters, and snails have been collected as a result of this activity. Recent dredging (1978, 1981) by the United States Army Corps of Engineers has helped expose a rich vertebrate fossil assemblage. It includes representatives from the classes Reptilia, Osteichthyes, and Chondrichthyes. An extensive literature search has revealed that a wealth of information exists which would aid in the identification of the vertebrate fossils of Delaware.

Most of the vertebrate material collected consists of teeth of sharks and their relatives, the skates and rays. The lack of published material specific to Delaware has led to the misidentification of many specimens. This paper will aid in the correct identification of fossil teeth from the Class Chondrichthyes and, we hope, stimulate a similar interest in the study of the other vertebrate faunas.

Definitions of terms found in the text are located in the Glossary (Appendix A); the classification and photographs of fossils in Appendix B and Appendix C, respectively.

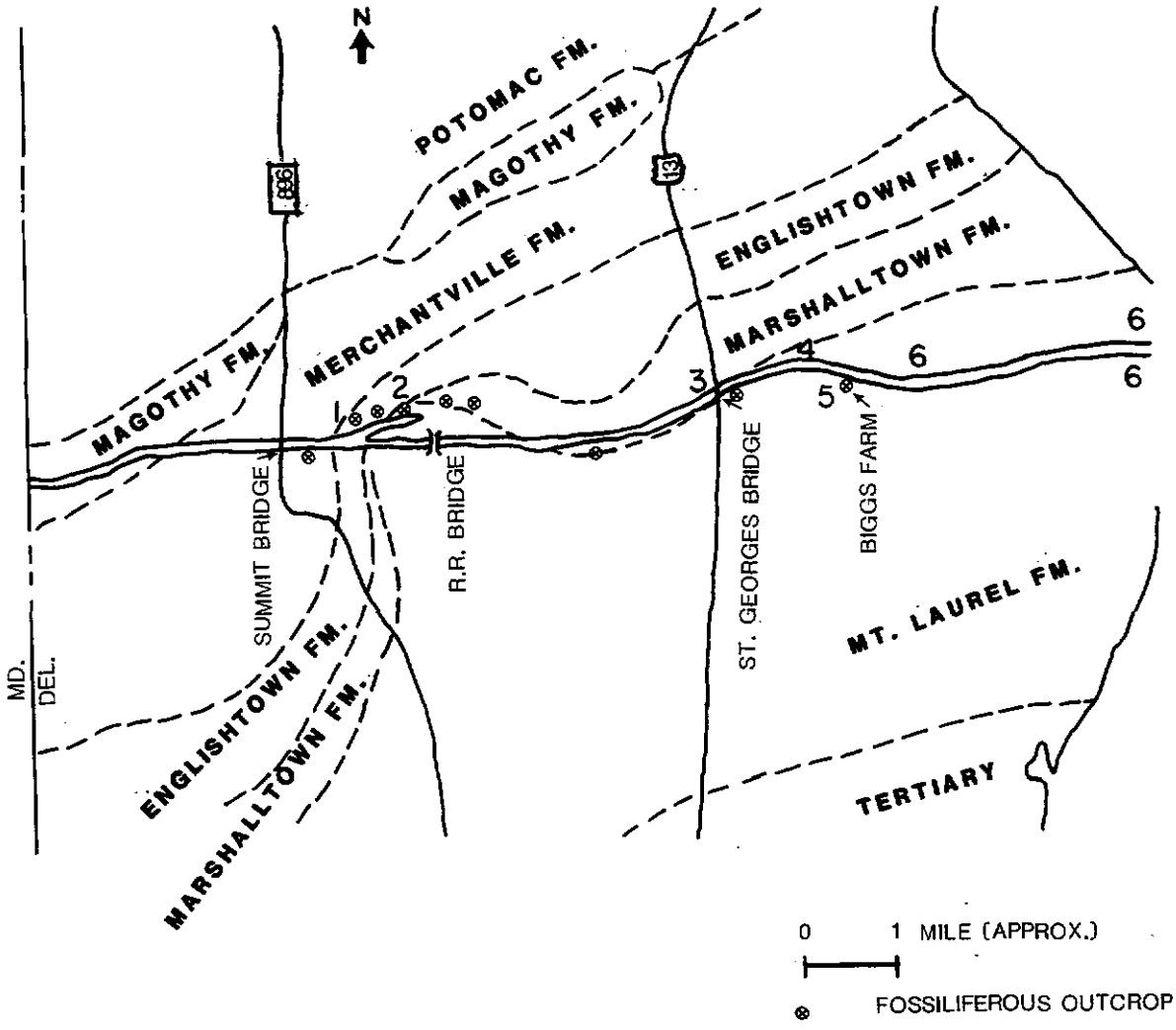


Figure 1. Locality locations (base map after Pickett, 1972).

1 - Deep Cut

2 - Deep Cut spoils

3 - Marshalltown spoils (new)

4 - Marshalltown spoils (old)

5 - Biggs Farm

6 - Mount Laurel spoils

ACKNOWLEDGMENTS

The authors would like to extend their thanks to Dr. Thomas E. Pickett, of the Delaware Geological Survey, who saw a need and suggested that we undertake this project. The staff of the Delaware Geological Survey provided technical assistance and aided in the review of this manuscript. Professor F. S. Swain of the Geology Department at the University of Delaware provided us with the scanning electron microscope pictures.

Mr. Gerard R. Case, Jersey City, New Jersey, gave us much needed assistance in the identification of specimens and in the review of this paper.

Ms. Sophie Homsey allowed us to study specimens she obtained from now inaccessible locations.

Mrs. Joanne Henderson and Mrs. Jane Lauginiger of the Wilmington Institute Library helped us to obtain documents without which this project could not have been completed.

D. Kenneth Gagon did the art work for some of the illustrations.

PREVIOUS STUDIES

The Chesapeake and Delaware Canal, built between 1824 and 1829, has been the site of many fossil studies. A brief history of the early works on the fossils and stratigraphy of the area may be found in Groot, Organist, and Richards (1954). An important early study of similar-age shark material from New Jersey was done by Fowler (1911). Richards et al. (1958, 1962) studied the invertebrate Cretaceous fossils of New Jersey and included information and illustrations of material from the Canal area.

The foraminifera from the area were studied by Mumby (1961). Olsson (1960) described the planktonic foraminifera from Late Cretaceous age.

Richards and Shapiro (1963) did a systematic study of the Upper Cretaceous macroinvertebrate fossils from the Biggs Farm locality. Pickett (1970, 1972) remapped the stratigraphy from the Canal area and reprinted the plates of Groot et al. (1954) and Richards and Shapiro (1963). Pickett, Kraft, and

Smith (1971) published a report on the Upper Cretaceous arthropod burrows found in the Canal exposures.

Fossil sharks from similar age deposits in New Jersey were studied and updated by Cappetta and Case (1975b).

Selected papers on the geology of Delaware were presented to the Delaware Academy of Science in 1976 and were edited for publication by Kraft and Carey (1979).

Dinosaurs from New Jersey and Delaware were studied by Baird and Horner (1977). Baird and Galton (1981) figured pterosaurian bones from the Merchantville Formation.

Lauginiger and Hartstein (1981) published a general guide to the Canal area which included illustrated plates of both vertebrate and invertebrate fossils.

Gallagher (1982) reported on Delaware hadrosaurian material in the newsletter of the Delaware Valley Paleontological Society.

GEOLOGY

The Upper Cretaceous marine deposits at the Chesapeake and Delaware Canal are represented by five formations (Fig. 2). The oldest formation, the Magothy, represent the transition from the non-marine Cretaceous Potomac Formation to later marine sediments. A small unconformity separates it from a sequence of transgressions and regressions that took place during the Late Cretaceous. The sediments indicate that there were two periods of transgression-regression separated by an unconformity.

DISCUSSION

Selachian (sharks and their close relatives) fossils were collected from the Merchantville and Marshalltown formations (Campanian) and the Mount Laurel Formation (Middle Maestrichtian)(Table 1). Collection techniques varied from surface inspection to the fine screening of suitable sediments.

Teeth from the Mount Laurel Formation were collected at the Reedy Point North and South spoil areas and the outcrop at

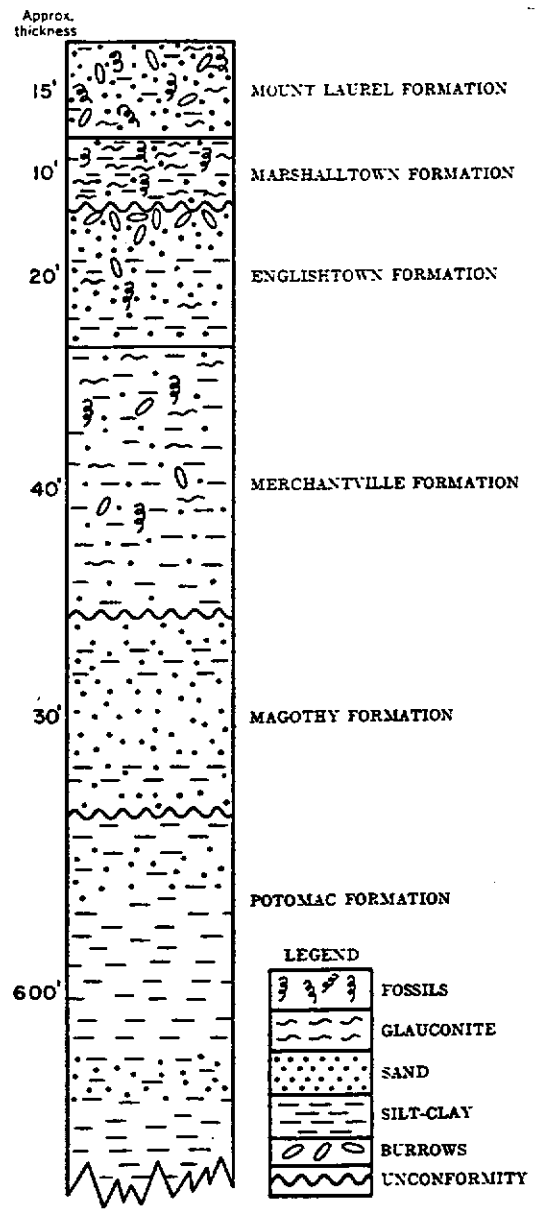


Figure 2. Stratigraphic column (after Pickett, 1970).

Figure 2 (continued).

Mount Laurel Formation:

Gray, green, white to red-brown, glauconitic, fine to medium silty quartz sand. Contains a macroinvertebrate fauna of well over a hundred species. This formation also contains a fair amount of shark material. The lithology and fossils indicate that it was deposited during a slight regression.

Marshalltown Formation:

Dark greenish gray, highly glauconitic, very fine silty sand. It has yielded mosasaur, turtle, and hadrosaur material. It contains the most diverse fauna of shark material. There are also abundant large pelecypods. The formation was deposited in a shallow, open marine, possibly embayed area.

Englishtown Formation:

White, gray, and red-brown, well sorted, micaceous, sparsely glauconitic, fine sand with thin interbedded layers of dark silty sand. The upper section is extensively burrowed and contains abundant nodulose burrows of the anthropod Protocallianassa. This formation has only a few very poorly preserved invertebrate fossils. There are no records of any vertebrate material from this formation. It represents sediments deposited during a drop in sea level.

Merchantville Formation:

Dark gray to dark blue, very micaceous, glauconitic, sandy silt and silty fine sand. This formation has many burrows made by benthic organisms and contains numerous siderite nodules. It has an extensive invertebrate macrofauna and has yielded large ammonites and numerous arthropods. The vertebrate remains are sparse but include many important finds including turtles, mosasaurs, pterosaurs, bony fish, as well as shark material. The sediments were deposited in an open marine, shallow water environment.

Magothy Formation:

White and buff, well sorted clean quartz sand with beds of gray and black clayey silt. The formation contains much lignite and is rich in sulfide minerals. No vertebrate and very few invertebrate fossils have been reported from this formation. It was deposited in a deltaic shoreline environment.

Table 1. Fossil Occurrences.

Fossil Names	Locations*					
	1	2	3	4	5	6
Hybodus sp.			x	x		
Lonchidion babulskii			x	x		
Rhinobatos casieri			x	x		
Ischyrhiza mira	x	x	x	x	x	x
Sclerorhynchus sp.			x			
Rhombodus levis			x	x		
Brachyrhizodus wichitaensis			x	x		
Pseudohypolophus sp.			x	x		
Ptychotrygon vermiculata			x	x		
Squatina hassei			x	x	x	
Ginglymostoma globidens			x	x		
Odontaspis holmdelensis			x	x	x	
Odontaspis samhammeri			x	x	x	x
Hypotodus aculeatus			x	x	x	
Scapanorhynchus texanus	x	x	x	x		
Plicatolamna arcuata			x	x		
Plicatolamna borodini			x			
Cretolamna appendiculata lata	x	x	x	x		
Cretolamna appendiculata pachyrhiza					x	x
Paranomotodon angustidens		x	x	x		
Squalicorax kaupi		x	x	x	x	x
Squalicorax pristodontus			x	x	x	x
Pseudocorax granti			x	x	x	

* Explanation:

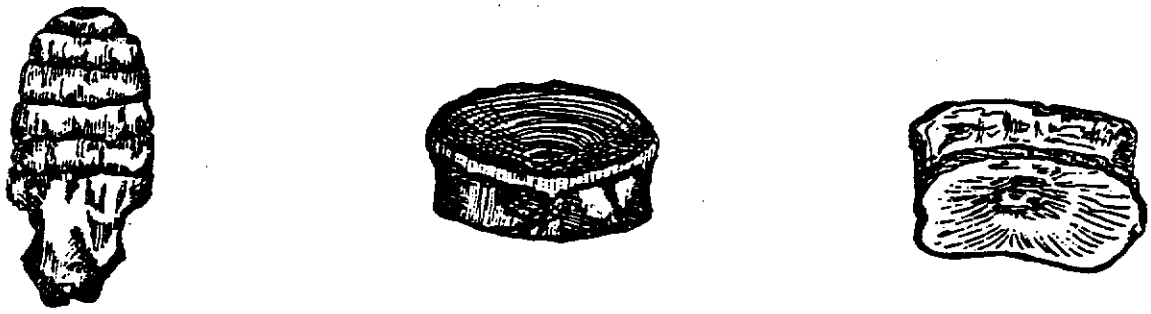
1 - Deep Cut (Merchantville Formation).
2 - Deep Cut spoils (Merchantville Formation).
3 - St. Georges-West (Marshalltown Formation).
4 - St. Georges-East (Marshalltown Formation).
5 - Biggs Farm (Mount Laurel Formation).
6 - Reedy Point spoils (Mount Laurel Formation).

Biggs Farm (refer to Fig. 1). Surface inspection was the predominant collecting technique used in spoils. This reduced the probability of obtaining the smallest teeth. At Biggs Farm, large quantities of the outcropping sediment were processed through a one-eighth inch screen, washed, dried, and subsequently inspected. The large quantity of invertebrate material made the use of a finer screen impractical and a number of tiny teeth were undoubtedly lost. Most notably, the Mount Laurel assemblage lacks Scapanorhynchus but includes Squalicorax pristodontus and Odontaspis samhammeri in fair numbers. Cretolamna appendiculata pachyrhiza occurs only here, replacing the typical subspecies C. appendiculata lata. We believe this to be the first reported occurrence of C. pachyrhiza in the Atlantic Coastal Plain.

The Marshalltown Formation is by far the richest source of vertebrate material. Spoils, interpreted to be derived from the Marshalltown on the north side of the Canal both east and west of the Town of St. Georges, contain a concentrated vertebrate fauna which exhibits some evidence of reworking. The general absence of calcitic or aragonitic remains, and the sandy nature of the deposits, facilitated fine sieving. The sievings revealed a large and varied assemblage similar to that reported by Cappetta and Case (1975b) for the Upper Cretaceous of New Jersey. Three genera, in addition to those described by Cappetta and Case, were noted: Pseudohypolophus, Sclerorhynchus, and Pseudocorax. A currently inaccessible outcrop at South St. Georges once produced similar teeth.

Merchantville shark teeth were collected by surface inspection of the Deep Cut (Fig. 1) and a now overgrown spoil pile nearby. The assemblage includes Scapanorhynchus, Squalicorax kaupi, Cretolamna appendiculata lata, and lacks Squalicorax pristodontus, Odontaspis, and Plicatolamna.

Shark vertebrae and coprolites have been recovered from all the formations (Fig. 3). The trend from older to younger sediments in an eastward direction along the Canal is reflected in the fauna. Scapanorhynchus and Brachyrhizodus, which occur in Campanian sediments, are absent from the easternmost deposits of probable Maestrichtian age. Squalicorax pristodontus becomes less common as the sediments become older (westward). Cretolamna appendiculata pachyrhiza, of the Mount Laurel Formation, exhibits characteristics suggestive of the early Tertiary Lamna obliqua.



a. b. c.

Figure 3. a - Shark coprolite (x1); b - Shark vertebra (x2); c - Batoid vertebra (x3).

SYSTEMATICS*

GENUS Hybodus (Agassiz, 1837)

Hybodus sp.

Edaphodon sp. (Case, 1967, p. 8, fig. 32).
?Asteracanthus sp. (Miller, 1968, p. 467, pl. 1, fig. 2).
Edaphodon? (Miller, 1968, p. 469, pl. 1, fig. 10).
Hybodus sp. (Case, 1973, p. 19, fig. 61).
Asteracanthus sp. (Case, 1973, p. 51, fig. 216; p. 52, fig. 218; p. 54, figs. 228, 230).
Ischyodus sp. (Case, 1973, p. 54, fig. 229).
Hybodus sp. (Cappetta and Case, 1975b, p. 4, fig. 2; pl. 1, figs. 1-6).
Hybodus sp. (Case 1979, p. 79, figs. 1-2).

Description

The crowns are typically 6-8 mm high and up to 8 mm wide at the base on isolated crown specimens (Fig. 4). All specimens collected were rootless and most have lost the enamel shoulder. Both faces of the acutely triangular central cusp are strongly convex. On some specimens there is evidence of one or more lateral cusps. The lingual face has numerous, distinct longitudinal pleats running one-half to two-thirds of the way up the crown. This feature is usually lost on worn specimens.

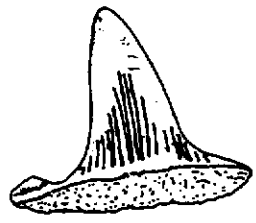


Figure 4. Hybodus sp. (lingual face)(x4).

* Classification and photographs of fossils are located in appendices.

Discussion

There have been no complete teeth collected from Delaware by the authors. Recently, however, one nearly complete specimen has been recovered from similar age deposits in New Jersey (Case, personal communication).

Comparison of the teeth from Delaware to teeth of the same genera collected in the western interior leaves little doubt of their identity.

In addition to teeth, dorsal fin, spines, and cephalic hooks of this genus have been found in Delaware, New Jersey, Montana, Wyoming, and Georgia.

Case (1979) has also reported this genus from the Upper Cretaceous Peedee Formation of North Carolina.

GENUS Lonchidion (Estes, 1964)

Lonchidion babulski (Cappetta and Case, 1975)

Lonchidion babulski (Cappetta and Case, 1975b, p. 7, pl. 1, figs. 7-12).

Description

The crown is low, about 2 mm in maximum height, and 5-7 mm in width, and without serrations or ornamentation. Its occlusal profile is elongate, tapered at the ends, inflated in the middle, and has a well developed transverse crest. The crown is constricted at the root margin and on most specimens has a well developed central labial projection. Wear spots often occur at the crown apex and on the labial projection.

The root is smaller than the crown, massive, and offset lingually. The root has numerous fenestrations on the labial and lingual faces with a prominent row immediately below the crown margin.

Discussion

Teeth of this hybodont shark have only been obtained by bulk screening of spoils believed to be Marshalltown-derived. It is an extremely rare tooth and most specimens are badly worn. All specimens, except one, were without a root. This may be because the many fenestrations facilitate root breakage. This species also occurs in New Jersey and Wyoming.

GENUS Rhinobatos (Linck, 1790)

Rhinobatos casieri (Herman, 1973)

Rhinobatos casieri (Herman, 1973, p. 273, pl. 13, fig. 1).
Rhinobatos casieri (Cappetta and Case, 1975b, p. 25, pl. 6, figs. 22-25).
Rhinobatos casieri (Case, 1981, p. 68, pl. 3, fig. 9).

Description

Teeth minute, averaging 1.5 mm in diameter. Tooth enameloid slightly larger than the biolobed root base, with two overhanging "cusplets", one on either side of the central cusp. Tooth in profile has a pronounced apex, no carinae (on specimens showing wear from crushing shells). Gross lateral facette foraminia on the root in lingual aspect, one on either side of the "uvala" caused by the central cusp overhanging the root boss. Foramina in median furrow (groove) on basal aspect (Case, 1981, p. 68).

Discussion

Teeth of this guitarfish are rare, and only ten, mostly incomplete, specimens have been collected by fine-screening sandy spoils believed to be from the Marshalltown Formation. The literature reports a broad geologic range from middle Cretaceous through the late Eocene. It has been reported from the Cretaceous of New Jersey and Belgium as well as the upper Eocene (Jackson Group) of Georgia.

GENUS Ischyrhiza (Leidy, 1856)

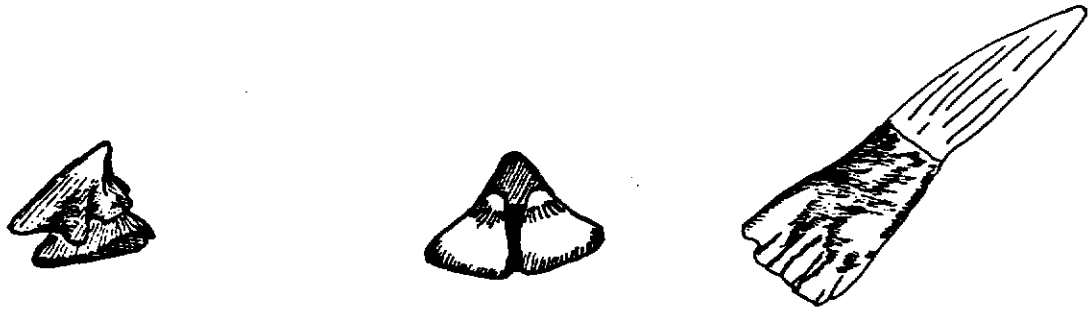
Ischyrhiza mira (Leidy, 1856)

Ischyrhiza mira (Leidy, 1856, p. 221).
Ischyrhiza mira (Fowler, 1911, p. 167-168, fig. 103).
Ischyrhiza mira (Case, 1967, p. 9, fig. 41).
Ischyrhiza mira (Cappetta and Case, 1975b, p. 27-29, pl. 8, figs. 1-20).
Ischyrhiza mira (Case, 1979, p. 85, figs. 27-30).

Description

The rostral spines are moderately large, averaging 3-4 cm in length, although numerous smaller specimens (1-2 cm) are also found (Fig. 5). The crown is elongate, trenchant, and laterally compressed without striations, serrations, or barbs on the edges or faces. The root is about equal to the crown in length and somewhat conical in shape. Its basal edges bear distinct pleats and are separated by a broad channel.

> The oral teeth are small in size ranging from 3 mm to 5 mm in their greatest width, and averaging 1 mm in their height. In the occlusal aspect, the crown is almost silhouetted against the root platform. The crown has a wide lateral buttress on either side of the central cusp, with border wrinkles on the labial edges of the buttress. There is a protruding and highly elevated cusp on the lingual aspect, and a thick apron overhanging the labial edge. In its labial view, the apron slopes downward posteriorly and butts up against a concavity on the lingual aspect of the tooth directly behind in the file. The root is bi-lobed. On the lingual aspect the root has two large foramina, one on either side of the concavity of the central crown. The exit canals from these foramina go through the medial groove of the basal aspect (Case, 1978, p. 196).



a. b. c.

Figure 5. Ischyrhiza mira. a - Lateral view of an oral tooth (x5); b - Basal view of an oral tooth (x6); c - Rostral spine (x1.5).

Discussion

While never very common, the sawfish Ischyrhiza mira occurs from the oldest (Merchantville) through the youngest (Mount Laurel) formations. This gives an early Campanian through middle Maestrichtian range and is in complete agreement with what Cappetta and Case (1975b) have reported for New Jersey. The authors have seen numerous specimens from the Upper Cretaceous of New Jersey, Delaware, and Maryland. Case reports them from the late Maestrichtian age, Peedee Formation of North Carolina (1979), and the Campanian age, Judith River Formation of Montana (1978).

The large rostral spines may be collected without special techniques. The oral teeth, due to their small size, may only be collected by bulk screening of suitable sediments. All the oral teeth collected are from Marshalltown-derived spoils.

Fowler (1911) incorrectly described a single incomplete rostral spine from Haddonfield, New Jersey as a fang belonging to a pike.

GENUS Sclerorhynchus Woodward, 1889

Schlerorhynchus sp.

Sclerorhynchus sp. (Case, 1973, p. 26, fig. 90).
Sclerorhynchus sp. (Herman, 1975, pl. 15, fig. 3).

Description

The rostral spines average 8 mm in length and 3 mm in width, with the root accounting for slightly less than half of the total length. The rostral spines are very similar to Ischyrhiza mira and have an elongate, trenchant, and laterally compressed crown without striations or serrations. The root is roughly conical in shape with the basal edges parallel, separated by a broad channel, and bearing pleats much less evident than those in I. mira of similar size and preservation. The most distinctive feature of the tooth is a broad enameloid blade with an obtuse hook on one edge near the enamel margin.

Discussion

Only two specimens, both of similar size and preservation, have been collected by the authors. Case (personal communication) has collected one specimen from New Jersey. Sclerorhynchus is not common in the Atlantic Coastal Plain, but is much more abundant in Europe.

GENUS Rhombodus (Dames, 1881)

Rhombodus levis (Cappetta and Case, 1975b)

Rhombodus levis (Cappetta and Case, 1975b, pl. 9, figs. 12-23).

Description

The teeth are small, typically 3 mm in height by 3 mm in width by 3 mm in depth, batoid in appearance, rhomboid in

occlusal outline, and have a flat enamel covered crown with a bifid root (Fig. 6). The crown has enamel on the occlusal surface, the sides, and the underside adjacent to the crown margin.

The root is smaller in diameter than the crown, although frequently higher. Its sides show a number of elongate fenestrations, particularly near the crown margin. A canal, containing a centrally located foramen, separates the two root lobes. The root exhibits a generally porous surface.

a. b. c.

Figure 6. Rhombodus levis. a - Basal view (x6); b - Occlusal view (x5); c - side view (x5).

Discussion

The teeth are regular in outline, angular in nature, and rarely exhibit an inflated occlusal surface. These characteristics make them distinguishable from Pseudohypolophus.

All the specimens collected by the authors are from spoils believed to be Marshalltown-derived. This species is also found in New Jersey.

Cappetta and Case (1975b) described oval dermal denticles from New Jersey and attributed them to Rhombodus. Similar shaped denticles have also been found in Delaware.

GENUS *Brachyrhizodus* (Romer, 1942)

Brachyrhizodus wichitaensis (Romer, 1942)

Brachyrhizodus wichitaensis (Romer, 1942, p. 221, pl. 1, figs. 7-8).
Rhinoptera sp. (Case, 1967, p. 9, fig. 38).
Myledaphus sp. (Case, 1967, p. 9, fig. 43).
Rhinoptera sp. (Case, 1973, p. 22, figs. 80-81; p. 23, fig. 82).
Brachyrhizodus wichitaensis (Cappetta and Case, 1975b, p. 32, pl. 9, figs. 1-11).

Description

The central teeth are larger and more elongate than the laterals, typically measuring 25 mm in length by 10 mm in width by 9 mm in height (Fig. 7). A typical lateral tooth measures 11 mm in length by 7 mm in width by 5 mm in height.

These pavement teeth are hexagonal in occlusal outline, laterally elongate, and bilaterally symmetrical.

The crown is massive, constricted at the root margin, convex on the occlusal and posterior surfaces, and concave on the anterior surface. The enamel on the occlusal surface is frequently textured with numerous irregular shallow cracks. The enamel is pleated near the crown margin.

The root is solid, massive, and subequal to the crown. Well preserved specimens show a regular fine porosity on the surface. The root base has two or more root lobes which are sometimes arranged symmetrically but not necessarily evenly spaced.

a. b.

Figure 7. Brachyrhizodus wichitaensis. a - Lateral view (x3); b - Occlusal view (x3).

Discussion

Specimens have been collected from various Marshalltown-type spoil areas in Delaware. These species is also native to New Jersey and appears to be restricted to Campanian time. These teeth are larger and proportionally more massive than Pseudohypolophus. Specimens from Delaware are usually smaller than those found in New Jersey.

GENUS Pseudohypolophus (Cappetta and Case, 1975a)

Pseudohypolophus sp.

Hypolophus sp. (Estes, 1964, p. 18-19, fig. 9).
Pseudohypolophus sp. (Cappetta and Case, 1975a, p. 306).

Description

The teeth are batoid in appearance and a large specimen measures 7 mm in length by 5 mm in width by 4 mm in height (Fig. 8). They are differentiated reflecting differences between upper and lower jaws as well as the position within a jaw. The enamel covered crown is smooth and slightly convex with a rhomboid or hexagonal occlusal outline. The sides of the crown are flat or inflated and constricted at the margin.

The teeth usually only have two root lobes. An antero-posterior canal which separates these two lobes has one or two foramina entering into the root interior. The root has numerous fenestrations and broken specimens show a generally porous structure.

Larger teeth, from the central jaw area, are usually hexagonal in occlusal outline exhibiting bilateral symmetry about the minor axis. Smaller lateral teeth are variable in shape and exhibit a less angular appearance with or without any apparent symmetry or regularity.

a. b.

Figure 8. Pseudohypolophus sp. a - Lateral view (x3.5); b - Basal view (x3.5).

Discussion

Teeth of Pseudohypolophus superficially resemble a miniature Brachyrhizodus but may be distinguished by a more inflated and generally less angular appearance. This tooth does not occur in equivalent formations in Monmouth County, New Jersey (Case, personal communication). Specimens, however, have been collected by the authors from the Hornerstown Formation of New Jersey and the Brightseat and Aquia formations of Maryland. The Canal teeth were all found in Marshalltown-type spoils.

Identification of these specimens was based upon descriptions by Estes (1964) and Cappetta and Case (1975a).

GENUS Ptychotrygon (Jaekel, 1894)

Ptychotrygon vermiculata (Cappetta, 1975)

Ptychotrygon triangularis (Cappetta and Case, 1975b, p. 32, fig. 9; pl. 4, figs. 23-28).
Ptychotrygon vermiculata (Cappetta, 1975, fig. 1).

Description

The teeth are small, typically batoid in overall form, and are about 4 mm at the widest point. The occlusal outline is bilaterally symmetrical, elongate, and rhomboidal with tapering ends. The crown is high with the labial face overhanging the root and the lingual face ending abruptly at the root's edge.

In occlusal aspect there are three distinct transverse folds midway along the labial face, along the lingual face, and along the apex of the crown. There may be additional folds on the labial face.

The root platform is rhomboid in outline and bilobed.

Discussion

Because teeth of this batoid are very small, nearly all properly aligned specimens will fall through a hole 3 mm square. About 30 teeth have been collected by fine screening of spoils interpreted to be Marshalltown-derived.

McNulty and Slaughter (1972) reported that Ptychotrygon is a rather ubiqutous genus occurring at fairly low density in the Upper Cretaceous rocks of Bohemia, the Gulf Coastal Plain, and South Dakota. Cappetta and Case (1975) have also reported it from New Jersey.

Several lower crowned specimens which resemble P. agujaensis McNulty and Slaughter (1972) have been collected. The sample, however, is too small and the specimens are too worn to assign them to a definitive species.

Rostral spines of this genus have also been collected. They consist of a slightly concave base, typically 2 mm in diameter, with a small elevated enamel crown rising from one edge and directed toward the head.

GENUS Squatina (Dumeril, 1806)

Squatina hassei (Leriche, 1929)

Squatina hassei (Leriche, 1929, p. 206, figs. 1-3).
Squatina sp. (Case, 1973, p. 23, fig. 83).
Squatina hassei (Cappetta and Case, 1975b, p. 2, pl. 1, figs. 17-24).

Description

The teeth are small, a large specimen measuring 6 mm high by 8 mm wide. The root platform is arched on a slightly concave base and forms a roughly triangular outline with a lingually directed crown. In some specimens this crown forms a rounded lobe. A single elevated central cusp is located centrally on the labial root edge, overhanging and forming a distinct uvula on the root below. A narrow shoulder of enamel extends laterally from the central cusp along the upper edge of the root's labial aspect nearly to the root's tip. The root face is inflated and in some specimens an enamel buttress extends lingually from the central cusp. The lingual root apron contains numerous fenestrations. A distinct foramen is centrally located on the root base.

Discussion

This representative of the angel sharks has been collected from spoils interpreted to be from the Marshalltown and in situ in the Mount Laurel outcrop at Biggs Farm. Cappetta and Case (1975b) report a similar stratigraphic range, Campanian to Maestrichtian, in New Jersey. The tooth is also found in Holland and Belgium.

Vertebrae of this genera are distinctive in shape, commonly found, dorso-ventrally compressed, and have one face much

larger than the other. The smaller face is usually found bordered by fossilized cartilage.

GENUS Ginglymostoma (Mueller and Henle, 1837)

Ginglymostoma globidens (Cappetta and Case, 1975b)

Ginglymostoma globidens (Cappetta and Case, 1975b, p. 12-14, fig. 6; pl. 9, figs. 24-25).

Description

The anterior teeth are small, typically 4 mm high by 5 mm wide. They have a flat base (root) and a broad crown inclined about forty-five degrees lingually.

In occlusal aspect the crown nearly obscures the root, is convex, and tri-lobed. A triangular central lobe is separated from a smaller lobe on each side by a broad enameloid depression except near the basal margin. The occlusal face has numerous longitudinal pleats which become more pronounced away from the margins.

The basal margin of the crown is complete and forms a fairly smooth overhanging arch. An enamel uvula on the lingual aspect does not overhang the root.

In basal aspect the root is flat and triangular with a lingually directed boss. The root has a centrally located pit or foramen in its basal aspect.

Both the upper and lower teeth are of similar types. The lateral teeth are similar to the anterior ones except they are broader with a more angular basal margin.

Discussion

These teeth, due to their small size, are uncommon. In addition, they frequently show serious damage and good quality specimens are very rare. In total less than a dozen good specimens have been obtained by the authors' fine-screening of the Marshalltown-type spoils.

This species, judging by the nature of the teeth and the habits of its modern cousins, the nurse sharks, was most likely a bottom feeder.

It has also been reported from the Cretaceous of New Jersey.

GENUS Odontaspis (Agassiz, 1838)

Odontaspis holmdelensis (Cappetta and Case, 1975b)

Odontaspis holmdelensis (Cappetta and Case, 1975b, p. 19, pl. 6, figs. 10-21).

Description

The teeth are small, less than 15 mm in height, highly differentiated, and typically odontaspid in overall appearance. The anterior teeth are lingually convex, sigmoid, slender, and erect with striations on the lingual face. A single narrow denticle appears on either side of the central cusp. The equal-sized root lobes meet at an acute angle. The root is inflated and has a median boss on the lingual face which contains a nutritive groove.

The lateral teeth are of a similar shape but smaller, broader, and curved or inclined toward the commissure. The striated crown is less sigmoid and has a pair of denticles on either side of the central cusp. The root lobes are broad and meet at an obtuse angle. A median groove is present on the lingual face of the root.

Discussion

This is the most common odontaspid, representing more than ninety percent of the collected specimens. It has been primarily found in Marshalltown-type spoils.

The species is named for Holmdel, Monmouth County, New Jersey, where it was first found. It is the only striated odontaspid found in the Upper Cretaceous of Delaware.

Odontaspis samhammeri (Cappetta and Case, 1975b)

Odontaspis samhammeri (Cappetta and Case, 1975b, p. 18, pl. 5, figs. 11-26).

Description

The teeth are medium sized, measuring up to 20 mm in height, and highly differentiated with a smooth enamel. Anterior teeth are erect, lingually convex, slightly sigmoid, and have a narrow denticle on either side of the main cusp. The root is robust and displaced lingually from the crown. The root lobes are narrow and acute, forming a prominent, grooved median boss. On some specimens the enamel partically covers the labial face of the root.

The lower lateral teeth are less robust in appearance and slightly broader with somewhat more triangular lateral denticles. The upper laterals are broad with a posteriorly inclined triangular central cusp and a triangular shaped lateral cusp on either side.

Discussion

This is the largest and most robust odontaspid from the Upper Cretaceous of New Jersey and Delaware. Specimens have been collected from both the Marshalltown and Mount Laurel formations. It is relatively more common in the Mount Laurel, and its geologic range extends into the Maestrichtian. These teeth are easy to distinguish from the smaller, more delicate, and striated Odontaspis holmdelensis.

GENUS Hypotodus (Jaekel, 1895)

Hypotodus aculeatus (Cappetta and Case, 1975b)

Odontaspis sp. (Case, 1973, p. 11, fig. 52).
Hypotodus aculeatus (Cappetta and Case, 1975b, p. 16, pl. 6, figs. 1-9).

Description

The anterior teeth are small, averaging 5-10 mm in height, and symmetrical with a bilobed root (Fig. 9). The crown has a slender central cusp flanked on each side by two acicular denticles. The central cusp constitutes roughly two-thirds of the total tooth length. The inner lateral denticles are nearly one-half the length of the central cusp while the outer denticles are somewhat smaller. All cusps are strongly convex in lingual aspect, slightly convex in labial aspect, and sigmoid in outline. The crown is smooth without striations or serrations.

The root is strongly inflated lingually with a grooved median boss. The root lobes join at nearly a right angle.

The lateral teeth are similar to the anterior ones but with a more central cusp and more inclined toward the commissure of the jaw.

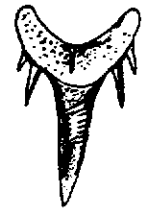


Figure 9. Hypotodus aculeatus Lingual view (x3).

Discussion

This tooth is quite distinctive due to the smooth crown and long lateral denticles. It is fairly common in Delaware and New Jersey but easily overlooked because of its size. The fragile side cusps are usually lost making it difficult to distinguish this species from a worn specimen of Odontaspis.

GENUS Scapanorhynchus (Woodward, 1889)

Scapanorhynchus texanus (Roemer, 1852)

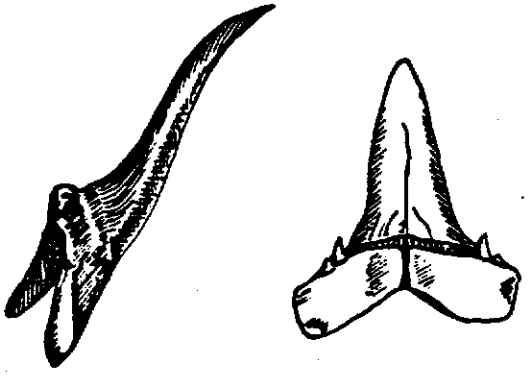
Lamna texana (Roemer, 1852, p. 29, pl. 2, fig. 7).
Lamna texana (Fowler, 1911, p. 52-53, fig. 19).
Lamna sp. (Case, 1967, p. 11, fig. 50).
Scapanorhynchus raphidon (Case, 1967, p. 11, fig. 53).
Carcharius? sp. (Miller, 1967, p. 223-, pl. 1, figs. 3-5).
Isurus sp. (Miller, 1967, p. 223, pl. 1, figs. 1-2).
Scapanorhynchus texanus (Cappetta and Case, 1975, p. 14-16, pl. 2, figs. 1-36).
Scapanorhynchus texanus (Case, 1979, p. 80-81, figs. 9-12).

Description

The teeth are large, averaging 2-5 cm in height, with the upper and lower teeth similar in shape (Fig. 10).

The anterior teeth are elongate and signoidal in lateral aspect with similarly shaped lateral cusplets. Striae on the lingual face extend toward the apex from the enamel margin one-third to two-thirds of the crown length. The root is large with a deeply furrowed median boss on the lingual face. Branches of the root are long and moderately divergent.

The lateral and antero-lateral teeth are broader and more flattened than the anterior ones. Striae, if present, are short, poorly developed, and limited to the crown margin. One or two triangular cusplets occur on each side of the crown. The root is flatter, broader, shorter, and more divergent than that of an anterior tooth.



a. b.

Figure 10. Scapanorhynchus texanus. a - Anterior tooth -lateral view (x1.5); b - Lateral tooth -lingual view (x1).

Discussion

Several authors have assigned teeth of this species to different genera because of their considerable morphological variability. Comparison to the extant goblin shark Mitsukurina, however, has shown them to belong to a single species type.

This rather large tooth is relatively common in the Upper Cretaceous of Eastern North America and has been collected by the authors in Delaware, New Jersey, Maryland and also in Texas.

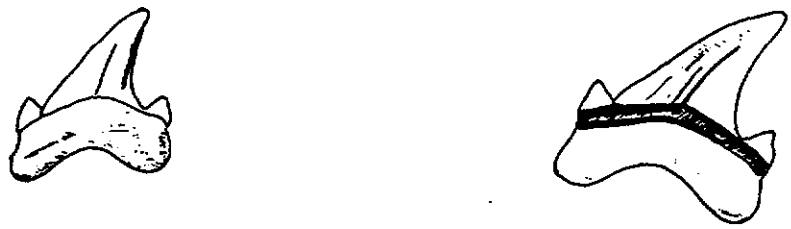
GENUS Plicatolamna (Herman, 1975)

Plicatolamna arcuata (Woodward, 1894)

Lamna arcuata (Woodward, 1894, p. 198, pl. VI, fig. 10).
Lamna appendiculata (Priem, 1897, p. 40, pl. 1, fig. 7).
Lamna arculata (Priem, 1897, p. 42, pl. 1, figs. 10-11).
Lamna arcuata (Woodward, 1911, p. 208, pl. XLIV, figs. 8-9).
Lamna appendiculata (Case, 1967, p. 11, fig. 57).
Plicatolamna arcuata (Herman, 1973, p. 311, pl. 8, fig. 5).
Plicatolamna arcuata (Cappetta and Case, 1975b, p. 23, pl. 4, figs. 1-18).

Description

The teeth are large, measuring 20-30 mm, with the upper teeth curved posteriorly and the lower teeth symmetrically erect or slightly inclined toward the commissure (Fig. 11). The central cusp is narrow (although somewhat broader on posterior teeth), convex on the lingual face, barely convex on the labial, and slightly sigmoidal in lateral aspect. There is a single, triangular, erect or divergent basal cusplet on either side of the central crown. Posterior teeth may have two such cusplets or lack them on one side altogether. The root is inflated lingually forming an ungrooved central boss. The root lobes are pointed in anterior specimens but rounded in lateral and posterior ones.



a. b.

Figure 11. Plicatolamna arcuata. a - Lingual view (x1.5); b - Labial view (x2).

Discussion

This is a fairly common species in the Marshalltown but is unknown from the Mount Laurel and Merchantville formations. The implied geological range, middle Campanian to early Maestrichtian, agrees well with what Case (1979) has reported for New Jersey. This species also occurs in the Cretaceous of Europe.

Plicatolamna borodini (Cappetta and Case, 1975b)

Plicatolmna borodini (Cappetta and Case, 1975b, p. 23, pl. 3, figs. 1-9).

Description

The teeth are small, averaging 7 mm in height and ranging up to 13 mm. The teeth are similar to Plicatolamna arcuata but with a proportionally more robust root accounting for two-thirds of the tooth height. The central cusp is usually posteriorly curved, narrow, convex on the lingual face, and slightly sigmoidal in lateral aspect. The labial crown face is concave with distinct longitudinal pleats extending from the enamel margin well up the crown and accessory cusps. The basal cusps are continuous with the main cusp on the labial face, but not on the lingual. The root is proportionally massive and bilobed with a large lingual central boss. There

is a distinct nutritive pit, but no groove at the center of the boss.

Discussion

This is a rather uncommon species in Delaware, perhaps because of its diminutive size. Fine screening has yielded two dozen, mostly incomplete, specimens from the Mount Laurel and Marshalltown sediments. It is a much more common tooth in New Jersey. The tooth may be mistaken for P. arcuata except for the pleated labial crown face and the proportionally more robust root.

The species was named for Paul Borodin, an amateur fossil collector from Long Island, New York.

GENUS Cretolamna (Glyckman, 1958)

Cretolamna appendiculata lata (Agassiz, 1843)

Otodus latus (Agassiz, 1843, p. 271, pl. 32, fig. 26).
Lamna appendiculata (Priem, 1896, p. 14, pl. 1, figs. 5-9).
Otodus appendiculatus (Case, 1967, p. 11, fig. 51).
Cretolamna appendiculata lata (Herman, 1973, p. 320, pl. 9, fig. 4).
Cretolamna appendiculata lata (Cappetta and Case, 1975b, p. 21-22, pl. 3, figs. 10-28).

Description

The anterior teeth are medium sized, typically 20 mm in height, and symmetrical in shape (Fig. 12). They consist of an elevated, triangular shaped central cusp with a similar shaped diverging lateral cusp on either side. The upper teeth are more laterally compressed than the lower ones and have broader accessory cusps. The lingual face of the crown is convex with the labial face nearly flat. The root is elevated in lateral aspect on the lingual surface, nearly flat on the labial, and pinched. The root has no medial groove on the lingual face and has an obtuse lobe angle.

The posterior teeth are similar to the anterior ones but with a posteriorly inclined central cusp. Case (1979) reports that some posterior teeth have vestiges of an additional accessory cusplet on one side of the crown.

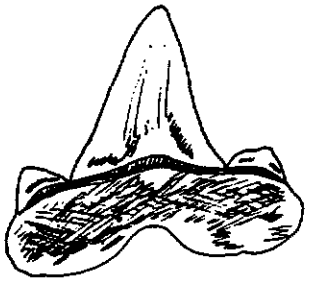


Figure 12. Cretolamna appendiculata lata. Lingual view (x2.5).

Discussion

These teeth are very abundant in both New Jersey and Delaware. The species has a large geographic range which includes Europe, Africa, Asia, and North America. Nearly all the Delaware specimens are from the Marshalltown Formation but they seem to be replaced in the Maestrichtian Mount Laurel Formation by Cretolamna appendiculata pachyrhiza.

Cretolamna appendiculata pachyrhiza (Herman, 1973)

Cretolamna appendiculata pachyrhiza (Herman, 1973, pl. 10, figs. 3A-G).

Description

The teeth are large, typically 25 mm in slant height (Fig. 13). The anterior teeth are erect and symmetrical consisting of an elevated, lingually inflated, triangular central cusp without striations or serrations and bearing a single, strongly divergent, triangular cusp on either side. The bilobed root is robust with a prominent ungrooved median boss. The root lobes are pinched near the ends.

The lateral teeth are laterally more compressed and posteriorly inclined. A single lateral denticle on either side of the central cusp is broad, triangular, and strongly divergent. The root is moderately inflated lingually and pinched at the ends.

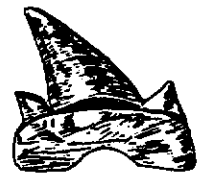


Figure 13. Cretolamna appendiculata pachyrhiza - Lingual view (x1.5).

Discussion

This distinctive tooth is restricted to the Mount Laurel Formation and differs from the subspecies (Cretolamna appendiculata lata in being larger, more robust, and having more strongly divergent side cusps. In general form it superficially resembles Lamna obliqua of the Paleocene/Eocene.

This tooth has not been reported from New Jersey. Herman (1973) described it from the Montian (Lower Paleocene) of Europe.

GENUS Paranomotodon (Herman, 1973)

Paranomotodon angustidens (Reuss, 1845)

Anomotodon plicatus (Case, 1973, p. 20, fig. 67).
Paranomotodon angustidens (Herman, 1973, pl. 7, figs. A-D).
Paranomotodon angustidens (Cappetta and Case, 1975b, p. 24, pl. 5, figs. 1-10).

Description

The teeth are small- to medium-sized, up to 12 mm in height. On the lateral teeth the crown is smooth, triangular, posteriorly inclined, and without side cusps. An enamel shoulder on the crown margin extends along the top of the root. The crown is convex lingually and nearly flat on the labial face. The root is broad, inflated lingually, and has a median groove.

Anterior teeth are slender, erect, slightly sigmoid with a smooth crown, and without accessory cusps. The root is lingually inflated with lobes which meet at an acute angle.

Discussion

A number of lateral teeth have been collected from the Marshalltown-type spoils. This tooth is very common in the Cretaceous of New Jersey.

GENUS Squalicorax (Whitley, 1939)

Squalicorax kaupi (Agassiz, 1843)

Corax kaupi (Agassiz, 1843, p. 225, pl. 26A, figs. 25-34; pl. 26, figs. 4-8).
Corax falcatus (Fowler, 1911, p. 63, fig. 28).
Corax kaupi (Arambourg, 1952, p. 113, pl. XX, figs. 11-26).
Squalicorax falcatus (Case, 1967, p. 11, fig. 54).
Squalicorax kaupi (Herman, 1973, p. 160, pl. 4, fig. 2).
Squalicorax kaupi (Cappetta and Case, 1975b, p. 8, pl. 7, figs. 17-29).

Description

The teeth are small- to medium-sized, typically less than 1.5 cm in width, and roughly triangular in shape (Fig. 14). The crown is flat to slightly convex on the labial face and convex on the lingual face. All crown edges are finely serrated with some specimens lacking serrations due to wear and abrasion.

The anterior edge of the crown is arched ending in a posteriorly directed apex. The posterior edge is generally straight and nearly vertical ending in a distinct notch near the posterior crown margin. The root is moderately broad and flattened.

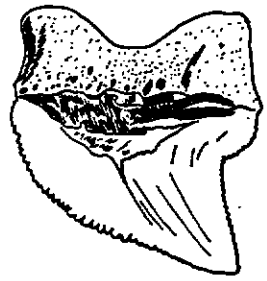


Figure 14. Squalicorax kaupi. Labial view (x3.5).

Discussion

This is the most commonly found tooth in Delaware. Case (1978, p. 186) reports the stratigraphic range as Turonian to late Maestrichtian. He reports the species as being so common in the United States that: "It is found in almost every Cretaceous outcrop..." The authors have collected numberous specimens from late Cretaceous and early Paleocene units in New Jersey, Delaware, and Maryland. The species is also native to Europe, Africa, Japan, and New Zealand.

Teeth of this species are typically one-half the size of Squalicorax pristodontus.

Squalicorax pristodontus (Agassiz, 1843)

Corax pristodontus (Agassiz, 1843, p. 224, pl. 26, figs. 9-13).
Corax pristodontus (Fowler, 1911, p. 64-66, fig. 29).
Corax pristodontus (Arambourg, 1952, p. 112, pl. XX, figs. 1-10).
Squalicorax pristodontus (Case, 1967, p. 11, fig. 56).
Squalicorax pristodontus (Cappetta and Case, 1975b, p. 8-9, pl. 7, figs. 30-41).

Description

The teeth are large, averaging 2-3 cm in width (Fig. 15), and similar in shape to Squalicorax kaupi. The crown is large, crescent shaped, and without the distinct posterior notch characteristic of S. kaupi. The crown serrations are fine, distinct, and complete. The root is large and broad.

a. b.

Figure 15. Squalicorax pristodontus. a - Lingual view (x1.5); b - Labial view (x1.5).

Discussion

Although occasional teeth have been found in the Marshalltown-type spoils, most specimens come from the Mount Laurel Formation. It is a rather uncommon tooth in Delaware. Case (1979) reports a middle to late Maestrichtian stratigraphic range. This tooth has been found in late Cretaceous and early Paleocene deposits of New Jersey, Delaware, and Maryland. It also occurs in Georgia, Texas, North Carolina, and Morocco.

GENUS Pseudocorax

Pseudocorax granti (Cappetta and Case, 1975a)

Pseudocorax granti (Cappetta and Case, 1975a, p. 304-305, fig. 1).

Description

Anterior teeth are small, 10 mm in height, symmetrical with a narrow crown. The labial face is flat and overhangs the root while the lingual face is moderately convex. Branches of the root are long and thin but not separated. Furrows are very clear. The lateral teeth have a wider cusp inclined toward the commissure. The distal heel is low and not greatly marked. The root has a basilar face, not very high, and is flat or slightly convex (Cappetta and Case, 1975, p. 304).

Discussion

This tooth is quite rare and only about one-half of a dozen have been collected by the authors from spoils believed to be from the Marshalltown Formation. It is common in the Campanian-age Taylor Group of Texas.

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APPENDIX A

GLOSSARY

GLOSSARY

Acicular - elongated: needle shaped.

Anterior - front end.

Apex - highest point: tip.

Apron - an overhanging lobe or elevation of the labial face.

Assemblage - collection or group

Basal - at the base or bottom.

Basal aspect - bottom view: bottom side.

Batoid - ray or ray-like.

Bifid root - clefted: divided: split root.

Bilobed - divided into two lobes or sections.

Boss - a rounded raised projection from a flat surface.

Buttress - a lateral projection on the side of an object.

Carinae - the ridge or keel along the bottom.

Cartilage - firm, flexible, elastic substance which takes the place of bone in certain types of fish.

Central - in the center or middle.

Commissure - the corner of the mouth.

Concave - curved inward.

Concavity - having an inward curved surface.

Convex - curved outward

Crown - part of the tooth which projects above the gum line: top of the tooth.

Crown margin - edge of the crown.

Cusplet - small pointed structure adjacent to the cusp.

Denticles - small tooth-like projections adjacent to the cusp.

Enamel - a hard thin glossy covering of the tooth surface.

Enamel shoulder - edge of the enamel.

Exit canal - opening through which a nerve or blood vessel passes.

Face - side: view: aspect.

Facette - a smooth, flat or nearly flat surface.

Fauna - a collection or group of animals in a given geologic formation or period.

Fenestration - an opening or perforation.

File - a row of teeth.

Foramen - a small opening or perforation.

Foramina - plural of foramen: small openings.

Furrowed - having trenches, narrow channels, or grooves.

Grooved - having narrow channels or furrows.

Hexagonal - having six sides.

Labial - pertaining to the lip side: outside of the tooth.

Labial aspect - lip or outside view of a tooth.

Lateral - of or pertaining to the side.

Lateral tooth - side tooth.

Lingual - pertaining to the tongue side: inside of the tooth.

Lingual aspect - tongue or inside of a tooth.

Medial groove - an elongated indentation found in the center.

Median boss - a rounded, raised central projection.

Nutritive groove - a channel through which a blood vessel passes.

Nutritive pit - opening or hole through which a blood vessel enters the inside of a tooth.

Occlusal - top or constricted part of a tooth.

Occlusal aspect - top view of a tooth.

Oral teeth - teeth found in the mouth.

Pleats - folds, plications.

Posterior - hind or rear view.

Root - part of the tooth below the gum line; part of the tooth which attaches it to the body.

Root lobes - projections or divisions of the root.

Root platform - base of the tooth on which the crown stands.

Rostral spine - tooth attached to the snout of a fish.

Serration - notch like that found on the edge of a saw blade.

Sigmoid - recurved in shape.

Striae - minute grooves or channels.

Striations - lines or stripes.

Terminus - end.

Transverse crest - ridge running from side to side on a tooth.

Trenchant - sharp or cutting.

Uvula - an overhanging lobe or elevation on the lingual face.

APPENDIX B

CLASSIFICATION

CLASSIFICATION

Class Chondrichthyes
- Subclass Elasmobranchii
  - Cohort Euselachii
    - Subcohort Selachii
      - Order Hybodontiformes
        - Family Hybodontidae
          - *Hybodus* sp.
          - *Lonchidion babulskii* Cappetta and Case
    - Subcohort Neoselachii
      - Superorder Batoidea
        - Order Rhinobatiformes
          - Family Rhinobatidae
            - *Rhinobatos casieri* Herman
        - Order Pristiformes
          - Family Sclerorhynchidae
            - *Ischyrhiza mira* Leidy
            - *Sclerorhynchus* sp.
        - Order Myliobatiformes
          - Family Myliobatidae
            - *Rhombodus levis* Cappetta and Case
            - *Brachyrhizodus wichitaensis* Romer
            - *Pseudohypolophus* sp.
        - Incertae Sedis
          - *Ptychotrygon vermiculata* Cappetta
      - Superorder Squatinomorphii
        - Order Squatiniformes
          - Family Squatinidae
            - *Squatina hassei* Leriche
      - Superorder Galeomorphii
        - Order Orectolobiformes
          - Family Ginglymostomatidae
            - *Ginglymostoma globidens* Cappetta and Case
        - Order Lamniformes
          - Family Odontaspididae
            - *Odontaspis holmdelensis* Cappetta and Case
            - *Odontaspis samhammeri* Cappetta and Case
            - *Hypotodus aculeatus* Cappetta and Case
          - Family Mitsukurinidae
            - *Scapanorhynchus texanus* (Roemer)
          - Family Lamnidae
            - *Plicatolamna arcuata* (Woodward)
            - *Plicatolamna borodini* Cappetta and Case

Cretolamna appendiculata lata (Agassiz)
Cretolamna appendiculata pachyrhiza Herman

Family Alopiidae
Paranomotodon angustidens (Reuss)

Family Anacoracidae
Squalicorax kaupi (Agassiz)
Squalicorax pristodontus (Agassiz)
Pseudocorax granti Cappetta and Case

APPENDIX C

PLATES AND DESCRIPTIONS

PLATE 1

Squalicorax pristodontis (Agassiz)

1. 27 mm in width, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

   LEFT - Lingual view
   RIGHT - Labial view

2. 27 mm from base to tip, Mount Laurel Formation, Biggs Farm locality.

   LEFT - Labial view
   RIGHT - Lingual view

Squalicorax kaupi (Agassiz)

3. 22 mm in height, Marshalltown Formation spoils, one mile east of north St. Georges.

   LEFT - Labial view
   RIGHT - Lingual view

4. 16 mm in height, Marshalltown Formation spoils, one mile east of north St. Georges.

   TOP - Lingual view
   BOTTOM - Labial view

Scapanorhynchus texanus (Roemer)

5. 25 mm in height, upper lateral tooth, Merchantville Formation, one-half mile east of the railroad bridge on the north side.

   LEFT - Labial view
   RIGHT - Lingual view

6. 41 mm in height, anterior tooth, spoils one-quarter mile west of north St. Georges.

   LEFT - Labial view
   RIGHT - Lingual view

Plate 1 (continued)

7. 32 mm in height, lower lateral tooth, Merchantville Formation spoils, one-half mile east of the railroad bridge on the north side.

Plicatolamna arcuata (Woodward)

8. 21 mm in height, upper lateral tooth, spoils one-half mile west of north St. Georges.

    TOP - Labial view
    BOTTOM - Lingual view

9. 24 mm in height, lower anterior tooth, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

    TOP - Lingual view
    BOTTOM - Labial view

Pseudocorax granti Cappetta and Case

10. 9 mm in height, Marshalltown Formation spoils, one-half mile west of north St. Georges.

    TOP - Labial view
    BOTTOM - Lingual view

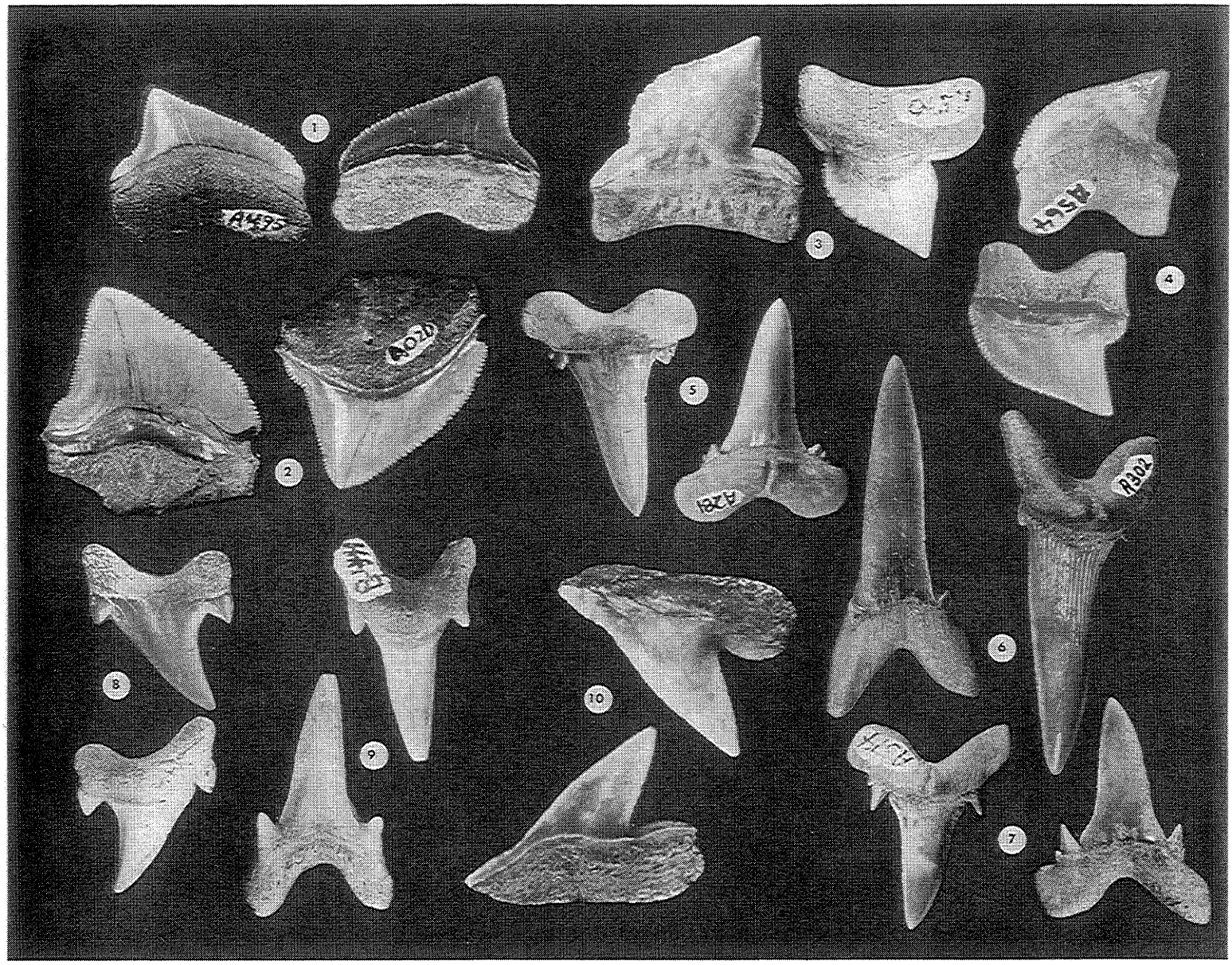
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PLATE 2

Cretolamna appendiculata pachyrhiza Herman

11. 25 mm in height, lateral tooth, labial view, Mount Laurel Formation, Biggs Farm locality.

12. 24 mm in height, anterior tooth, Mount Laurel Formation, Biggs Farm locality.

    LEFT - Lingual view
    RIGHT - Labial view

13. 24 mm in height, anterior tooth, Mount Laurel Formation spoils, 2 miles east of north St. Georges.

    LEFT - Labial view
    RIGHT - Lingual view

14. 21 mm in height, lateral tooth, Mount Laurel Formation, Biggs Farm locality.

    TOP - Lingual view
    BOTTOM - Labial view

Cretolamna appendiculata lata (Agassiz)

15. 15 mm in height, Marshalltown Formation spoils, one mile west of north St. Georges.

    LEFT - Labial view
    RIGHT - Lingual view

Paranomotodon angustidens (Reuss)

16. 9 mm in height, lateral tooth, Marshalltown Formation spoils, one mile west of north St. Georges.

    LEFT - Labial view
    RIGHT - Lingual view

17. 18 mm in height, anterior tooth, labial view, Marshalltown Formation spoils, one mile west of north St. Georges.

Plate 2 (continued)

18. 13 mm in height, lateral tooth, Merchantville Formation spoils, on the north side one-half mile east of the railroad bridge.

LEFT - Labial view
RIGHT - Lingual view

Pseudohypolophus sp.

19-24. 6 mm in length, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

19-21 - Occlusal view
22 - Basal view
23 - Lateral view
24 - Basal view

Ginglymostoma globidens Cappetta and Case

25-26. 4 mm in width, scanning electron microscope photograph, Marshalltown Formation spoils, 1½ miles west of north St. Georges.

25 - Basal view
26 - Labial view

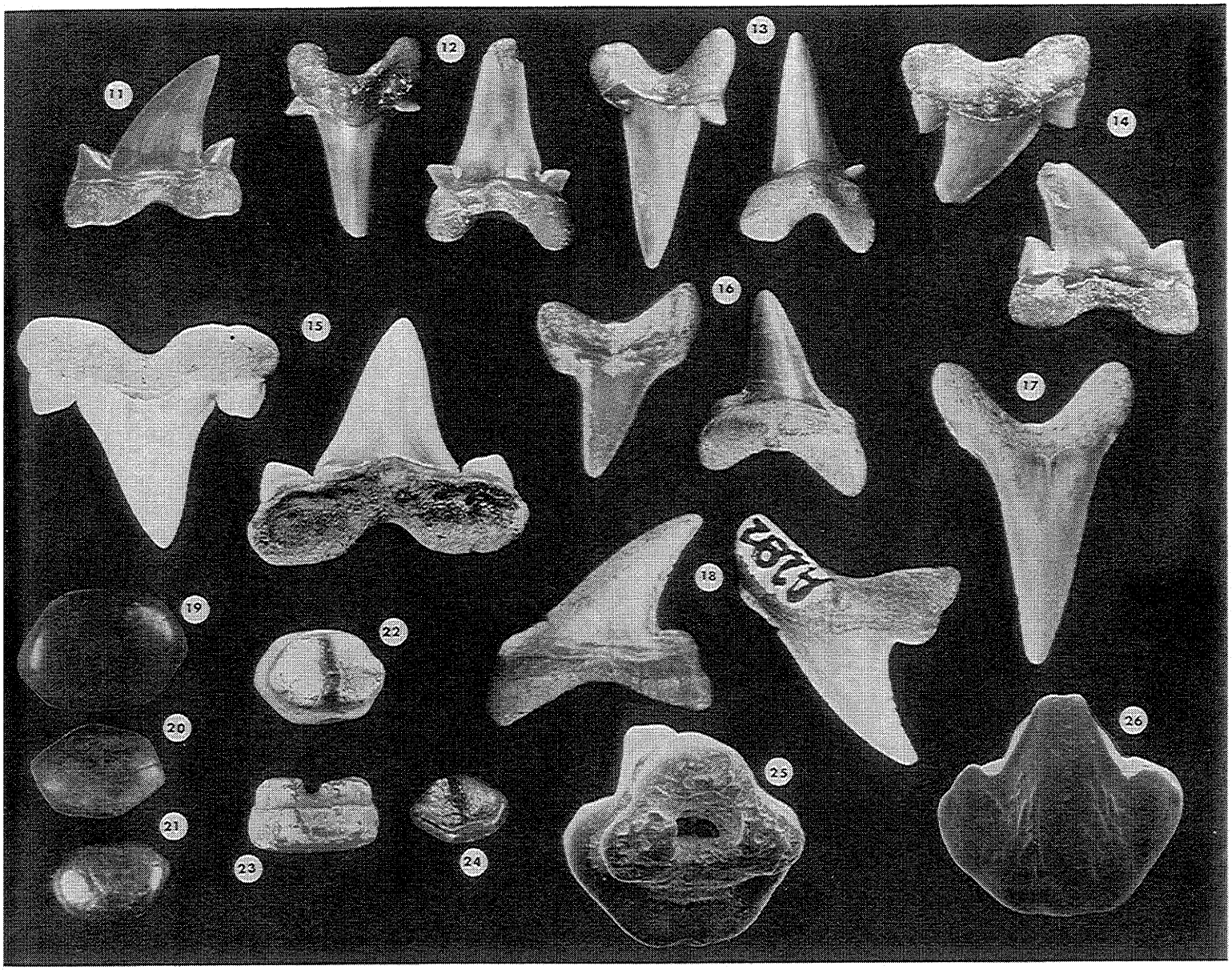
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PLATE 3

Ptychotrygon vermiculata Cappetta

27-29. 5 mm, scanning electron microscope photograph, "oral" tooth, Marshalltown Formation spoils, one-half mile west of north St. Georges.

27 - Occlusal view
28 - Basal view
29 - Lingual view

30. 5 mm in height, scanning electron microscope photograph, rostral spine, Marshalltown Formation spoils, one-half mile west of north St. Georges.

Rhinobatos casieri Herman

31. 3 mm in width, scanning electron microscope photograph, Marshalltown Formation spoils, one-half mile west of north St. Georges.

Plicatolamna borodini Cappetta and Case

32-33. 4.5 mm in height, scanning electron microscope photograph, Marshalltown Formation spoils, one-half mile west of north St. Georges.

32 - Lingual view
33 - Labial view

Ischyrhiza mira Leidy

34-37. 5 mm maximum dimension, "oral" tooth, scanning electron microscope photograph, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

34 - Occlusal view
35 - Labial view
36 - Basal view
37 - Lingual view

Plate 3 (continued)

Hypotodus aculeatus Cappetta and Case

38. 8 mm in height, lingual face, Marshalltown Formation spoils, one-half mile west of north St. Georges.

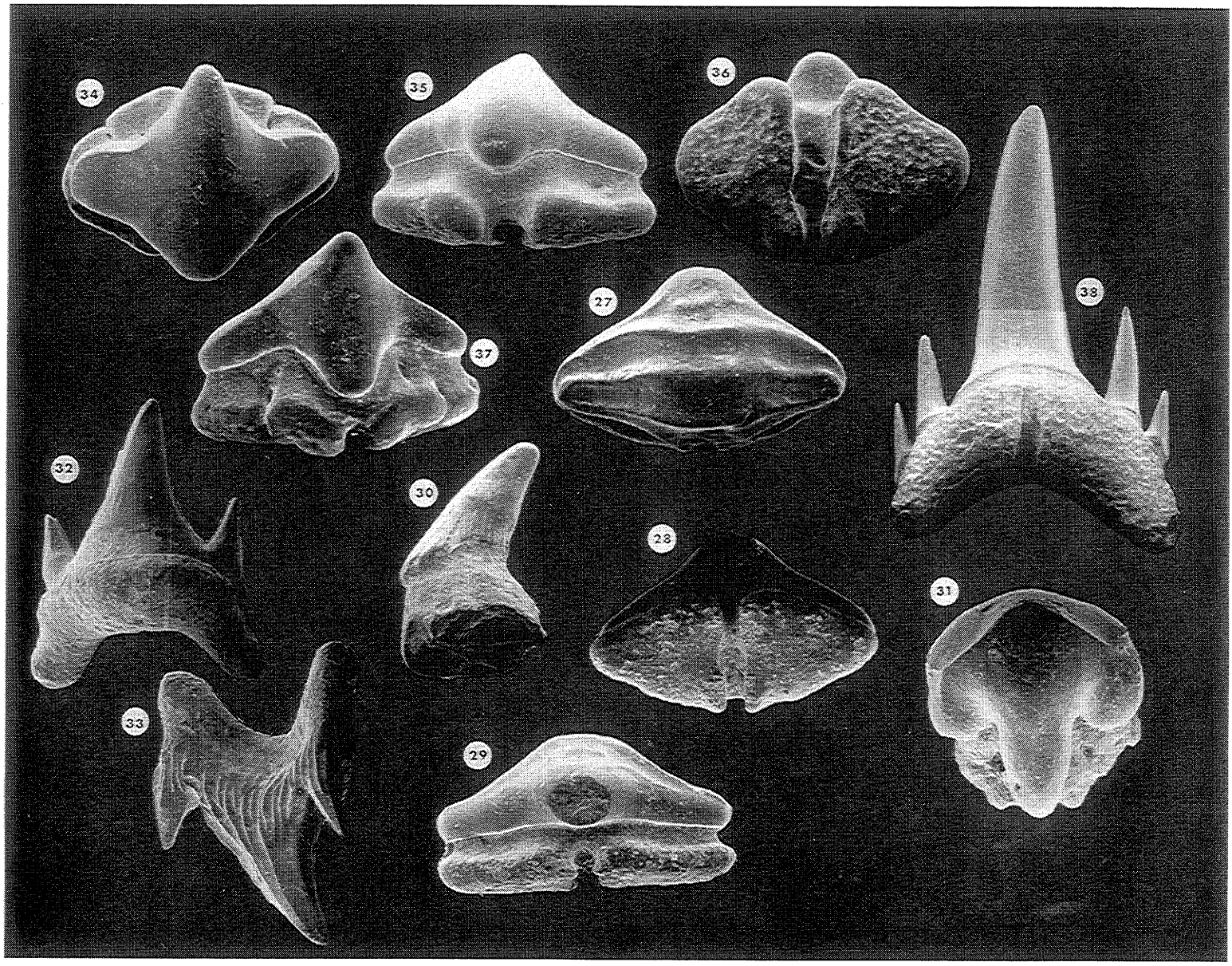
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PLATE 4

Batoid (Skate, Ray) Type Vertebra

39. 29 mm maximum diameter, Marshalltown Formation spoils, one mile east of north St. Georges.

40. 22 mm maximum diameter, Marshalltown Formation spoils, one mile east of north St. Georges.

Squatina hassei Leriche

41. 25 mm maximum diameter, vertebra, Mount Laurel Formation spoils, Reedy Point on the north side.

Shark Vertebra

42. 45 mm maximum diameter, Merchantville Formation, Deep Cut.

Shark Coprolite

43. 51 mm in length, Big Brook, Holmdel, Monmouth County, New Jersey.

44. 30 mm in length, Merchantville Formation, Deep Cut spoils.

Hybodus sp.

45. 6.5 mm in height, incomplete tooth, lingual face, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

46. 11 mm in length, cephalic hook, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

47. 11.5 mm in length, fragment of a dorsal fin spine, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

Plate 4 (continued)

Ischyrhiza mira Leidy

48-49. 16 mm in length, rostral spine, Marshalltown Formation spoils, one-half mile west of north St. Georges.

50-51. 38 mm in length, rostral spine, Merchantville Formation, Deep Cut spoils.

Sclerorhynchus sp.

52. 8 mm in length, rostral spine, Marshalltown Formation spoils, one-half mile west of north St. Georges.

Pseudohypolophus ? sp.

53. 9 mm in length, dermal ossicle, Marshalltown Formation spoils, one-half mile west of north St. Georges.

Brachyrhizodus wichitaensis Roemer

54-56. 14 mm in length, pavement teeth, Marshalltown Formation spoils, 1½ miles east of north St. Georges.

54 - Occlusal view
55 - Basal view
56 - Labial/lingual view

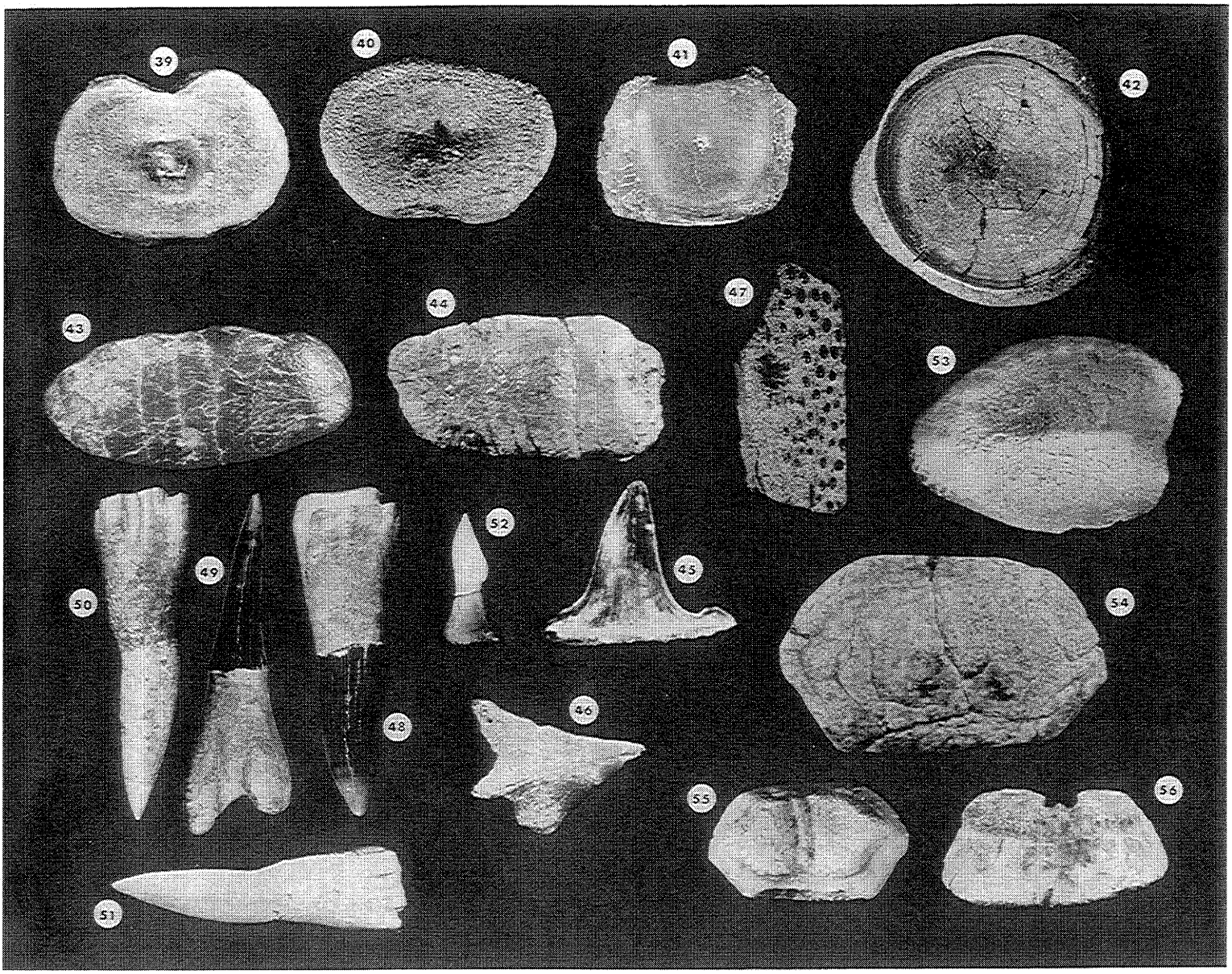
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PLATE 5

Squatina hassei Leriche

57-59. 4 mm in height, 4 mm in width at the base, scanning electron microscope photograph, Marshalltown Formation spoils, one-half mile west of north St. Georges.

57 - Labial view
58 - Occlusal view
59 - Lingual view

Lonchidion babulski Cappetta and Case

60. 5 mm maximum dimension, occlusal view, scanning electron microscope photograph, Marshalltown Formation spoils, one-half mile west of north St. Georges.

Odontaspis samhammeri Cappetta and Case

61. 11 mm in height, lateral tooth, Mount Laurel Formation, Reedy Point spoils, north side.

62. 17 mm in height, anterior tooth, Mount Laurel Formation, Biggs Farm locality.

LEFT - Labial view
RIGHT - Lingual view

63. 12 mm in height, lateral tooth, lingual view, Mount Laurel Formation, Biggs Farm locality.

Rhombodus levis Cappetta and Case

64-69. 6 mm in height, 5 mm on each side, two different pavement teeth, Marshalltown Formation spoils, one-half mile west of north St. Georges.

Plate 5 (continued)

64 - Occlusal view
65 - Lateral view
66 - Basal view
67 - Basal view
68 - Lateral view
69 - Occlusal view

Odontaspis holmdelensis Cappetta and Case

70. 15 mm in height, anterior tooth, Marshalltown Formation spoils, one-half mile west of north St. Georges.

LEFT - Lingual view
RIGHT - Labial view

71. 13 mm in height, anterior tooth, Marshalltown Formation spoils, one-half mile west of north St. Georges.

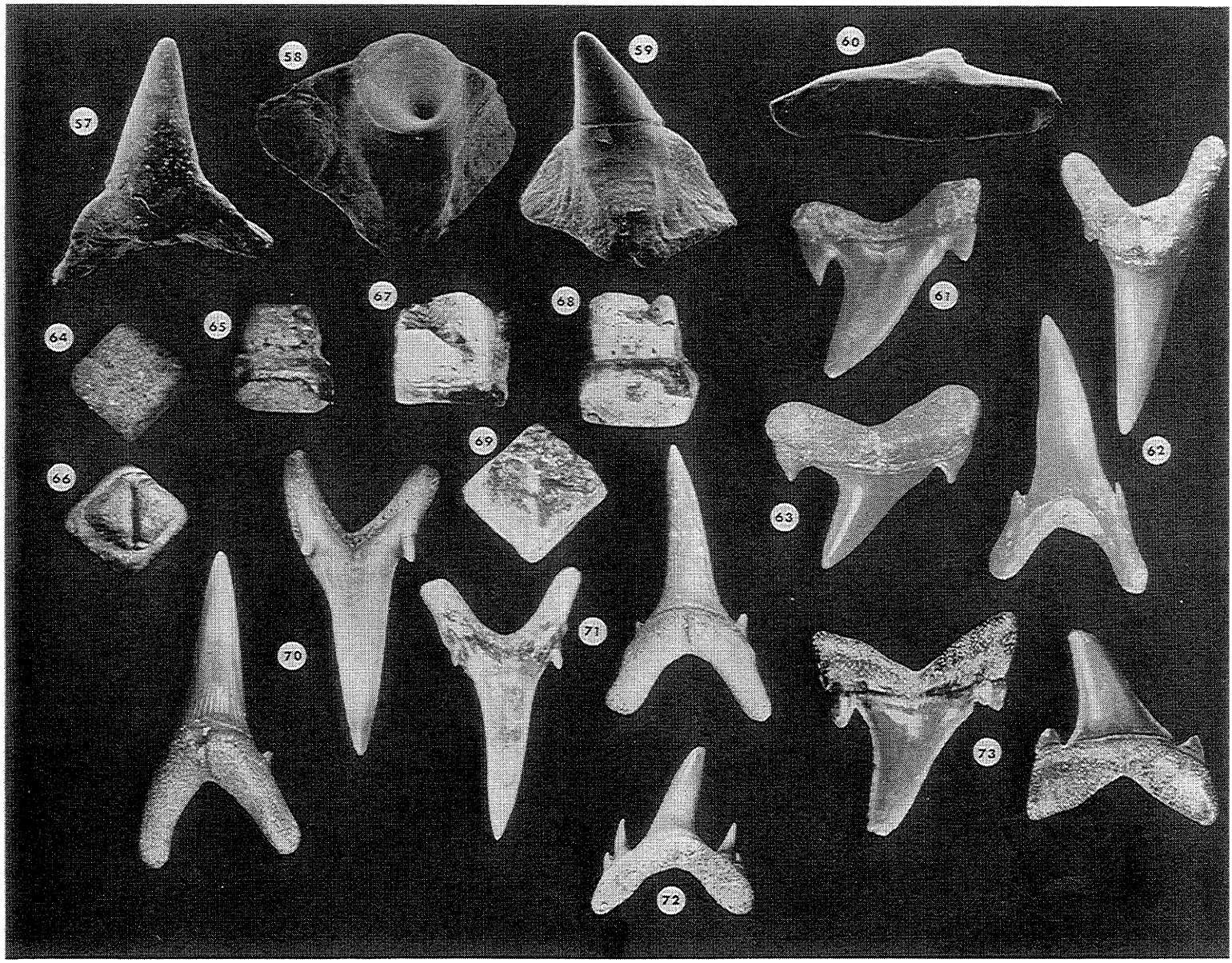
LEFT - Labial view
RIGHT - Lingual view

72. 7 mm in height, small lateral tooth (note striations on the central cusp), Marshalltown Formation spoils, one-half mile west of north St. Georges.

Odontaspis samhammeri Cappetta and Case

73. 17 mm in height, lateral tooth, Marshalltown Formation, one-half mile west of north St. Georges.

LEFT - Labial view
RIGHT - Lingual view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