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**GEOLOGY**

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## Bandringa rayi

A New Ctenacanthoid Shark from the  
Pennsylvanian Essex Fauna of Illinois<sup>1</sup>RAINER ZANGERL  
CHIEF CURATOR, DEPARTMENT OF GEOLOGY

In the summer of 1967 Mr. Ray Bandringa, Jr., of Chicago, collected an ironstone concretion containing a small specimen of a shark from a strip mine dump in the coal mining area south of Wilmington, Will County, Illinois.

I would like to especially commend Mr. Bandringa for his understanding of the scientific significance of this specimen and his ready willingness to deposit it in the collection of Field Museum of Natural History. I wish to express our sincere thanks to this enthusiastic young collector for having brought the specimen to our attention.

Class Chondrichthyes  
Subclass Elasmobranchii  
Order Selachii  
Suborder Ctenacanthoidea  
Family Bandringidae

*Diagnosis.*—Same as for genus (see below). The more completely preserved ctenacanthoid sharks may tentatively be assigned to two families: the Ctenacanthidae and the Tristychiidae. The Ctenacanthidae include *Ctenacanthus costellatus*, possibly *C. clarki*, *Goodrichia eskdalensis*, an undescribed form from the Mississippian of North America and one or two undescribed forms from the Mecca-Logan shales of Indiana. The family Tristychiidae is presently monotypic, including only *Tristychius arcuatus*. The present family Bandringidae differs from both of these by the marked elongation of the rostral region of the head.

<sup>1</sup> This report is part of the study of Pennsylvanian Paleocology and faunas of the Mazon Creek area, Illinois, by E. S. Richardson and Ralph G. Johnson, which is supported by NSF Grant GB 5772.



FIG. 84. *Bandringa rayi*, n.g., n.sp., plate and counterplate of concretion, FMNH PF 5686.

### **Bandringa**, new genus

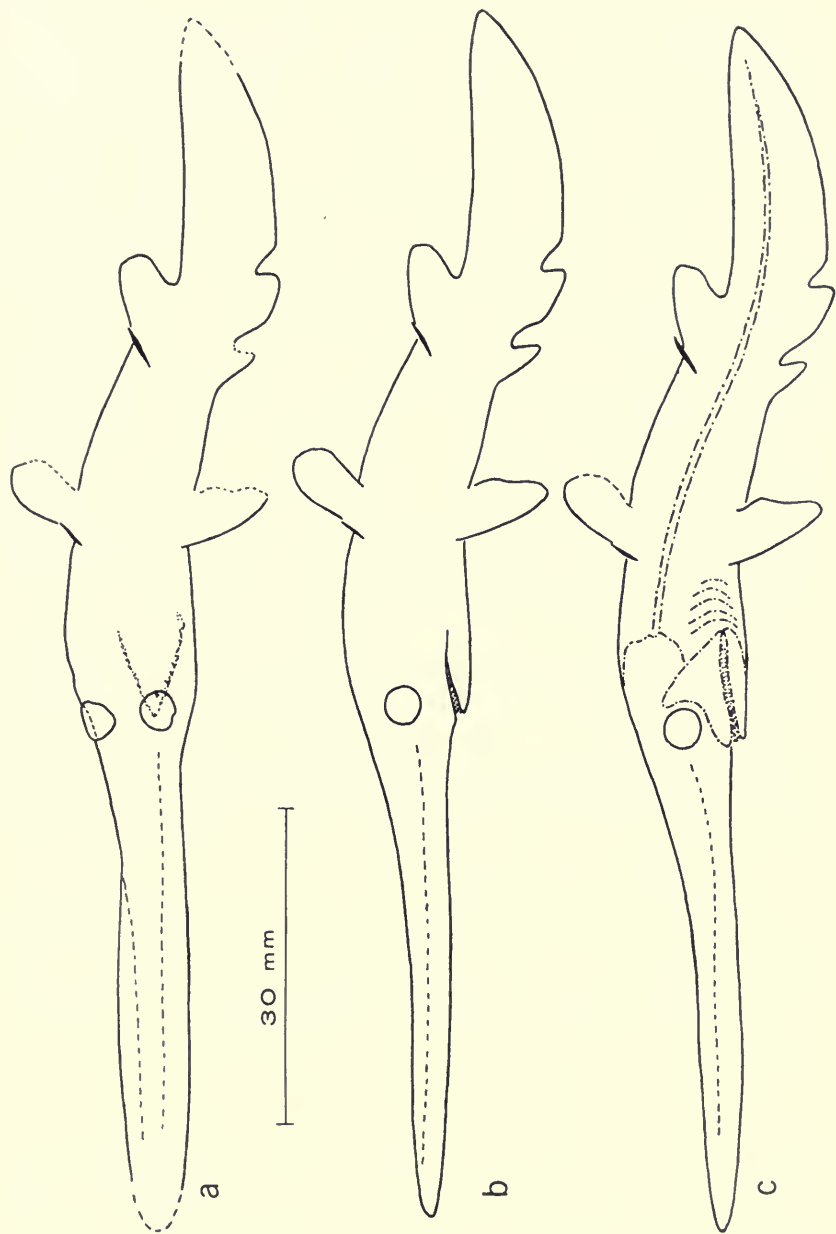
*Diagnosis*.—Sharks with two dorsal fins equipped with fin spines. An anal fin present. Teeth cladodontid, snout enormously elongated, but Meckel's cartilage of normal length, hence mouth opening sub-terminal.

*Type of genus*.—*Bandringa rayi*, new species.

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FIG. 85. *Bandringa rayi*, a, outline of specimen as preserved with indication of the position of tooth rows; b, restoration of outline in lateral view; c, lateral outline with presumed jaw apparatus, gill slits and notochord.





**Bandringa rayi**, new species

*Holotype*.—FMNH PF 5686, both halves of a concretion, containing a small shark as an areal imprint, lacking the tip of the snout and the tip of the tail fin both extending beyond the concretion.

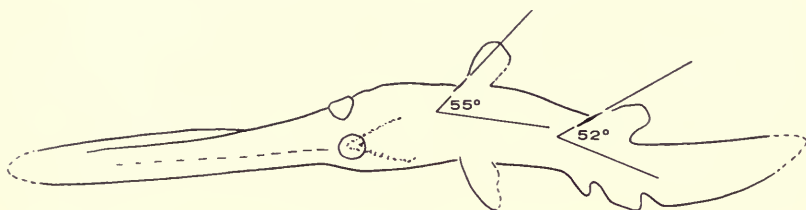


FIG. 86. *Bandringa rayi*, outline of specimen showing angulation of dorsal fin spines.

*Locality and Horizon*.—Area 3 of Pit 11, Peabody Coal Company SW  $\frac{1}{4}$  of Section 32, T32N, R9E, Will County, Illinois; Francis Creek shale, Carbondale formation. (Essex concretion fauna, Johnson and Richardson, 1966), Westphalian, Pennsylvanian.

*Diagnosis*.—Same as that of genus.

The specimen presents an almost complete outline of the body in the form of an areal imprint which contrasts sharply with the surrounding break surface of the concretion (fig. 84). There is no trace of an internal skeleton, but there are patches of a brownish organic material especially in the head region and the eyes are preserved as black, lensoid structures containing a calcite filling presumably in place of the former vitreous body. No dermal denticles were observed anywhere on the body.

The post-cranial portion of the specimen lies on the burial plane in side position whereas the head and snout are seen in approximately dorso-ventral view (fig. 85a). This probably indicates that the head and snout were dorso-ventrally flattened in life, as is the case in modern saw sharks and saw fishes (fig. 85b). The fins may have determined the side position of the remainder of the specimen.

There are two dorsal fins, both provided with small fin spines anterior to the fins. The spine of the first dorsal fin is smaller than that of the second dorsal fin (fig. 86), and the anterior spine stands at a steeper angle (about  $55^\circ$ ) to the longitudinal axis of the body than the posterior spine (about  $52^\circ$ ). This is the opposite to the usual condition in ctenacanthoid sharks (for example, *Ctenacanthus costellatus*, *Goodrichia*, *Tristychius*) and in hybodonts (*Hybodus*, *Lisso-*

*cus*) where it is the posterior spine that stands at a steeper angle to the horizontal body axis. Opposite the second dorsal fin is a rather extensive anal fin, and the tail fin consists primarily of the dorsal lobe, the ventral lobe being very small.

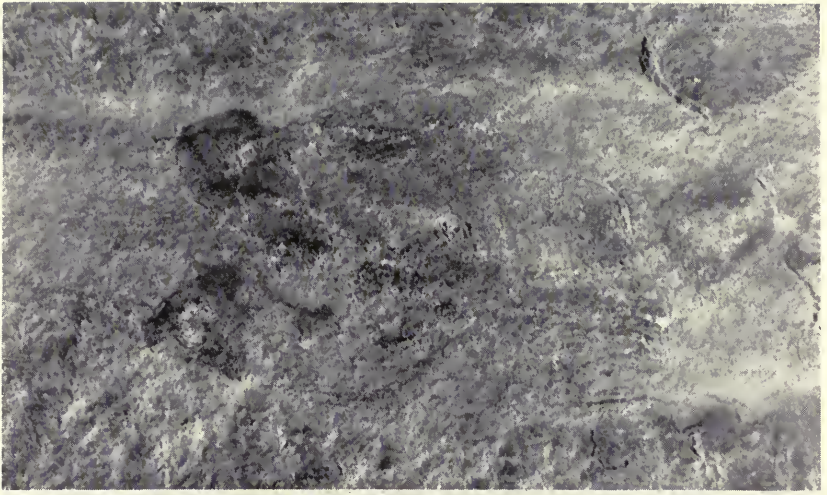
The paired fins of the right and left sides appear to be superimposed. Their shapes, as seen on the specimen, may thus reflect the combined outlines of each pair of fins, unless the superposition is perfectly congruous, as indeed seems to be the case. The pectoral fins are much larger than the pelvics (figs. 84, 85).

In the head region two converging lines of cladodontid teeth preserved as negative impressions are clearly discernible and best seen on the counter plate (fig. 87). They are very small, the largest having a base to tip of crown dimension of  $30.4 \mu$ . The apex of the tooth line lies within the area of the eye that is preserved in near-circular condition. Another, much vaguer line of teeth is located near the inner limb of the V-shaped tooth line, but it is not possible to clearly distinguish upper and lower dentitions. The more lateral limb of the V-shaped tooth line I take to belong to the lower jaw since behind it and lateral to it there is an extremely faint outline of a structure on the specimen surface that might be regarded as representing Meckel's cartilage. Palatoquadrate and Meckel's cartilages, as represented in Figure 85c, are postulated merely on the basis of general correspondence of these elements in all Paleozoic sharks that have cladodont teeth, rather than from evidence of these elements in the fossil; there are, to be sure, indistinct surface irregularities in the head region that might be interpreted as jaw structures but they are far too indistinct to permit definite identification (fig. 87a).

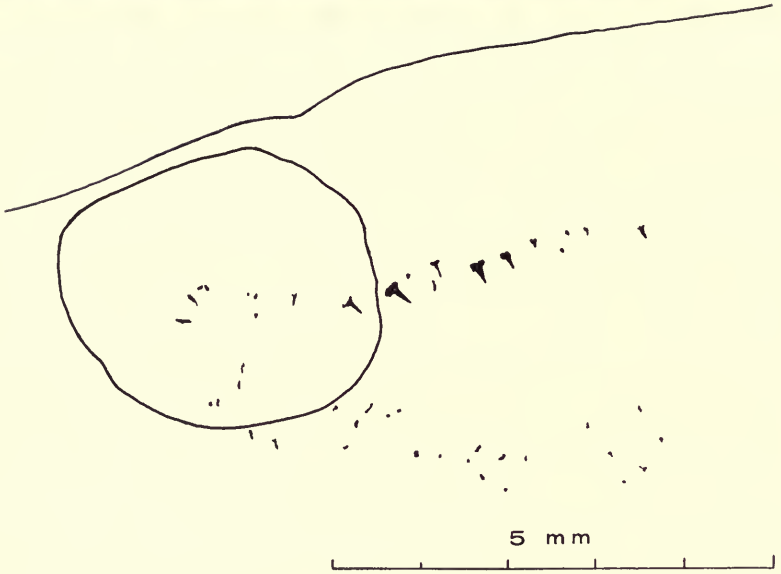
The eyes are well defined, relatively large, not entirely flattened structures that consist of a dark brown material surrounding small vugs of white crystalline calcite. The latter might be the replacement of the former vitreous bodies within the eyeballs (fig. 87a).

#### MEASUREMENTS (in mm.)

Straight line length of preserved specimen . . . . .	110.7
Length of preserved rostrum from anterior edges of eyes . . . . .	45.0
Length of head region (anterior edges of eyes to base of first dorsal fin spine) . . . . .	20.0
Distance between bases of dorsal fin spines . . . . .	18.6
Width of head region (maximum) . . . . .	12.6
Antero-posterior diameter of near-circular eye spot . . . . .	3.8



a



b

The antorbital region of the skull is enormously elongated. Two very slightly converging darker lines extend from the region of the eyes forward on the rostrum. I assume that this represents the axial, slightly thicker portion of the rostrum which was flanked by a thinner lateral fringe. No teeth or denticles of any kind could be detected on the rostrum.

*The ontogenetic age of the specimen.*—Even disregarding the long snout, the head of this specimen is extremely large compared to the body from the pectoral fins to the base of the tail; this strongly suggests a very young individual. The very weak dentition tends to corroborate this conclusion. The total absence of shagreen (dermal denticles) and of a calcified cartilage skeleton further support the view that the specimen is a juvenile, although it is possible, of course, that the adult fish was smooth-skinned and lacked calcifications in its cartilaginous skeleton.

Since the preservation of the specimen is near perfect, one should expect to see indications of a skeleton (even an uncalcified one), especially fin rays, if the cartilage had the density to be expected in a fully mature fish; yet there is no trace of any skeletal structures in the fins, and only very hazy ones in the head region.

Although none of these arguments proves conclusively that the specimen is a very immature individual, they very strongly suggest it. Assuming the foregoing conclusion to be correct, it is tempting to speculate on the possible shape of this fish as an adult. As a model, the proportions of a young (though not juvenile) and adult specimen of *Mitsukurina owstoni* are compared (fig. 88a and b). As might be expected, there is a notable, relative lengthening of the abdominal region in the adult individual and relative shortening of the head and snout. If about the same amount of distortion is applied to the outline of *Bandringa* (fig. 88c and d) the distorted figure (d) has a more mature appearance. In Figure 88e the distortion is indicated that is necessary to give the outline a scapanorhynchid look. Obviously, it is not possible to predict the direction or the degree of the change in proportion in *Bandringa*, except, perhaps, that the abdominal region would be relatively longer than it is in the present specimen.

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FIG. 87. *Bandringa rayi*, a, enlargement of the head region showing the eye-spots and indications of the tooth rows; b, camera lucida drawing of the tooth rows. The teeth are negative impressions, often unsharp, and most of them are minute pits that are molds of the tooth crowns. Only very few teeth are seen in side view. Two of these have been drawn at high magnification.

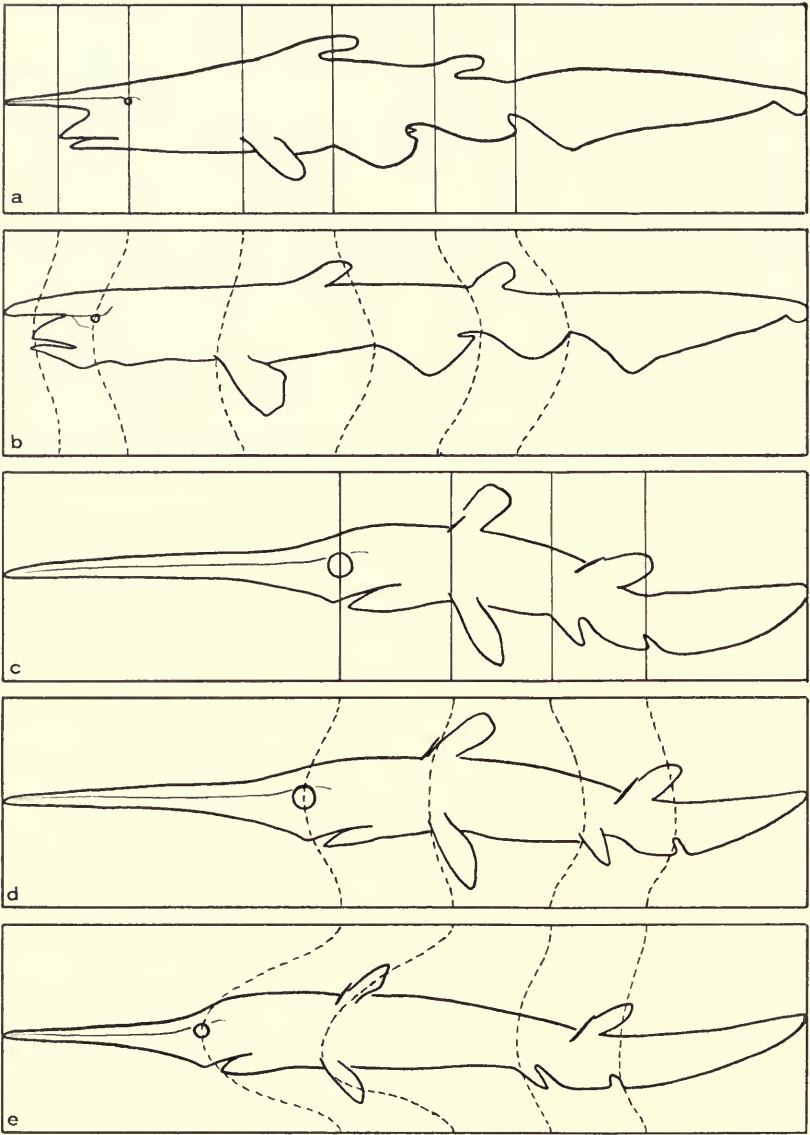


FIG. 88. Diagrams to show the ontogenetic changes in the body proportions of a young and an adult individual of *Mitsukurina owstoni*, and the possible body outline in adult specimens of *Bandringa*. a, young (42-inch) specimen of *Mitsukurina owstoni* (type specimen) after Jordan from Hussakof; b, adult individual (11-foot) of *M. owstoni*, after Bean; c, *Bandringa rayi*, reconstructed side view; d, *B. rayi* outline distorted in the same direction and magnitude as seen in *Mitsukurina*; e, degree and direction of distortion necessary to give the *B. rayi* outline a scapanorhynchid look.

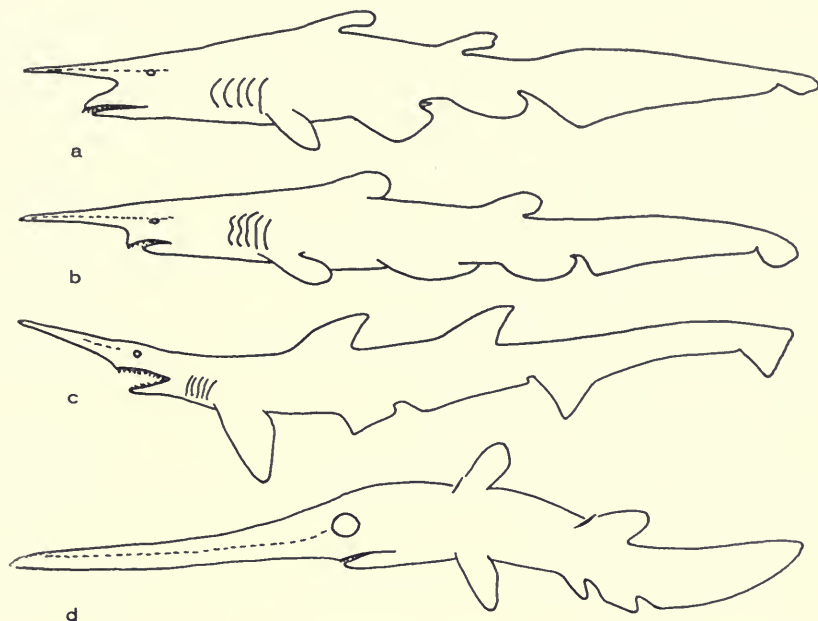


FIG. 89. Comparison of lateral body outlines of a, *Mitsukurina owstoni* (after Jordan); b, *M. jordani* (after Hussakof); c, *Scapanorhynchus lewisi* (after J. Signeux); d, *Bandringa rayi*.

*Adaptive type.*—Among modern elasmobranchs there are two groups of forms with much elongated rostra: the saw sharks (Pristiophoridae) which are Selachii and the saw fishes (Pristidae) which are Batoidei. The acquisition of a greatly elongated rostrum took place by convergence.

In both groups the rostrum is armed with teeth (or modified dermal denticles) and thus represents a different adaptive type from some long-snouted members of the Odontaspidae: two modern species of *Mitsukurina* (Goblin sharks) from around Japan and their close relative *Scapanorhynchus* from the Senonian of Mt. Lebanon and elsewhere.

These last fishes are strikingly similar in the number and differentiation of the fins, especially the caudal fin, to *Bandringa* (fig. 89), and there is an unmistakable similarity in the rostral projection. If my assumption of the juvenile age of the present specimen of *Bandringa rayi* and the above suggestions concerning a change in body proportions with age seem possible, the similarities between this

Pennsylvanian species and the long-snouted odontaspids should be even greater. At any rate there can be little doubt that these odontaspids and *Bandringa* represent very similar adaptive types.

*Systematic relationships.*—The paleozoic sharks that have cladodontid dentitions (broadly defined) may be clustered into three groups:

1. Cladodontoid sharks characterized by a single dorsal fin without fin spine. Canal fin absent. For example, *Cladodus*, *Symmorium*,<sup>1</sup> *Stethacanthus*,<sup>1</sup> *Denaea*.<sup>1</sup>

2. Cladoselachoid sharks characterized by two dorsal fins both provided with short spines.<sup>2</sup> Anal fin absent. For example, *Cladoselache*, *?Diademodus*.

3. Ctenacanthoid sharks characteristically possessing two dorsal fins with long, usually ornamented spines. An anal fin is present. Genera: *Ctenacanthus costellatus*, *Goodrichia*, *Tristychius* and undescribed additional forms.

Although this simple grouping is no more than a tentative effort to sort out the main groups of sharks with cladodontid teeth, and does not reflect levels of phyletic advancement (see Schaeffer, 1965), it does provide a needed classificatory differentiation in a rather amorphous corner of the system.

*Bandringa* falls easily into the ctenacanthoid group and is the most specialized member of the group so far known.

This ctenacanthoid group is the most diversified of the three groups distinguished. There are good reasons (see Schaeffer, 1967) to believe that the Mesozoic radiation of the sharks (and perhaps the batoids as well) may have stemmed largely from this group of Paleozoic sharks. If the ctenacanthoids are looked upon as a relatively primitive reservoir of modestly differentiated forms that gave rise, at a later date, to the spectacular diversification of the Mesozoic radiation, then *Bandringa* represents an early, specialized form, convergent in adaptive type with *Scapanorhynchus* and its modern relatives.

<sup>1</sup> Specimens in Mecca-Logan Quarry fauna; not yet described.

<sup>2</sup> Surface of spines has an "unfinished" look; they probably consist of trabecular dentine only.

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FIG. 90. Chart showing the ranges in millions of years of a number of shark genera indicating the great conservatism and phyletic longevity of these shark groups. For further detail see text.





This is *one* possible interpretation, but there is another. It seems probable that only a small sample of the variety of forms of ctenacanthoid sharks that lived in Carboniferous times have become known to date. It is thus conceivable that the so-called Mesozoic radiation had already begun during Carboniferous time and that the familiar picture of two successive radiations—one Paleozoic, the other Mesozoic–Recent, from the hybodontoids (White, 1937, Schweizer, 1964)—is the result of the poor fossil record of sharks during the Permo–Triassic, a period from which there are few presently accessible sediments of epicontinental seas.

Seen in this light, the Mesozoic and modern shark groups would have their roots among the Paleozoic sharks. *Bandringa*, for example, could be a member of the family Odontaspidae (Carchariidae), most closely related, within this family, to *Scapanorhynchus*. This interpretation would require the assumption of great phyletic longevity of families and even genera. The known record does bear this out (fig. 90). A number of modern genera, for example, *Squatina*, guitarfishes, *Heterodontus*, *Notidanus* (*Hexanchus*), *Orectolobus* and others are found in the Late Jurassic of Solnhofen and/or Cerin, thus have an age of some 150 million years. *Scapanorhynchus* from the Mt. Lebanon ( $\pm 80$  million years) is very similar to the modern *Mitsukurina jordani* (fig. 89b). A small shark in the Mecca–Logan fauna (Latest Westphalian) is difficult to differentiate even specifically from the type material of *Denaëa pruvosti* from the Lower Mississippian of Denée, Belgium. The genus, if not indeed the species, thus ranges through a period of some 60 million years. Fin spines identifiable as those of *Cladoselache* occur in the Mecca–Logan Quarry fauna. The genus *Cladoselache* is best known from the Late Devonian Cleveland Shales of Ohio. The genus thus has a vertical range upward of 80 million years. The genera *Hybodus* and *Acrodus* range from the Lias to the Late Cretaceous, a period spanning about a hundred million years. There can thus be no doubt that sharks are extremely conservative, displaying a very slow rate of evolutionary change, and the Permo–Triassic gap in the record (some 100 million years) could easily have been bridged at the family level.

This is not to say, of course, that the Permo–Triassic gap is not of great importance in any discussion of the phylogenetic history of the sharks and batoids. It is the time when profound changes in the chondrification and calcification of the vertebral column took place (development of cartilaginous centra and their calcification); reduc-

tion of the calcification of the neural and haemal arches along with the reduction of the cartilaginous fin rays in the fin skeleton, changes in the jaw suspension and so on. But the achievement of successively higher levels of organization, as Schaeffer (1967) has sketched it, is independent of time, and in the case of the sharks the achievement of an advanced level of organization of the basal skeleton of the pectoral fins, which Schaeffer rightly considers important, occurs in one line already in the Mississippian (*Tristychius*).

The two interpretations suggested regarding the relationships of *Bandringa*, namely, that of a ctenacanthoid of convergent adaptive type with *Scapanorhynchus* (and other odontaspids), or that of a genetic relationship within the family Odontaspidae whose record would then reach back into the Pennsylvanian appear to be equally justified in the sense that there is no more evidence for the one than for the other conclusion on the strength of present meager evidence. The first represents the conservative view, the second stresses the necessity of keeping in mind alternatives other than those currently in vogue.

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