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SELACHIANS FROM THE HOSTA TONGUE OF THE POINT LOOKOUT SANDSTONE (UPPER CRETACEOUS, SANTONIAN), CENTRAL NEW MEXICO

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Abstract—Selachian taxa collected from the Santonian Hosta Tongue of the Point Lookout Sandstone at NMMNH locality 297 in central New Mexico are: *Scapanorhynchus raphiodon, Squalicorax kaupi, Hybodus* cf. *H. butleri, Ptychodus mortoni, Cantioscyllium decipiens, Squatina* sp., *Ptychotrygon triangularis, Ischyrhiza mira,* cf. *Onchosaurus* sp., cf. *Pseudohypolophus* sp. and cf. Lamnoidea. These selachians include pelagic taxa (*Squalicorax* and *Scapanorhynchus*) that were streamlined, active predators and benthic taxa (*Pseudohypolophus, Ptychodus, Hybodus, Ischyrhiza, Onchosaurus* and *Cantioscyllium*) that ate a varied diet of bivalves, cephalopods, crustaceans and small fish. The Hosta Tongue selachian assemblage suggests that pelagic lamnoid sharks were the most abundant large marine vertebrates in the nearshore environment in which the fossils accumulated.

INTRODUCTION

Most of the pre-Campanian Cretaceous strata in New Mexico are of marine origin. Vertebrates, especially selachians, are a significant proportion of the fossils within these marine rocks. Nevertheless, these vertebrates are, with few exceptions, poorly known. Wolberg (1985) described the selachian fauna of the Turonian Atarque Sandstone Member of the Tres Hermanos Formation in Socorro County, New Mexico. Lucas et al. (1988a) briefly reviewed the selachian fauna of the Late Cretaceous (Cenomanian-Turonian) Greenhorn Formation in the Cooke's Range, Luna County, New Mexico. This paper reviews in a preliminary way the large selachian fauna of the Late Cretaceous (Santonian) Hosta Tongue of the Point Lookout Sandstone at a locality in Bernalillo County. This locality, NMMNH (New Mexico Museum of Natural History) locality 297 (=University of New Mexico locality 602), is in the SE¼ NE¼ SE¼, sec. 9, T11N, R2W (Fig. 1). Lucas et al. (1988b) described its geological context. Pence et al. (1986) presented a brief synopsis of the selachian fauna.

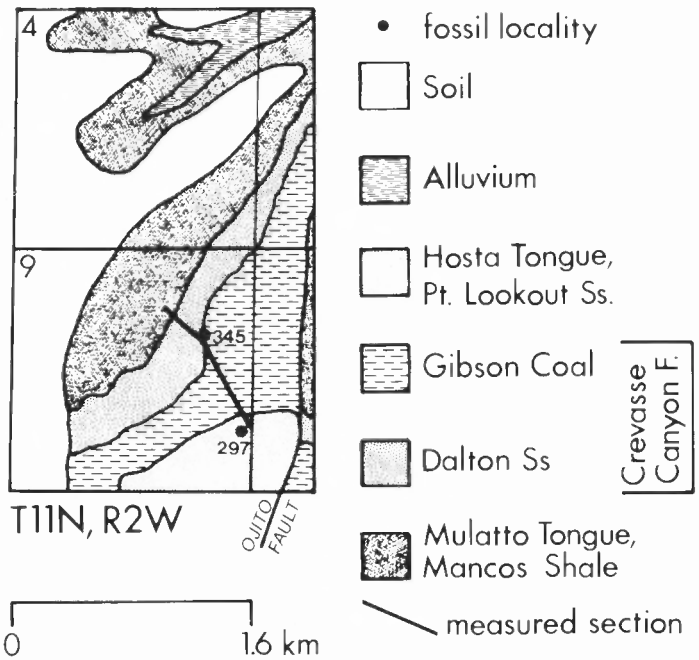

FIGURE 1. Geologic map of part of T11N, R2W in central New Mexico showing locations of NMMNH localities 297 and 345 (geology after Hunt, 1936, pl. 19).

The fossils from NMMNH locality 297 consist almost entirely of isolated teeth collected by both surface picking and screenwashing about 200 kg of eroded sandstone through a 30-per-inch grid. Concentrate was then picked under a microscope. Collecting yielded more than 5000 identifiable specimens now in the NMMNH collection.

Lucas et al. (1988b) described the reptiles from this locality. They reported turtle shell fragments, isolated teeth and bone fragments of plesiosaurs, mosasaurs and crocodiles, and tooth fragments of several dinosaurs, including hadrosaurs, dromaeosaurs and tyrannosaurids. Other elements of the fauna include several large, thick, diamond-shaped scales of gars (*Lepisosteus* or *Atractosteus*) and large ovoid, ganoid scales with fine concentric rings of a bowfin (*Amia*). Several hundred teleost vertebrae and calcified selachian centra were recovered from this locality as well as a number of dental elements of teleosts not described here.

PALEONTOLOGY

Scapanorhynchus raphiodon

The most abundant elements of this fauna are the teeth of *Scapanorhynchus*. These are easily identified by their long and narrow blades with pronounced sigmoidal flexure (Fig. 2A–E) Large specimens have a single cusp, though smaller specimens may have a pair of small accessory cusps. The bilobed roots are large and divergent. A central foramen penetrates the labial side of the root. Scapanorhynchids show a great deal of tooth heterodonty. These specimens are referred to *S. raphiodon* because the lingual faces of anterior teeth are convex and finely striated to their tip. Also, the labial faces are nearly flat and lack striations. Lateral teeth either completely lack vertical striations or bear very subdued striations restricted to the basal half of the lingual faces. Lateral teeth of *Scapanorhynchus raphiodon* are sometimes confused with those of *Odontaspis*. For example, *O. macrotus* of Wolberg (1985, p. 13, fig. 9–13) is probably a lateral tooth of *Scapanorhynchus*. Specimens from NMMNH locality 297 assigned to *S. raphiodon* are the single anterior teeth NMMNH-P4046 (Fig. 2A–C), NMMNH-P4038, the lateral tooth NMMNH-P4037 (Fig. 2D–E) and the lots assigned to NMMNH-P4015, NMMNH-P4016 and NMMNH-P4044, a total of 3196 teeth. In Cretaceous deposits, *Scapanorhynchus* ranges from the Aptian to the Maastrichtian with an essentially worldwide distribution (Cappetta, 1987).

Squalicorax kaupi

The teeth of *Squalicorax* (Fig. 2F–G) are readily identified by their large, trenchant and distally pointing blades with serrated edges. These teeth have widely convex mesial edges. The distal edge is deeply notched. The high angle of acuity (65°; cf. Bilelo, 1969; Meyer, 1974) justifies assignment of 225 teeth from NMMNH locality 297—the lots NMMNH-

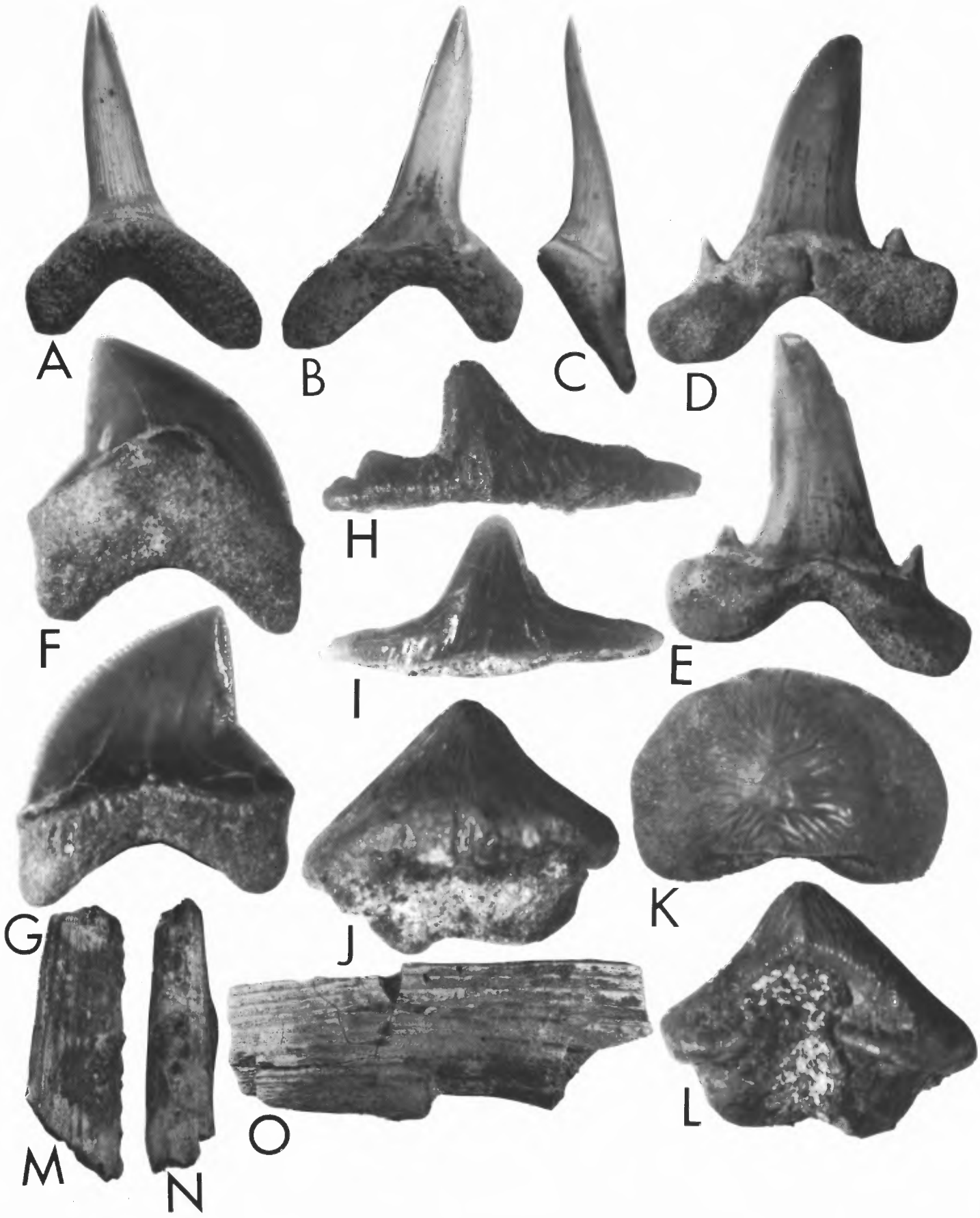
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FIGURE 2. *Scapanorhynchus, Squalicorax, Hybodus* and *Ptychodus* from NMMNH locality 297. **A–E,** *Scapanorhynchus raphiodon,* anterior tooth, NMMNH-P4046, lingual (A), labial (B) and lateral (C) views, ×3; lateral tooth, NMMNH-P4037, lingual (D) and labial (E) views, ×3; **F–G,** *Squalicorax kaupi,* NMMNH-P4036, lingual (F) and labial (G) views, ×3; **H,** *Hybodus* cf. *H. butleri,* NMMNH-P4027, lateral view, ×12; **I,** *Hybodus* cf. *H. butleri,* NMMNH-P4028, lateral view, ×6.5; **J–L,** *Ptychodus mortoni,* NMMNH-P4029, labial (J), occlusal (K) and lingual (L) views, ×3; **M–O,** fin spines of *Hybodus* cf. *H. butleri,* NMMNH-P4017, lateral (M) and anterior (N) views near tip and lateral view near base (O), ×2.

P4014 and NMMNH-P4039 and the single tooth NMMNH-P4036 (Fig. 2F–G)—to *S. kaupi*. The teeth of *Squalicorax* are perhaps the most easily recognizable shark teeth of Cretaceous marine rocks. The genus ranges from the Albian to Maastrichtian nearly worldwide (Cappetta, 1987). Meyer (1974) reported a Santonian to Campanian range for *S. kaupi* or *S.* aff. *S. kaupi* in the Texas Gulf Coast.

Hybodus cf. *H. butleri*

Teeth of *Hybodus* (Fig. 2H–I) are usually small with a short, conical central crown flanked laterally by low ridges. The lingual and labial faces of each tooth are striated. Low, lateral ridges may give rise to one or two small accessory cusps. Eighty-one teeth from NMMNH locality 297—the lot NMMNH-P4007 and single teeth NMMNH-P4027 (Fig. 2H) and NMMNH-P4028 (Fig. 2I)—are assigned to *Hybodus* cf. *H. butleri* because of their lack of or poor development of these accessory cusps (cf. Meyer, 1974). Fragments of one or more dorsal spines belonging to a hybodont shark, NMMNH-P4017 (Fig. 2M–O), are also referred to *Hybodus* cf. *H. butleri* because it is the only hybodont shark found at this site. The spine fragments are fairly large (diameter as much as 15 mm) and deeply striated. There is a row of widely spaced tubercles on the anterior edge of one of the spine fragments. *Hybodus* ranges from the Middle Triassic to the Maastrichtian of Europe, North America, Africa and Asia (Cappetta, 1987). Meyer (1974) reported *H. butleri* and *H.* aff. *H. butleri* from the Cenomanian to the Santonian of the Texas Gulf Coast.

Ptychodus mortoni

Several teeth of the shark *Ptychodus* were found at NMMNH locality 297. The crowns of these teeth (Fig. 2J–L) are not particularly high and are not steep-sided, giving the teeth a broad, roughly triangular shape in anterior view. In occlusal view, the labial edges are semicircular, and the lingual margins are indented. The crowns of these teeth are strongly ornamented by a radiating pattern of fine ridges that extend out to a rugose margin, thus indicating they belong to *P. mortoni*. However, these teeth differ slightly from the specimens of *P. mortoni* described by Meyer (1974) in that they have only the pair of mesial-distal-directed primary ridges and lack the additional pair of labio-lingual primary ridges. It is possible that these teeth represent the "transitional form" between *P. anonymus* and *P. mortoni* discussed by Meyer (1974). We assign nine teeth from NMMNH locality 297—the lot NMMNH-P4008 and the single tooth NMMNH-P4029 (Fig. 2J–L)—to *P. mortoni*. Cappetta (1987) reported that *Ptychodus* can be found in Late Cretaceous marine rocks of Europe, North and South America, Africa and Asia. In North America, the genus ranges from the Albian to the Santonian (Cappetta, 1987).

Cantioscyllium decipiens

Teeth of *Cantioscyllium decipiens* (Fig. 3A–E) have a small, posteriorly pointed central cusp with a pair of smaller lateral cusps. A round, lingual protuberance projects from the base of the main cusp. The labial face of the tooth is coarsely striated. The root is flat and bilobed. On the root, a large central foramen is flanked by a pair of margino-lingual foramina. Specimens of *C. decipiens* from NMMNH locality 297 include the lot NMMNH-P4001 and single teeth NMMNH-P4019 (Fig. 3A–C) and NMMNH-P4020 (Fig. 3D–E), a total of 38 teeth. Cappetta (1987) reports that this monospecific genus ranges only from the Cenomanian to the Turonian of Europe and North America. Meyer (1974), however, reported a Cenomanian to Santonian range for this genus in the Texas Gulf Coast.

Squatina sp.

The teeth of *Squatina* are small and laterally elongate (Fig. 3F–G). A small central cusp projects posteriorly, and from its base, long ridges extend laterally. A small labial process projects from the center of the tooth. The root is flat and lacks a basal medial groove. According to Meyer (1974), it is unlikely, due to the similarity of squatinid teeth, that specific identification can be made on the basis of isolated teeth. Specimens of *Squatina* from NMMNH locality 297 are NMMNH-P4005 (Fig. 3F–G), NMMNH-P4023 and NMMNH-P4024, a total of three teeth. The genus *Squatina* is very far ranging, extending from the Oxfordian (Late Jurassic) to Recent of Europe, the USSR, Greenland, North America, North Africa and Asia.

Ptychotrygon triangularis

The teeth of *Ptychotrygon* (Fig. 3H–K) are easily distinguished by their small size and by their low crowned, laterally elongate, triangular shape. The roots are bilobed and divided by a narrow groove. Ninety-six teeth from NMMNH locality 297—the lot NMMNH-P4002 and the single teeth NMMNH-P4021 (Fig. 3H–K) and NMMNH-P4022—are confidently referred to *P. triangularis* because of their diagnostic ornamentation consisting of broad, parallel lateral ridges. *Ptychotrygon* has a range of Cenomanian to Campanian in Europe, North America and North Africa (Cappetta, 1987).

Ischyrhiza mira

Numerous rostral teeth of the sawfish *Ischyrhiza* are present in the NMMNH collection (Fig. 3N–O). The rostral teeth have long, smoothly-enameled and dorso-ventrally compressed crowns. The teeth expand proximally to a large peduncle which is rectangular in proximal view. A large pulp cavity resides within this base. Several deep crenulations mark the dorsal and ventral sides of the peduncle. The anterior and posterior sides of the base are slightly excavated. A shallow longitudinal notch bifurcates the proximal end. Two hundred and two rostral teeth from NMMNH locality 297 referred to *Ischyrhiza mira* are the lots NMMNH-P4009 and NMMNH-P4010, as well as the single tooth NMMNH-P4030 (Fig. 3N–O). At least one tooth from NMMNH locality 297, NMMNH-P4031 (Fig. 3L–M), is believed to represent an oral tooth of *Ischyrhiza mira*. It is very small with a strong, sharp and posteriorly pointed central cusp which recedes laterally to low crests. The labial face of the tooth is smooth, and a short, well-rounded lingual protuberance projects from the base of the central cusp. The root is flat and bilobed, divided by a narrow groove. Cappetta (1987) reported that *Ischyrhiza* ranges from the Turonian to the Maastrichtian of North and South America, Europe and West Africa.

cf. *Onchosaurus* sp.

Several extremely large fragments of sawfish rostral teeth, NMMNH-P4013, NMMNH-P4033 (Fig. 4H–J), NMMNH-P4034 and NMMNH-P4035 (Fig. 4G), are tentatively referred to *Onchosaurus*. These four peduncles are dorso-ventrally compressed and rectangular in proximal view and appear to be composed of orthodentine and lack enameloid. The entire perimeter of the base is striated. The striations extend well up the base but eventually give way to a smooth surface. The proximal end of the base is excavated, and the posterior(?) face of the base is marked by a distinct sulcus. These rostral teeth are clearly distinguished from *Ischyrhiza* by their much greater size and their lack of a pulp cavity. Their peduncle morphology closely resembles that of *Onchosaurus* (Cappetta, 1987, p. 154, fig. 131A–B). These fragments also resemble specimens of *Onchopristis* to a lesser extent (see Cappetta, 1987, p. 153, fig. 129, J–L), except that the crown enameloid apparently did not extend as far down the peduncle. However, until the crown histology and morphology can be determined, any identification must remain tentative.

The genus *Onchosaurus* ranges from the Turonian to Santonian of Europe, Africa and South America (Cappetta, 1987). If the teeth belong

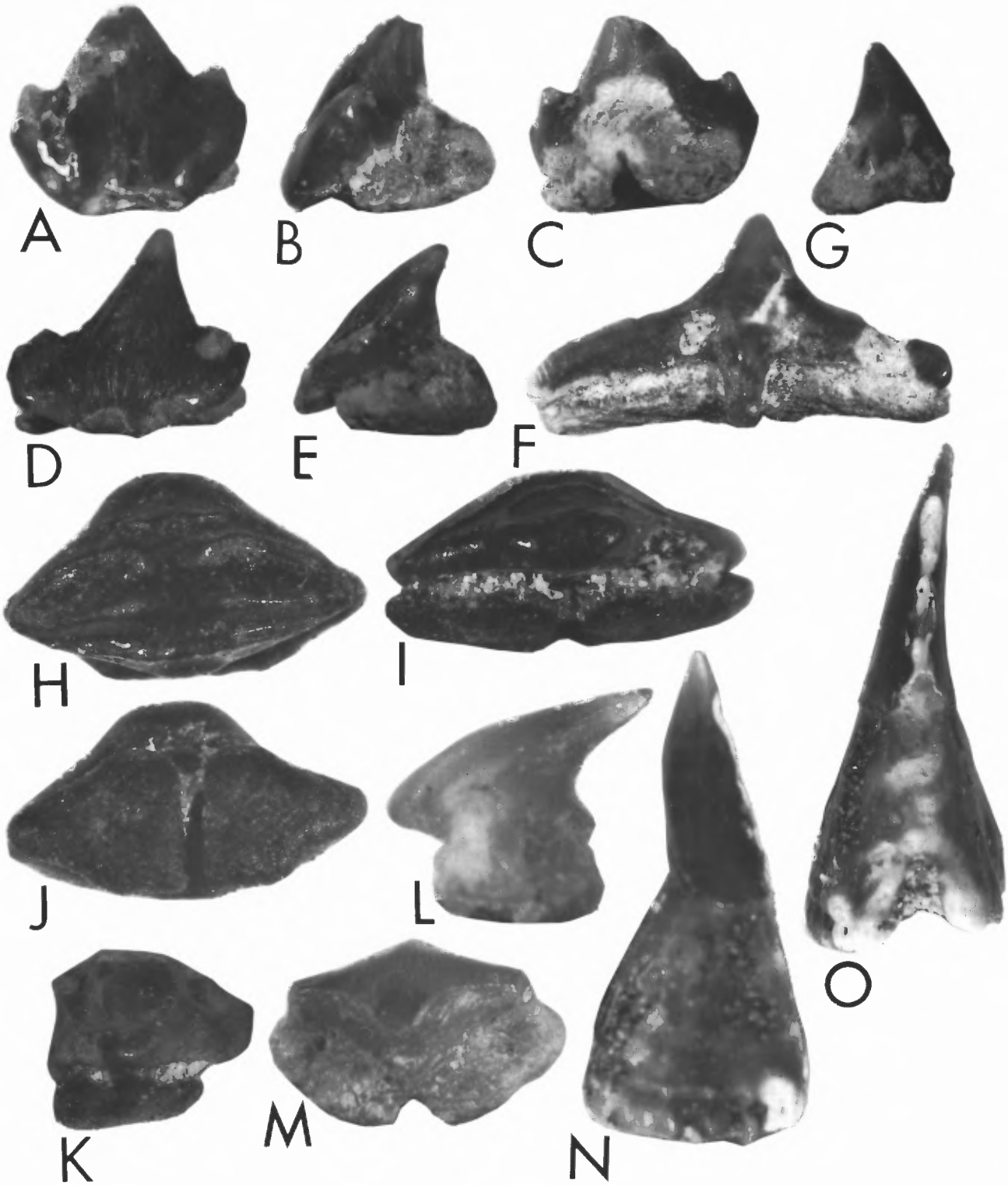

FIGURE 3. *Cantioscyllium, Squatina, Ptychotrygon* and *Ischyrhiza* from NMMNH locality 297. **A–C,** *Cantioscyllium decipiens*, NMMNH-P4019, labial (A), lateral (B) and lingual views, ×12; **D–E,** *C. decipiens*, NMMNH-P4020, labial (D) and lateral (E) views, ×12; **F–G,** *Squatina* sp., NMMNH-P4005, lingual (F) and lateral (G) views, ×8; **H–K,** *Ptychotrygon triangularis*, NMMNH-P4021, occlusal (H), labial (I), basal (J) and lateral (K) views, ×20; **L–M,** *Ischyrhiza mira* oral tooth, NMMNH-P4031, lateral (L) and oblique lingual (M) views, ×25; **N–O,** *I. mira* rostral tooth, NMMNH-P4030, dorsal (N) and anterior (O) views, ×9.

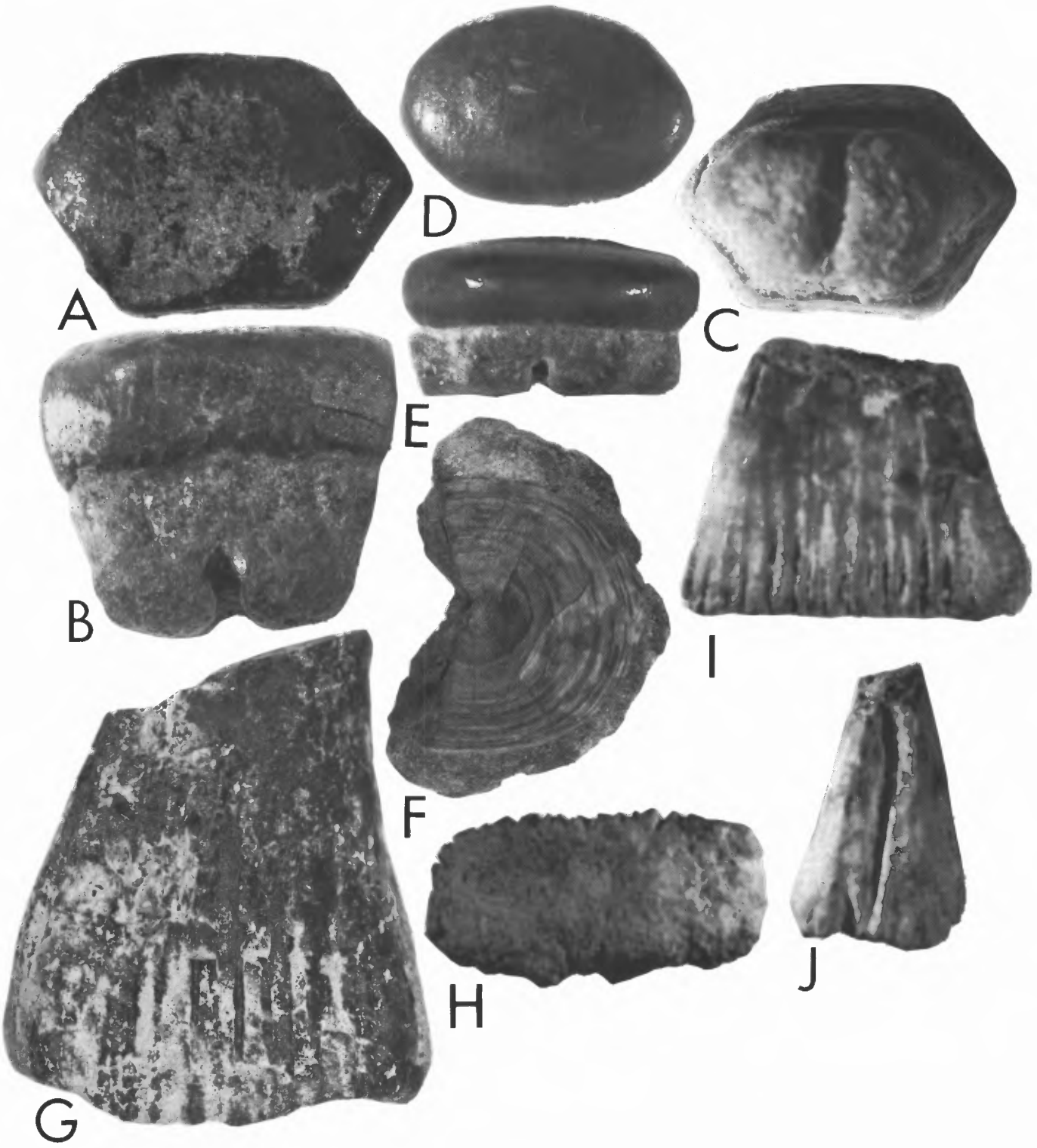

FIGURE 4. cf. *Pseudohypolophus*, cf. *Onchosaurus* and cf. lamnoid from NMMNH locality 297. **A–C,** cf. *Pseudohypolophus* sp., NMMNH-P4025, occlusal (A), profile (B) and basal (C) views, ×9; **D–E,** cf. *Pseudohypolophus* sp., NMMNH-P4026, occlusal (D) and profile (E) views, ×14; **F,** cf. lamnoid, centrum, NMMNH-P4047, view of articular surface, ×2; **G,** cf. *Onchosaurus* sp., NMMNH-P4035, dorsal? view, ×2.5; **H–J,** cf. *Onchosaurus* sp., NMMNH-P4033, proximal (H), dorsal? (I) and posterior? (J) views, ×2.5.

to *Onchosaurus*, then a geographic range extension to North America is required.

Cappetta (1978) reported that the genus *Onchopristis* ranges from the Aptian to Cenomanian of North America, North Africa and India. Keyes (1977) reported a Campanian to Maastrichtian occurrence of this genus in New Zealand, although Cappetta (1987) doubts this identification. If the specimens described here belong to *Onchopristis*, they indicate a modest range extension for the genus, at least in North America.

cf. *Pseudohypolophus* sp.

The small, ovoid and polygonal teeth of cf. *Pseudohypolophus* (Fig. 4A–E) are very abundant at NMMNH locality 297. They have a relatively high and smoothly enameled crown with vertical sides. The occlusal surface is flat to slightly convex. Two roots are separated by a narrow notch. Two or more small foramina can be seen around the perimeter of the root below the crown. Until the histology of the root and crown are verified, these 292 teeth—the lot NMMNH-P4006 and single teeth NMMNH-P4025 (Fig. 4A–C) and NMMNH-P4026 (Fig. 4D–E)—are tentatively referred to the genus *Parahypolophus*. Meyer (1974) reported an Albian to Campanian range for *Pseudohypolophus* in the Texas Gulf Coast.

cf. Lamnoidea

Several hundred calcified centra were found at NMMNH locality 297. These centra—lots NMMNH-P4048 and NMMNH-P4049 and the single centra NMMNH-P4018 and NMMNH-P4047—are biconvex discs. The articular surface of a centrum (Fig. 4F) shows a central notochord surrounded by a smooth zone which probably corresponds to the primary double-cone calcification. A wide outer zone is marked by concentric lamellae (Ridgewood, 1921, figs. 2, 3). These centra resemble lamnoid centra (Hasse, 1879–1882, pls. 29, 34, 37; Goodrich, 1930, fig. 25; Applegate, 1967, pl. 2–4, fig. 1; Lucas et al., 1985). More precise identification is not possible (cf. Lucas et al., 1985).

ECOLOGY

The fauna from NMMNH locality 297 includes a diverse array of selachians which lived in a wide range of adaptive zones. Tooth morphology and analogy with contemporary, closely related species can be used to reconstruct the ecology of this fauna.

The selachian fauna of NMMNH locality 297 (Fig. 5) can be generally divided into two ecological groups, one of pelagic and the other of benthic taxa. The pelagic taxa include *Squalicorax* and *Scapanorhynchus*. These sharks were probably streamlined, active predators. They, together with the associated plesiosaurs and mosasaurs, comprised the apex of the marine food chain in the Late Cretaceous epicontinental seaway.

Functionally, the teeth of *Scapanorhynchus* belong to Cappetta's (1987) tearing-type dentition. They were used to maim quickly and dismember prey. The sole living representative of the Scapanorhynchidae is the goblin shark. It is rare, though wide-ranging in very deep water (Castro, 1983). Scapanorhynchids were much more abundant and probably lived in shallower water than the highly specialized modern species.

Squalicorax, with its cutting-type dentition (Cappetta, 1987), was probably very similar to certain living carcharhinid sharks such as the tiger shark. Tiger sharks inhabit tropical and warm temperate waters in both deep oceanic and shallow coastal regions. They are especially voracious and will eat fish, sharks, turtles, marine birds and garbage of any kind (Castro, 1983).

The bottom-dwelling taxa tend to be dorso-ventrally flattened and slow moving. The ray *Pseudohypolophus* and the hybodontid shark *Ptychodus* (Fig. 5) have a blunt, grinding-type dentition (Cappetta, 1987). This was probably used to mill through the thick shells of oysters and other invertebrates. The teeth of the shark *Hybodus* and the nurse-shark-like *Cantioscyllium* have a clutching-type dentition that generally characterizes small, bottom-dwelling sharks (Cappetta, 1987). They probably ate a varied diet including bivalves, cephalopods, crustaceans and small fish. The sawfish *Ischyrhiza* and *Onchosaurus* (Fig. 5) were

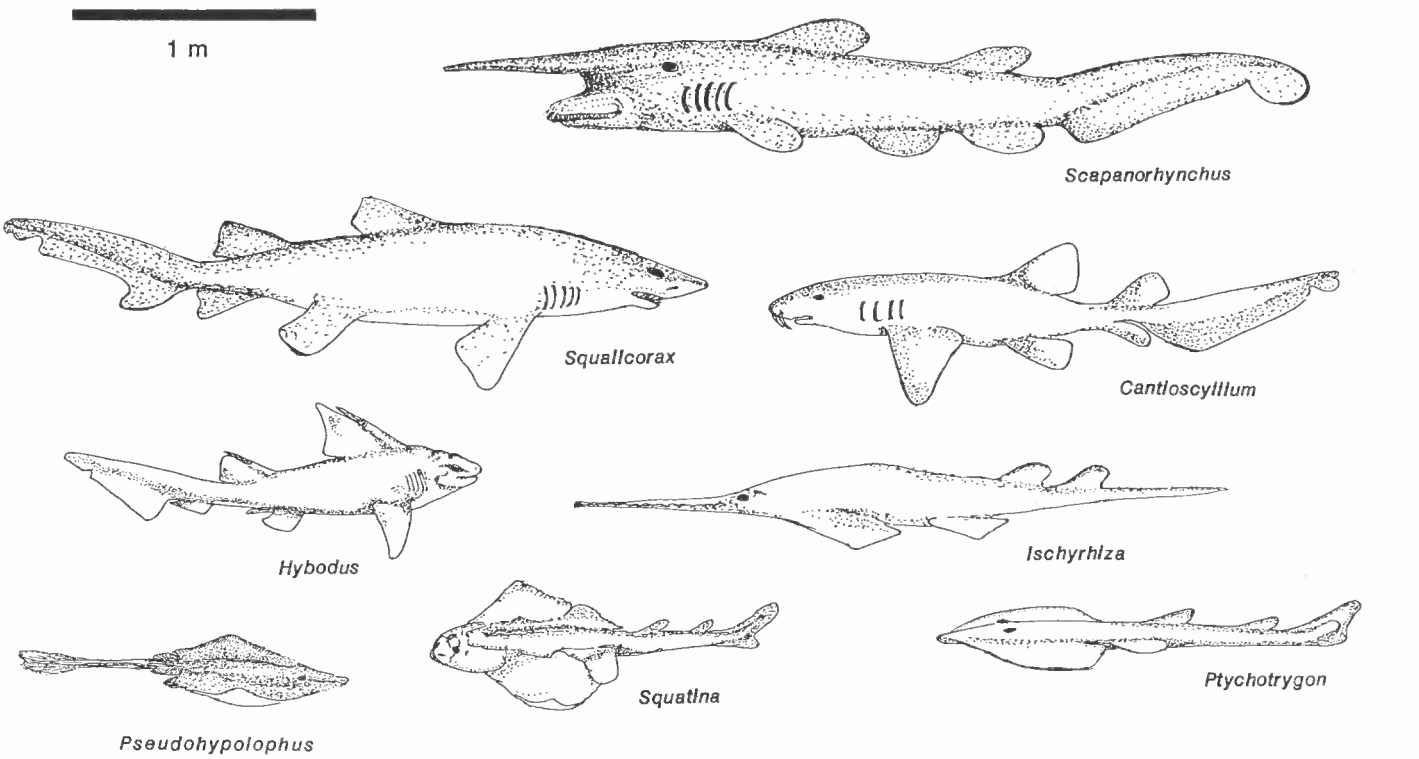

FIGURE 5. Selachian denizens of the Late Cretaceous (Santonian) seas of New Mexico drawn to approximate relative sizes. The pelagic sharks *Scapanorhynchus* and *Squalicorax* probably attained lengths of about 4 m. Most of the benthic forms such as *Hybodus* (resembles *Ptychodus*), *Cantioscyllium*, *Pseudohypolophus*, *Squatina* and *Ptychotrygon* were smaller, probably not exceeding about 2 m. The size of the sawfish *Ischyrhiza* (resembles *Onchosaurus*) is not known. Castro (1983) reported that some species of living sawfish may attain lengths of more than 6 m. *Scapanorhynchus*, *Cantioscyllium* and *Ischyrhiza* were drawn after Castro (1983); *Hybodus* was drawn after Cappetta (1987). Other reconstructions based on photographs of closely related living species.

able to stun their prey by swimming into schools of fish while slashing their barbed rostrum from side-to-side. Living sawfish inhabit shallow water throughout tropical and subtropical waters (Castro, 1983).

CONCLUSION

The selachian fossils of NMMNH locality 297 were probably deposited in a shallow, nearshore environment in warm temperate waters. The remains of freshwater gar and bowfin scales as well as turtle, crocodilian and terrestrial dinosaur bone fragments and teeth (Fig. 6A) indicate that there was an estuary or fluvial system nearby. The relative abundance of benthic and pelagic forms (Fig. 6B) indicates that a wide range of habitats and prey items were available. The fauna is similar to but less diverse than those of the shallow waters off the present Atlantic coast. For example, Hoese (1962) reported a selachian fauna of seven species of sharks and six species of rays in the shallow, highly saline seaside bays of Virginia. Six of the shark species could be classified as streamlined pelagic forms, whereas the shark *Squatina* and the rays from this area are benthic forms.

The selachian fauna of NMMNH locality 297 is also similar to the fauna described by Wolberg (1985a, b) from the Atarque Sandstone Member of the Tres Hermanos Formation (Turonian) in Socorro County, New Mexico. This fauna is also believed to have occupied a nearshore environment (Baker, 1981; Baker and Wolberg, 1981). While the relative abundances of elements of the Atarque Sandstone fauna are not known, it shares many of the same benthic genera and species as NMMNH locality 297. The benthic forms from the Atarque Sandstone fauna are about equally diverse. The Atarque Sandstone fauna, however, includes about twice as many species of pelagic lamnoid sharks. These differences in relative diversity are at least partly due to misidentification of some specimens by Wolberg (1985a, b) and may also be due to environmental factors. Relative abundance diagrams (Fig. 6) of the vertebrate fossils collected at NMMNH locality 297 are much biased by taphonomic factors. Nevertheless, these diagrams do suggest, in a general way, that selachians and especially pelagic lamnoid sharks were the most abundant large marine vertebrates in this nearshore environment.

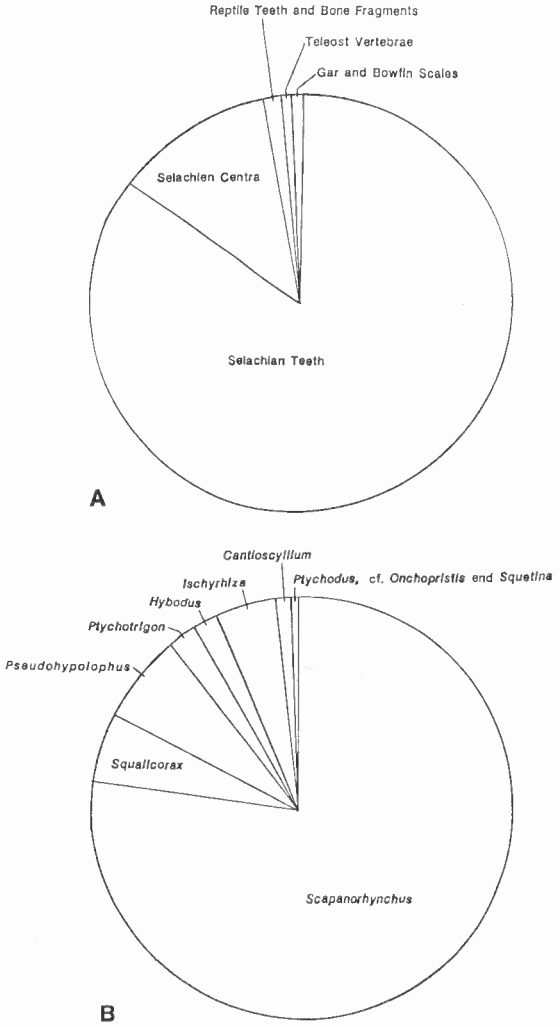

FIGURE 6. Relative abundance of elements from NMMNH locality 297, **A**, Total fauna. **B**, Selachian teeth (abundance of *Ischyrhiza* and cf. *Onchosaurus* sp. based on rostral teeth only). These plots do not necessarily reflect true relative abundance of taxa but do allow comparisons to be made with other faunas.

ACKNOWLEDGMENTS

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REFERENCES

Applegate, S. P., 1967, A survey of shark hard parts; *in* Gilbert, P. W., Mathewson, R. F. and Rall, D. P., eds., Sharks, skates, and rays: Baltimore, The Johns Hopkins Press, p. 37–67.

Baker, B. W., 1981, Geology and depositional environments of Upper Cretaceous rocks, Sevilleta Grant, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 159 p.

Baker, B. and Wolberg, D. L., 1981, Upper Cretaceous stratigraphy and paleontology, lower Tres Hermanos Sandstone, Sevilleta Grant near La Joya, Socorro County, New Mexico: American Association of Petroleum Geologists Bulletin, v. 65, p. 554.

Bilelo, M. A. M., 1969, The fossil shark genus *Squalicorax* in north-central Texas: Texas Journal of Science, v. 20, p. 339–348.

Cappetta, H., 1987, Chondrichthyes II: Mesozoic and Cenozoic Elasmobranchii. Handbook of paleoichthyology vol. 3B: Stuttgart, Gustav Fisher Verlag, 193 p.

Castro, J. I., 1983, The sharks of North American waters. College Station, Texas A&M University Press, 180 p.

Goodrich, E. S., 1930, Studies on the structure and development of vertebrates. New York, Dover Publications Inc., 837 p. [1958 republication in two volumes].

Hasse, J. C. F., 1879–1882, Das naturliche System der Elasmobranchier auf Grundlage des Baues und der Entwicklung ihrer Wirbesaule: Jena, Gustav Fischer Verlag, 284 p.

Hoese, H. D., 1962, Sharks and rays of Virginia's seaside bays: Chesapeake Science, v. 3, p. 166–172.

Hunt, C. B., 1936, Geology and fuel resources of the southern part of the San Juan Basin, New Mexico, pt. 2. The Mount Taylor coal field: U.S. Geological Survey, Bulletin 860-B, p. 31–80.

Keyes, I. W., 1977, Records of the northern hemisphere Cretaceous sawfish genus *Onchopristis* (Order Batoidea) from New Zealand: New Zealand Journal of Geology and Geophysics, v. 20, p. 263–272.

Lucas, S. G., Hunt, A. P. and Pence, R., 1988[a], Some Late Cretaceous reptiles from New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 122, p. 49–60.

Lucas, S. G., Reser, P. K. and Wolberg, D. L., 1985, Shark vertebrae from the Upper Cretaceous Pierre Shale, northeastern New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 195, p. 21–23.

Lucas, S. G., Kues, B. S., Hayden, S. N., Allen, B. D., Kietzke, K. K., Williamson, T. E., Sealey, P. and Pence, R., 1988[b], Cretaceous stratigraphy and biostratigraphy, Cooke's Range, Luna County, New Mexico: New Mexico Geological Society, Guidebook 39, p. 143–167.

Meyer, R. L., 1974, Late Cretaceous elasmobranchs from the Mississippi and east Texas embayments of the Gulf Coastal Plain [Ph.D. dissertation]: Dallas, Southern Methodist University, 400 p.

Pence, R., Lucas, S. G. and Hunt, A. P., 1986, Santonian (Late Cretaceous) fossil vertebrates, Hosta Tongue of Point Lookout Sandstone, central New Mexico, New Mexico Geology, v. 8, p. 69.

Wolberg, D. L., 1985a, Selachians from the Late Cretaceous (Turonian) Atarque Sandstone Member, Tres Hermanos Formation, Sevilleta Grant, Socorro County, New Mexico: New Mexico Geology, v. 7, p. 1–7.

Wolberg, D. L., 1985b, Selachians from the Atarque Sandstone Member of the Tres Hermanos Formation (Upper Cretaceous: Turonian), Sevilleta Grant near La Joya, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 195, p. 7–19.

View to north of Nutria conglomerate beds (hogback at center photo) forming base of Jurassic section at Upper Nutria.