SWOLLEN DORSAL FIN ELEMENTS IN LIVING AND FOSSIL *CARANX* (TELEOSTEI: CARANGIDAE)

By HARRY L. FIERSTINE[1]

ABSTRACT: Thirty-two specimens of *Caranx hippos* (Linnaeus) and two large specimens each of *C. caballus* Günther, *C. lugubris* Poey, *C. marginatus* Gill, and *C. melampygus* Cuvier from the Gulf of California and the eastern Pacific Ocean were examined for an hypertrophied basal bone of the first dorsal spine. The hyperostoses were found only in specimens of *C. hippos* larger than 343 mm standard length, regardless of sex. The bone is egg-shaped with a deep posterior notch. It is here suggested that this structure may aid in erection of the dorsal fin by increasing the surface area and by changing the direction of pull of the inclinator muscles of the dorsal fin. The element is formed of a thin outer layer of acellular compact bone which surrounds an hypertrophied center of cancellous bone. The cancellous bone is arranged in honeycomblike chambers which are filled with adipose tissue.

Bony elements found in the marine middle Miocene deposits of Sharktooth Hill, Kern County, California, are identified as belonging to *Caranx* sp. and constitute the first record of the genus from the California Miocene. The presence of numerous branching canals, laminae, and lack of honeycomblike chambers eliminate their positive identification as *C. hippos*. The presence of an incipient posterior notch and a more oval shape eliminate their positive identification as *C. carangopsis* Heckel from the Austrian Miocene. This record lends support for assuming a near-shore, tropical or sub-tropical environment for the Sharktooth Hill fauna.

INTRODUCTION

Hyperostosis or hypertrophied bone is often encountered in various parts of the skeleton of perciform fishes (Korschelt, 1940; Schlumberger and Lucké, 1948; Lucké and Schlumberger, 1949; Breder, 1952; Konnerth, 1966). When hyperostosis occurs, it is normally not restricted to one element but is found in more than one area of the skeleton. The structures most commonly affected are the supraoccipital crest and the basal elements of the dorsal and anal fins. In certain species, hypertrophied bony elements are so common that the condition cannot be considered abnormal even though closely related species lack swollen bones (Breder, 1952). The families of fishes that commonly display hyperostoses are the Carangidae (Stein-

[1]Research Associate in Vertebrate Paleontology, Los Angeles County Museum of Natural History, and Department of Biology, California State College, Long Beach, California. Current address: Biological Sciences Department, California State Polytechnic College, San Luis Obispo, California, 93401.

dachner, 1859; Starks, 1911; Korschelt, 1940; Barnard, 1948; Gopinath, 1952; Konnerth, 1966), Ephippidae (Gregory, 1933; Schlumberger and Lucké, 1948; Breder, 1952), Sciaenidae (Chabanaud, 1926), Sparidae (Kesteven, 1928; Takahashi, 1929; Ebina, 1936), and Trichiuridae (Günther, 1860; James, 1960).

The following study reveals the morphology of the swollen dorsal basal elements in the carangid fish, *Caranx hippos* (Linnaeus). This information is applied to the identification of hyperostoses in the marine middle Miocene deposits of Sharktooth Hill, Kern County, California.

Materials and Methods

Thirty-two specimens of *Caranx hippos* (Linnaeus) and two large specimens each of *C. caballus* Günther, *C. lugubris* Poey, *C. marginatus* Gill, and *C. melampygus* Cuvier from the Gulf of California and the eastern Pacific Ocean were examined by dissection or by X-ray photographs. Except for fifteen small specimens of *C. hippos* examined by Mr. Edmund S. Hobson (Zoology Department, University of California, Los Angeles) and discarded in the field, all specimens are contained in the ichthyological collections of the University of California, Los Angeles, or the Los Angeles County Museum of Natural History.

Fossil hyperostoses from the marine middle Miocene deposits of Sharktooth Hill, Kern County, California, are housed in the Vertebrate Paleontology Section of the Los Angeles County Museum of Natural History. Ground thin sections of the fossil bones were prepared by the method described by Enlow and Brown (1956).

Acknowledgements

I wish to thank Dr. Boyd W. Walker and Mr. Wayne Baldwin for the use of the ichthyological collection and equipment at the University of California, Los Angeles. Dr. Shelton P. Applegate, Associate Curator of Vertebrate Paleontology, Los Angeles County Museum of Natural History, offered encouragement and advice as well as access to the paleontological collection. Mr. Frederick H. Berry, Mr. Robert K. Liu, and Drs. David K. Caldwell, Tilly Edinger, and Richard R. Rosenblatt referred me to important literature. Mr. Edward D. Mitchell called attention to examples of fossil hyperostosis, Mr. Dick Bishop gave the Los Angeles County Museum of Natural History fossil hyperostoses from his personal collection, and Mr. Edmund Hobson made observations on 18 *Caranx hippos* at Rancho Buena Vista, Baja California del Sur, Mexico. One recent hyperostosis was stained, sectioned, and photographed through the courtesy of Dr. Marshall R. Urist, M.D., Director of the Bone Research Laboratory, School of Medicine, University of California, Los Angeles. Mr. Armando Solis of the Los Angeles

County Museum of Natural History deserves the entire credit for Figures 2 and 4 and for the printing of Figures 1, 3, and 5.

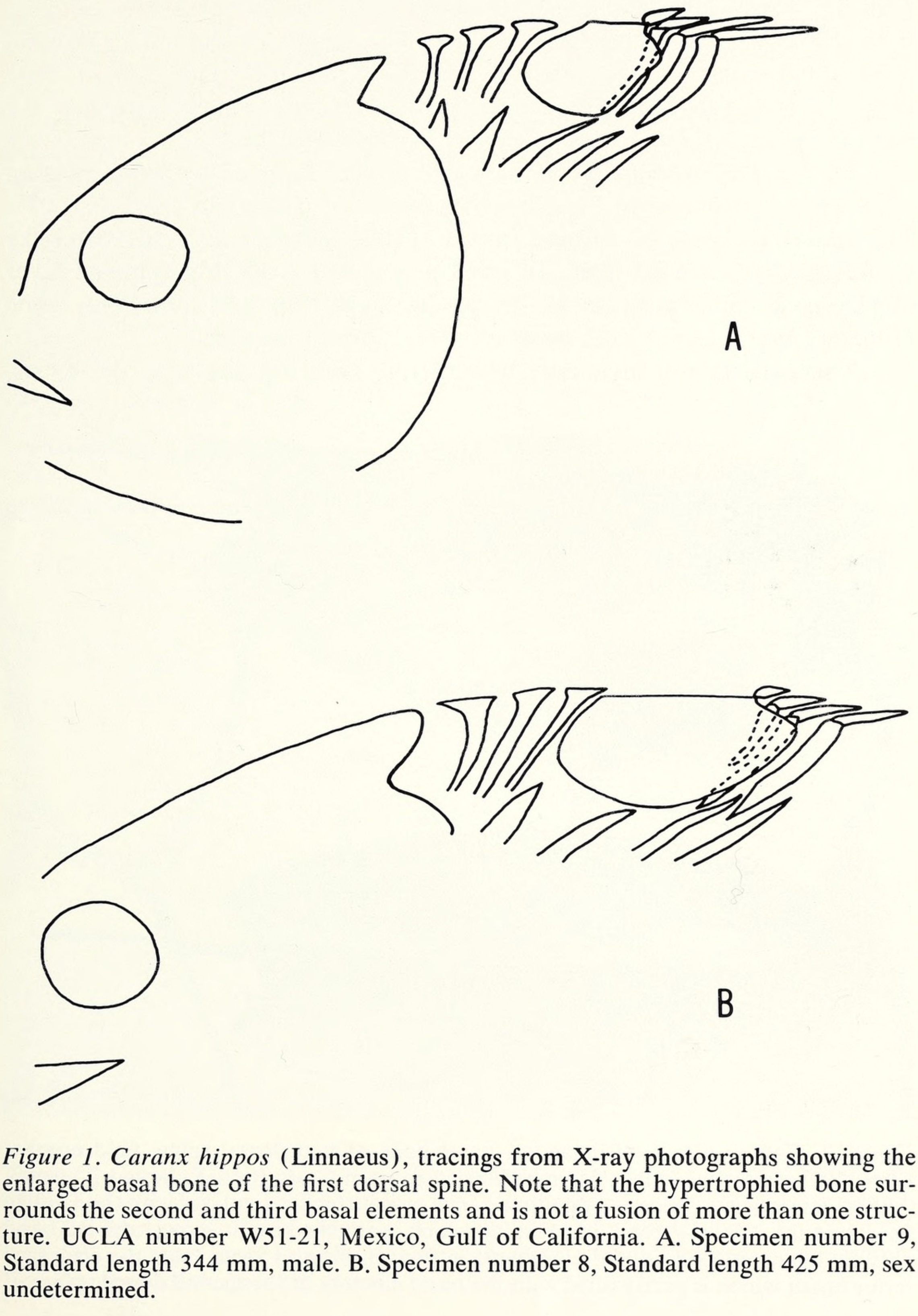

Figure 1. Caranx hippos (Linnaeus), tracings from X-ray photographs showing the enlarged basal bone of the first dorsal spine. Note that the hypertrophied bone surrounds the second and third basal elements and is not a fusion of more than one structure. UCLA number W51-21, Mexico, Gulf of California. A. Specimen number 9, Standard length 344 mm, male. B. Specimen number 8, Standard length 425 mm, sex undetermined.

RESULTS

The basal bone of the first dorsal spine is swollen in all specimens of *Caranx hippos* larger than 343 mm standard length, regardless of sex (Fig. 1). The swollen fin element is absent in 22 smaller specimens (ranging from 170 to 225 mm standard length). The length of the enlarged basal tends to increase linearly with the length of the fish. The excised bone (Fig. 2) is egg-shaped with a deep posterior notch which surrounds the succeeding one or more basal elements of the dorsal fin.

Histological examination reveals a thin outer layer of acellular compact bone which surrounds an hypertrophied center of cancellous bone (Fig. 3). The cancellous bone is formed into a regular network of honeycomblike chambers which are fat filled. In dried preparations, the thin compact layer often cracks and pulls away from the hypertrophied cancellous bone (Fig. 2). No unusual blood vessel or nerve supply was noted.

The great lateral myomeric musculature does not attach to the hyper-

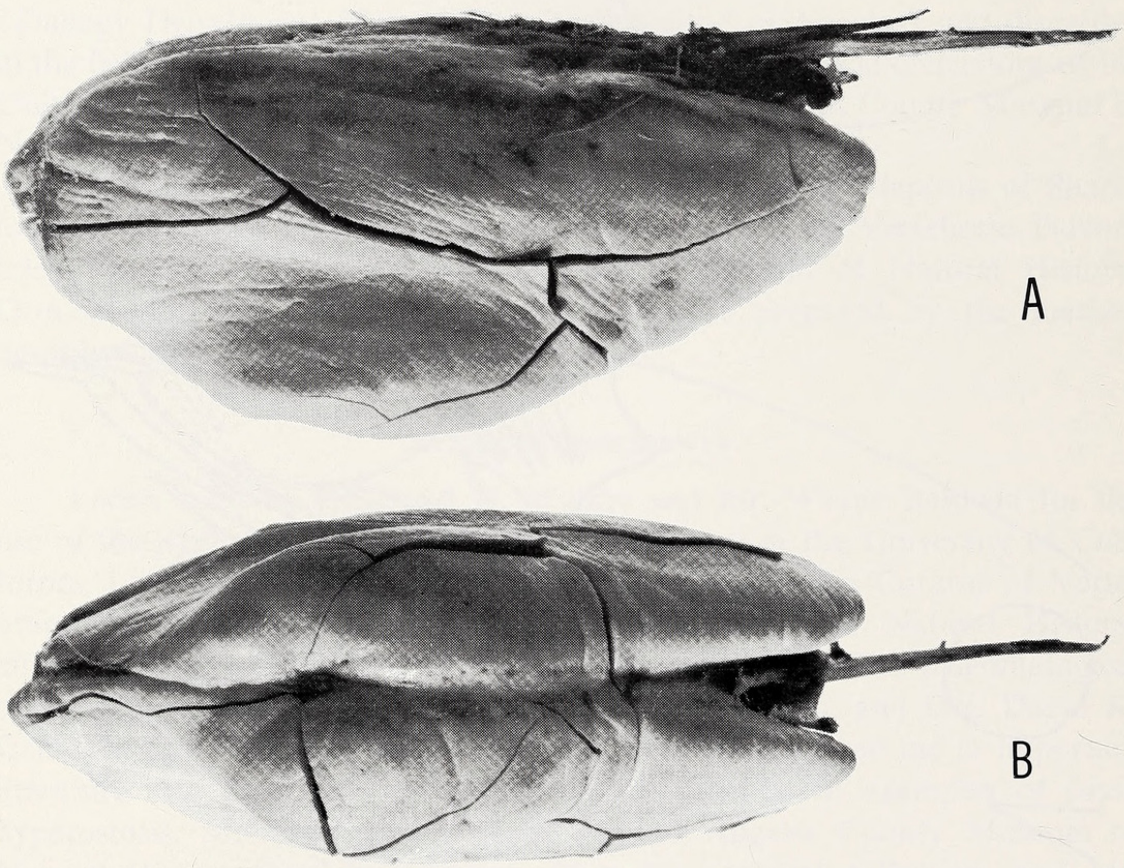

Figure 2. Caranx hippos (Linnaeus), basal bone of first dorsal spine, field number 63040203, male, fork length 443 mm, Pacific coast of Costa Rica. Enlarged 1.5 times. A. Left lateral view. Note the thin first dorsal spine which articulates with the swollen basal and the stouter second dorsal spine which is attached to the hypertrophied basal only by ligaments. Additional comments in text. B. Ventral view. Note the deep posterior notch which is partly filled with the basal element of the second dorsal spine.

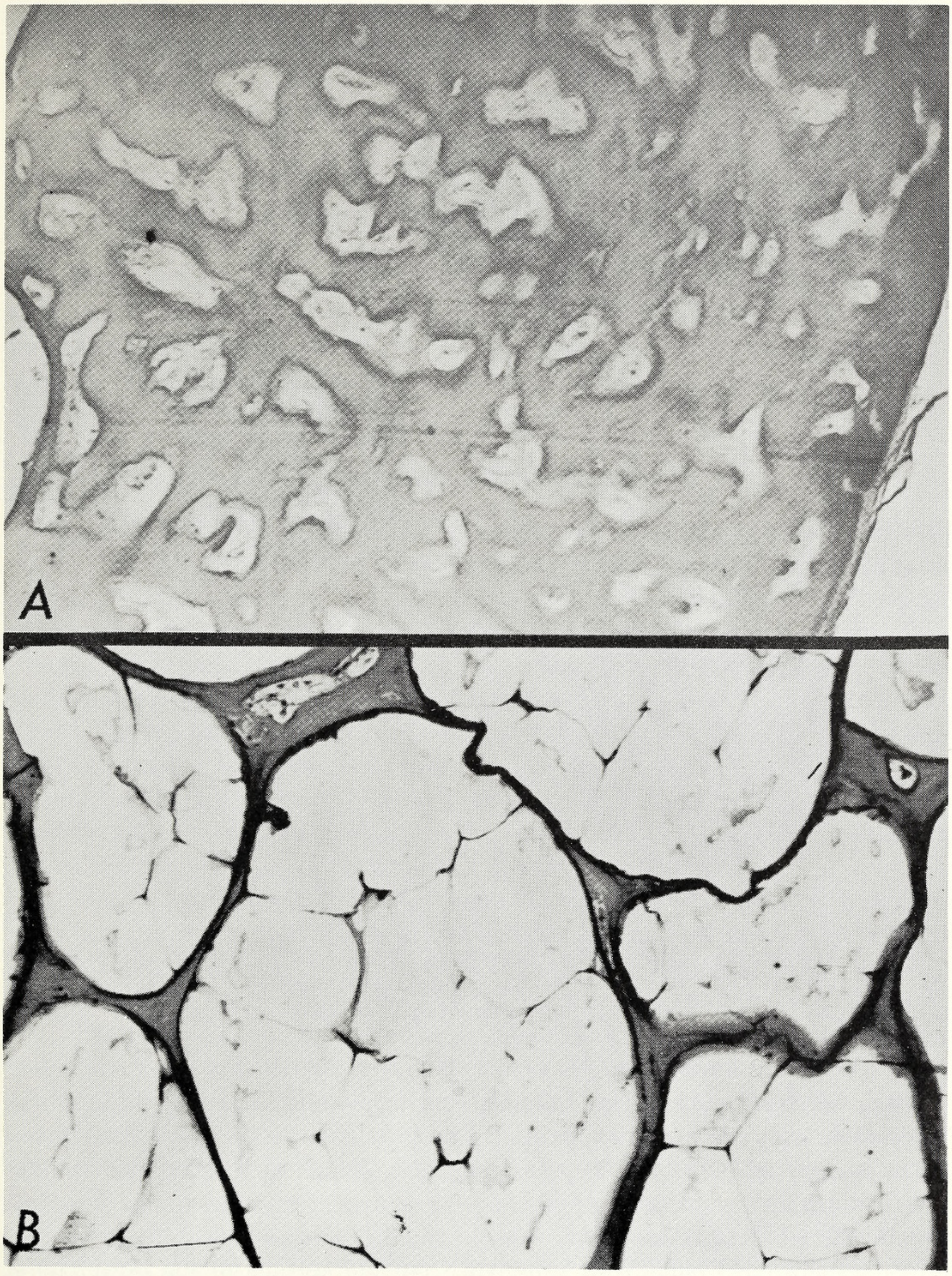

Figure 3. Caranx hippos (Linnaeus), longitudinal section of the enlarged basal bone of the first dorsal spine, UCLA number W51-21, specimen number 9, standard length 344 mm, Mexico, Gulf of California. A. Acellular outer compact layer. Enlarged 225 times. B. Acellular inner cancellous layer with adipose tissue enclosed in honeycomb-like chambers. Enlarged 225 times.

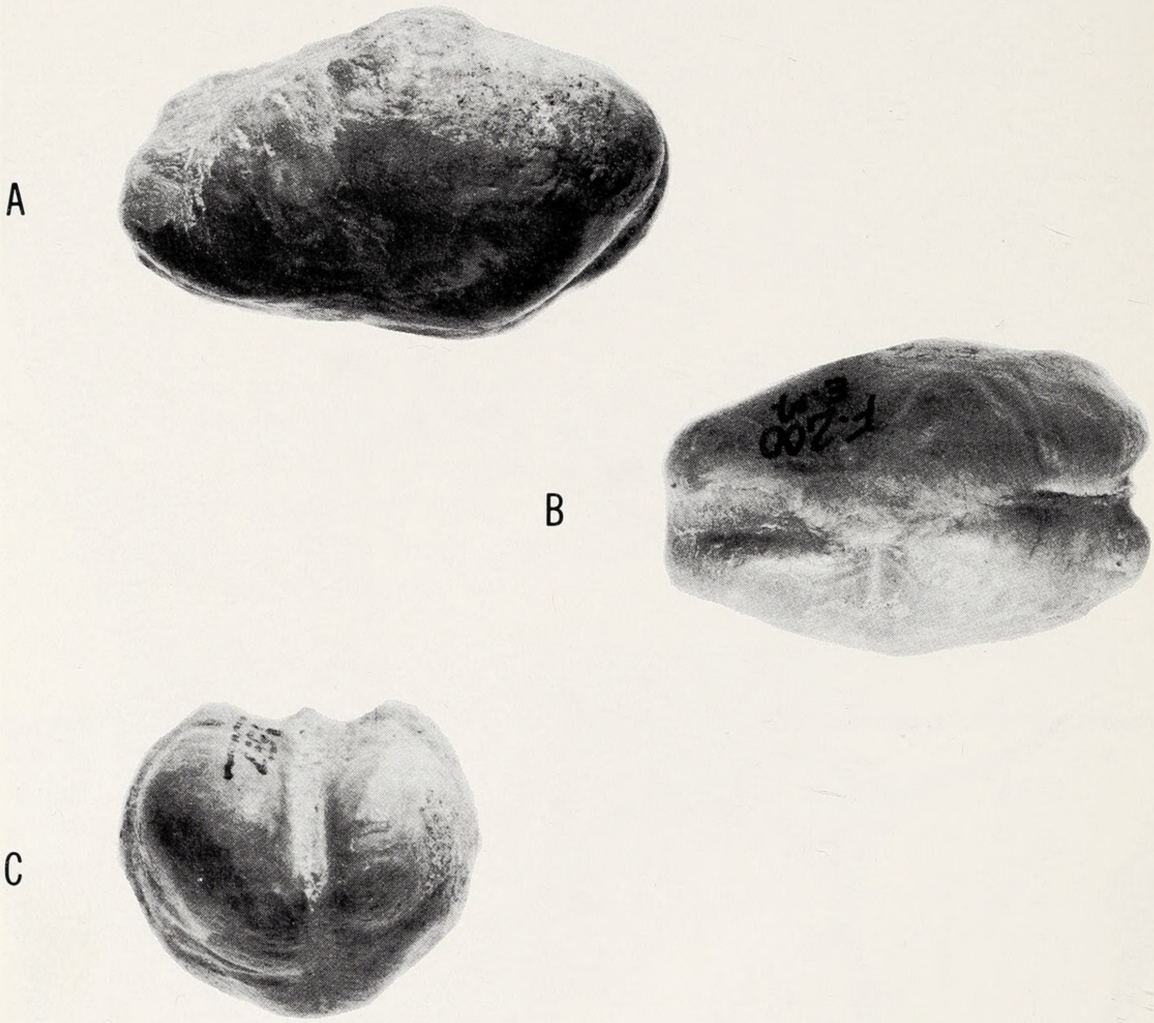

Figure 4. Caranx sp. Basal bone of first dorsal spine, LACM number $\frac{1557}{16762}$, Middle Miocene, Sharktooth Hill, Kern County, California. Enlarged 2.5 times. A. Left lateral view. B. Ventral view. Note the shallow posterior notch. C. Posterior view. Note the shallow posterior notch.

ostosis, but curves around it. The supracarinales muscle forms a thin anterior layer which originates on the posteriormost free basal and inserts on the anterior midborder of the hyperostosis. The dorsal surface of the swollen basal serves as the point of origin for the inclinator muscles of the first and second spines of the dorsal fin. The inclinator muscles are unusual in two ways: (1) in most fishes they originate from the surface of the great lateral muscles rather than from a bony surface and (2) they normally take a lateral-medial orientation rather than an anterior-posterior direction. These two differences suggest that the enlarged basal may function to erect the dorsal fin by increasing the surface area for the origin of the inclinator muscles of the first and second dorsal spines.

Two large specimens each of *C. caballus, C. lugubris, C. marginatus,* and *C. melampygus* from the eastern Pacific Ocean lacked the enlarged basal bone.

Fossil bones from the marine middle Miocene deposits of Sharktooth Hill, Kern County, California, are readily identified as hypertrophied teleost elements. The shallow posterior notch in the larger bones and the general shape suggest that they are dorsal basal elements of a fish similar to *C. hippos* (Fig. 4).

Ground bone sections reveal a very different histology than that found in recent *C. hippos* (Fig. 5). The compact bone is hypertrophied, laminated, and filled with a lacework of fine canals. These smaller canals interconnect with larger spaces in the cancellous center.

DISCUSSION AND CONCLUSION

The shape of the hyperostosis, particularly the deep posterior notch, seems to be characteristic for the swollen first dorsal basal in *Caranx hippos.* Starks (1911) mentioned a swollen post-temporal in a 355-mm *C. crysos* (Mitchill) and readily distinguished it from the hypertrophied dorsal bone of a 736-mm *C. hippos.* Steindachner (1859) described the unique shape of the swollen dorsal basal in an 1220-mm *C. carangus* Bloch (= *C. hippos,* see Berry, 1959) and readily distinguished it from swollen ribs, post-temporals, and other swollen bones in the same fish. Gopinath (1952) described the swollen supraoccipital of *C. sexfasciatus* Quoy and Gaimard as peapod-shaped. None of the published figures of swollen elements in other teleost fishes appear similar to the swollen dorsal basal of *C. hippos.*

The histology of the hypertrophied dorsal basal is similar to a figured cross-section of the normal (unswollen) lower jaw of *C. bartholomaei* Cuvier figured by Moss (1961), except for the hypertrophy of the cancellous tissue in *Caranx hippos.*

The function of the swollen basal element is enigmatic. Breder (1952) states that bony growths are never added to a fish as a response to equilibrium or for counter-balancing structures. Furthermore, he noted that they are fat-filled and would not alter the specific gravity. To me, the best functional explanation seems to be that it provides a better mechanism for erection of the dorsal fin. If the growth has a selective advantage (such as surface area for muscle origin), it could not increase linearly with the length of the fish unless it could increase its volume without increasing in weight. This problem could be solved by increasing the cancellous tissue and filling the spaces with buoyant fat, so that an increase in volume would not change the center of gravity for the fish. However, a large *C. hippos* may have other hypertrophied bones (Starks, 1911; Konnerth, 1966), and it is likely that a more complex explanation is necessary to explain the phenomena of hyperostoses.

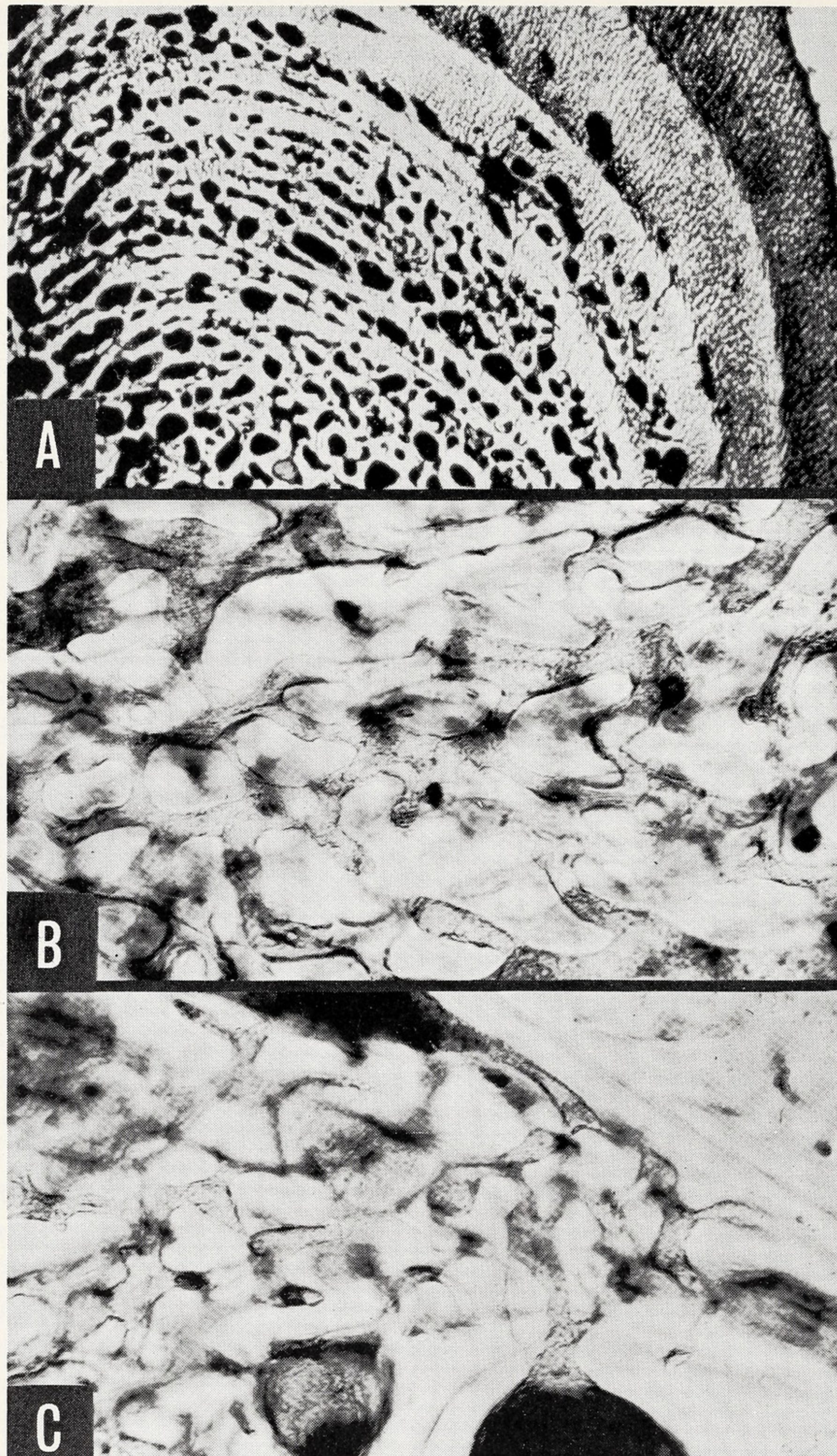

Figure 5. Caranx sp. Cross-section of fossil hyperostosis, LACM number $\frac{1655}{16761}$, Middle Miocene, Sharktooth Hill, Kern County, California. A. Outer and inner layers showing small canals, lamellae, and large central spaces. Enlarged 21 times. B. Anastomosing small canals. Enlarged 225 times. C. Inner layer showing anastomosing of large central spaces and small canals. Enlarged 225 times.

The branching tubular network in the fossil bones may have contained fat and may represent an early attempt to increase in volume without increasing the specific gravity. Since the largest fossil hyperostoses are only about one-half the size of those found in living *C. hippos,* it is possible that this method of increasing volume was unsuccessful.

The shape of the fossil hyperostoses from Sharktooth Hill indicate that they belong to the genus *Caranx.* The histological differences detract from their identification as *C. hippos.* Steindachner (1859), in a redescription of *C. carangopsis* Heckel from the Miocene of the Vienna Basin, Austria, described a swollen basal bone. His material was fragmentary and neither his illustrations nor his description indicate a shallow posterior notch. The overall shape may be more spherical than that of the Sharktooth Hill specimens. The type description (Heckel, 1852) is too brief to be helpful. Considering these discrepancies, I choose to identify the hyperostoses as belonging to *Caranx* sp. If reexamination of the Austrian material shows a similar histology, then the Sharktooth Hill specimen should be considered as belonging to *C. carangopsis.*

Since most living species of *Caranx* are restricted to near-shore tropical and subtropical waters, a similar environment for the Sharktooth Hill fauna is suggested. Other piscine evidence (Applegate and Fierstine, unpublished data) supports this supposition.

LITERATURE CITED

Barnard, K. H.
1948. Further notes on South African marine fishes. Ann. So. African Mus., 36:341-406.

Berry, F. H.
1959. Young Jack Crevalles (*Caranx* species) off the southeastern Atlantic coast of the United States. U.S. Fish and Wildlife Serv., Fish. Bull., 59(152):417-535.

Breder, C. M., Jr.
1952. The problem of directives to cellular proliferation as illustrated by ontogenetic processes in certain fishes. Growth, 16:189-198.

Chabanaud, P.
1926. Fréquence, Symétrie et Constance spécifique d'Hyperostoses Externes chez divers Poissons de la Famille des Sciénidés. Comptes Rendus de l'Académie des Sciences, Paris, 182: 1647-1649.

Ebina, K.
1936. On the growth of *Evynnis cardinalis* (Lacépède). J. Imp. Fish. Inst., Tokyo, 31:69-78.

Enlow, D. H., and S. O. Brown
1956. A comparative histological study of fossil and recent bone tissues. Part I. Texas J. Sci., 8:405-443.

Gopinath, K.
1952. On a peculiar bone formation in the supra-occipital crest of some carangid fishes. J. Zool. Soc. India, 3:267-276.