

A New Late Miocene Species of Sciaenid Fish, Based Primarily on an *in situ* Otolith from California

Richard W. Huddleston^{1,2} and Gary T. Takeuchi²

¹ *Scientific Research Systems, 11044 McGirk Avenue, El Monte, California 91731*

² *Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007*

Abstract.—A new species of sciaenid, *Seriphus lavenbergi* sp. nov., is described from the late Miocene Yorba Member of the Puente Formation, southern California. The holotype is represented by an incomplete disarticulated skull with the right saccular (= sagitta) otolith *in situ*, an extremely rare occurrence. This is the earliest known geological occurrence of *Seriphus* and represents a second species within the genus. It is hypothesized that the ancestor of *Seriphus* emigrated from the Gulf Stream of the Atlantic into the Pacific via the Panama Seaway and the genus evolved entirely in the eastern Pacific.

During the spring of 1969, students from Rio Hondo College (Whittier, California) collected fossils from a late Miocene marine site referred to locally as “Chalk Hill” in the western Puente Hills, City of Industry, California. Mr. Melvin Caskey, former Associate Professor of Geology at Rio Hondo College, allowed one of us (RWH) to examine some of the material collected. Among the specimens was a small block of diatomaceous shale, which contained a crushed, incomplete neurocranium of a fossil fish that still contained both saccular (= sagitta) otoliths *in situ*. We describe a new species of the sciaenid genus *Seriphus* based on this specimen. Previous to this report, *Seriphus* was considered monospecific (see discussion) with its earliest geological occurrence in the late Pliocene (Fitch and Reimer 1967).

The family Sciaenidae represents a strongly provincialized worldwide group of nearshore fishes containing some 270 extant species (Nelson 1994). This family is confined to shallow, coastal, and estuarine environments with a few freshwater taxa. These fishes are most abundant in tropical and subtropical areas, diminishing in more temperate zones. Sciaenids are absent from the Ryukyu Islands, New Zealand, and Pacific Oceanic Island groups (Sasaki 1989). They are also absent from the North Sea and only a single species is recorded in southern Australia (Schwarzhan 1993). This strongly suggests that the open ocean regions and cold extreme temperate zones were effective barriers to the distribution of this group.

The fossil record of *Seriphus* is confined to the extant species *S. politus* Ayres, 1860, and is represented only by isolated otoliths from the Plio-Pleistocene of California. The earliest geological occurrence of *Seriphus* is from the Fernando Formation, late Pliocene (Fitch and Reimer 1967). *Seriphus politus* has also been reported from the Timms Point Silt, early Pleistocene (Fitch 1968), from the late Pleistocene Sand Pedro Sand, and overlying Palos Verdes Sand (Kanakoff 1956; Fitch 1964, 1966, 1967, 1970). Fitch (1970) reported *S. politus* from the Crannell

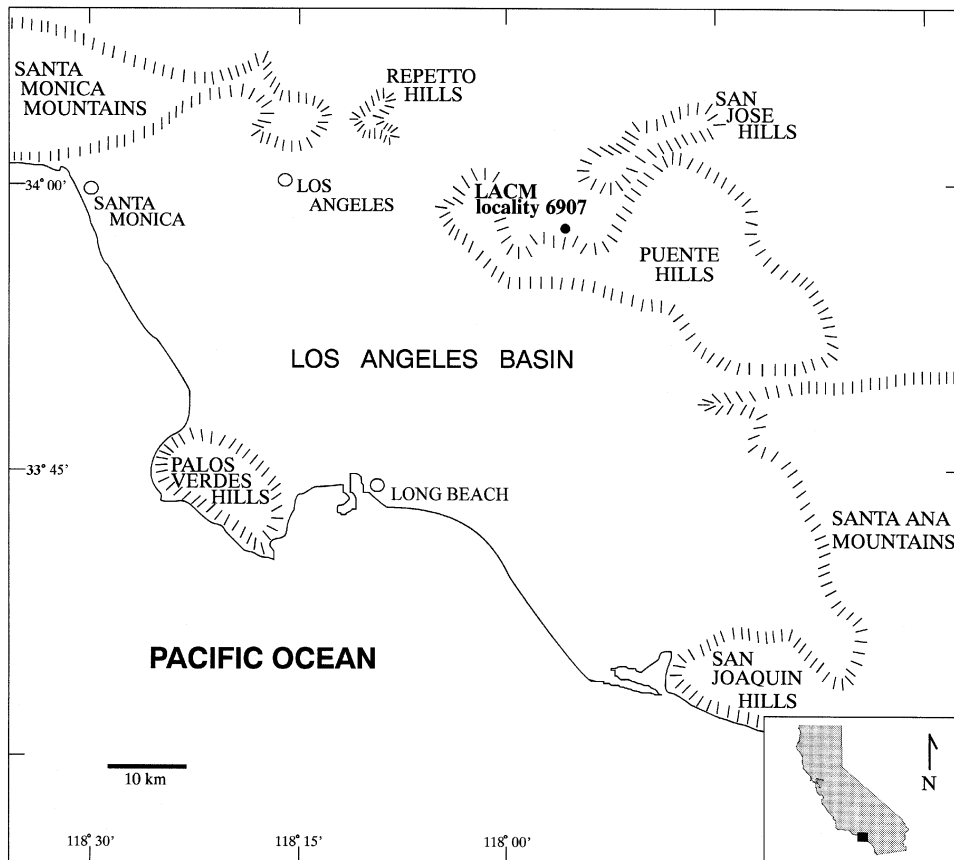


Fig. 1. Map of the Los Angeles basin indicating type locality (LACM locality 6907) of *Seriphus lavenbergi*, sp. nov. (LACM 55484), holotype, late Miocene, Yorba Member of the Puente Formation, California.

Road locality near Arcata, northern California and referred this site to be age-equivalent to the late Pleistocene Palos Verdes Sand of southern California. We have determined these deposits to represent the late Pleistocene Battery Formation and constitutes the northern most fossil occurrence of *Seriphus*.

Locality and Geology

The locality, Natural History Museum of Los Angeles County (LACM) locality 6907, was an approximately 10 m vertical exposure on a small west-facing hill in the western Puente Hills, City of Industry, Los Angeles County, California (Fig. 1). This site is located approximately 31 km east of downtown Los Angeles, but was largely destroyed by construction activity in the 1980's. The stratigraphic thickness of the section is 100 m and is composed of finely laminated diatomaceous shale interbedded with gray siltstone and fine dark mudstone deposited on a submarine fan at bathyal depths (Durham and Yerkes 1964; Yerkes 1972; Critelli et al. 1995). Durham and Yerkes (1964) and Yerkes (1972) have assigned this interval to the lower part of the Yorba Member of the Puente Formation. The

Puente Formation was named by Eldridge and Arnold (1907) for exposures in the Puente Hills in the eastern Los Angeles basin, and they recognized a lower shale member, an intermediate sandstone member, and an upper shale member. Daviess and Woodford (1949) informally divided the formation into four members, and subsequently, Schoellhamer et al. (1954) formally named the members: The La Vida Member, the Soquel Member, the Yorba Member, and the Sycamore Canyon Member.

Recently, some confusion about the naming of the Puente Formation has arisen by the assignment of the La Vida, Soquel, and Yorba members to the Monterey Formation and by the elevation of the Sycamore Canyon Member to formational rank (Dibblee 1995; 2001). The Puente Formation is considered by most workers equivalent in age to the upper portion of the Monterey Formation; however, it is distinctly different in lithology and depositional environment. The Monterey Formation consists of siliceous hemipelagic shale deposited at bathyal depth (Pis-ciotto and Garrison 1981), whereas the Puente Formation consists of more terrigenous sediments derived from the southeastern San Gabriel Mountains deposited as turbidites on submarine fans at bathyal depths (Critelli et al. 1995). Thus, we use Yerkes' (1972) terminology for the purposes of this study.

Based upon benthic foraminiferans, Durham and Yerkes (1964) placed a late Miocene (upper Mohnian) age to the Yorba Member of the Puente Formation. Benthic foraminiferan ages have been found to be time transgressive in the Cenozoic rocks of the Pacific coast of North America and are not, by themselves, reliable age indicators relative to ages derived from planktonic microfossils (Prothero 2001). Micropaleontological studies at the locality have yielded diagnostic diatom floras that confirm the late Miocene age. The diatoms are assignable to the *Thalassionema schraderi* Zone, which indicates an age of 8.6–7.6 Ma (J. D. Stewart, pers. comm.).

The Chalk Hill locality has produced a large, as yet undescribed, ichthyofauna dominated by mesopelagic forms with additional epipelagic as well as nearshore taxa (Table 1). A single specimen of the deep sea anglerfish *Acentrophryne* has been reported from the Chalk Hill area (Pietsch and Lavenberg 1980). Other megafossils recovered include an odontocete, an unidentified bird, algal remains, and terrestrial spermatophyte leaves (L. G. Barnes, pers. comm.; J. D. Stewart, pers. comm.). Invertebrates collected include *Delectopecten pedroana* Trask, *Mytilus* sp., *Lepas* sp., and an unidentified shrimp. Probable marine mammal coprolitic material has also been collected.

Material and Methods

Recent comparative materials used in this study are from the collections of the Department of Ichthyology, LACM, and includes skeletons and otoliths of Recent sciaenids. Additional comparative materials came from an otolith collection of one of the authors (RWH).

The holotype of *Seriphus lavenbergi*, sp. nov. (LACM 55484), is catalogued and housed in the collections of the Department of Vertebrate Paleontology, LACM. The holotype was discovered by splitting the diatomaceous shale along bedding planes using small hand tools in the field and was damaged in the process. This method of recovery often damages the specimens because the skeleton splits between the two sides of the shale. Additional preparation, using a fine needle

Table 1. Late Miocene ichthyofauna at LACM locality 6907 Pomona Freeway Chalk Hill, Yorba Member of the Puente Formation, California. Data from Fitch (1969), Pietsch and Lavenberg (1980), J. D. Stewart pers. comm., and personal observation.

Chondrichthyes	
Lamnidae	<i>Isurus oxyrinchus</i> Rafinesque, 1810
Cetorhinidae	<i>Cetorhinus</i> sp.
Osteichthyes	
Clupeidae	<i>Ganolytes cameo</i> Jordan in Jordan and Gilbert, 1919 <i>Ganolytes</i> sp. <i>Xyne grex</i> Jordan and Gilbert, 1919
Atherinidae	<i>Atherinops</i> sp. <i>Atherinopsis</i> sp.
Argentiniidae	<i>Argentina</i> sp.
Bathylagidae	Genus and species not determined
Gonostomatidae	<i>Cyclothone</i> sp.
Sternoptychidae	<i>Argyropelecus</i> sp.
Chauliodontidae	<i>Chauliodus eximius</i> (Jordan and Gilbert in Jordan, 1925)
Myctophidae	<i>Lampanyctus</i> sp. Genus and species not determined
Linophryniidae	<i>Acentrophryne longidens</i> Regan, 1926
Moridae	Genus and species not determined
Serranidae	<i>Paralabrax</i> sp.
Carangidae	<i>Decapterus</i> sp.
Sciaenidae	<i>Lompoquia</i> sp. <i>Seriphus lavenbergi</i> sp. nov. (this paper)
Zaphlegidae	<i>Thyrsocles kriegeri</i> (Jordan and Gilbert, 1919)
Scombridae	<i>Sarda</i> sp. <i>Scomber</i> sp.
Plurionectiformes	Family not determined

and a dissecting microscope, was required to carefully remove the fragmented left saccular otolith. This otolith had been crushed, inner face down, on top of the right otolith, and it was removed to expose the underlying diagnostic inner surface of the right otolith for study.

Morphological terms used in the general description follow Nolf (1985), Sasaki (1989), and Schwarzhans (1993). Linear measurements were made on an EPOI Shopscope optical micrometer. Otolith measurements for the Sciaenidae (Fig. 2) follow Schwarzhans (1993), and characters and their definitions for features of the saccular otolith are described below. Measurements used for proportional ratios on the inner face include the following: otolith length (L) is the greatest anterior to posterior length; otolith height (H) is the greatest dorsal to ventral height; ostium length (OL) is taken from the anterior edge of the ostium to the posterior most extension of the ostium, including the postostial lobe if present; ostium height (OH) is the greatest dorsal to ventral height of the ostium with the otolith in natural position; caudal length (CL) is measured from the dorsal edge of the cauda, at the dorsal caudal joint and extending to the posterior most extension of the dorsal caudal margin; length of horizontal portion of the cauda (X) is measured from the caudal joint of the ventral caudal margin and extending to the posterior most extension of the ventral caudal margin; length of down turned portion of cauda (Y) is from the highest point of the ventral caudal margin to the

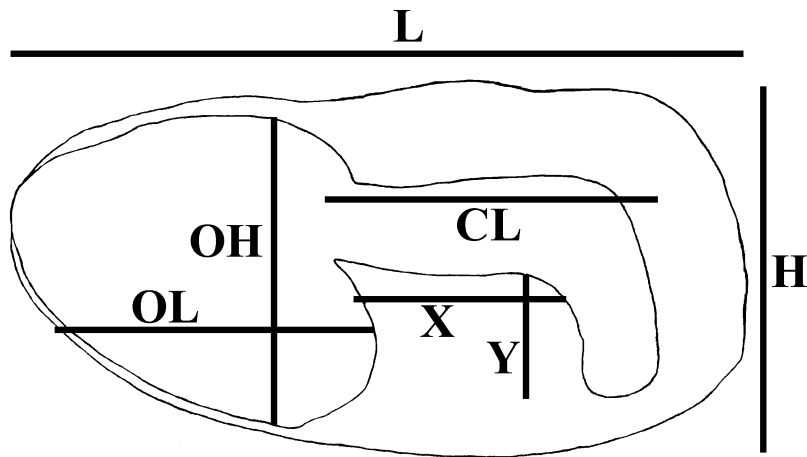


Fig. 2. Inner face of generalized sciaenid saccular otolith with measurements used for proportional ratios. **Abbreviations:** *cl*, cauda length; *h*, otolith height; *l*, otolith length; *oh*, ostium height; *ol*, ostium length; *xy*, caudal curvature index (cci). Follows Schwarzhans (1993).

posterior most point of the cauda termination. The measurement used for proportional ratios from lateral view is otolith thickness (*T*), which is the greatest inner face to outer face thickness taken in dorsal view.

Systematic Paleontology

Class Actinopterygii (sensu Nelson, 1994)

Division Teleostei (sensu Nelson, 1994)

Order Perciformes (sensu Johnson and Patterson, 1993)

Family Sciaenidae Cuvier, 1829

Subfamily Sciaeninae Gill, 1861

Genus Seriphus Ayres, 1860

Seriphus lavenbergi sp. nov.

Figs. 3–4; Table 2

Holotype.—LACM 55484, incomplete disarticulated skull with right saccular otolith *in situ* (Fig. 3).

Additional specimens.—The holotype is the only known specimen.

Type locality.—LACM locality 6907, Pomona Freeway Chalk Hill, City of Industry, Los Angeles County, California, USA; 117° 54' 41" W. longitude and 33° 59' 28" N. latitude, La Habra 7.5 quadrangle (U.S.G.S).

Horizon.—The Yorba Member of the Puente Formation, late Miocene described by Durham and Yerkes (1964) and Yerkes (1972).

Etymology.—The holotype is named in honor of Robert J. Lavenberg, Curator Emeritus, Department of Ichthyology, LACM, who along with the late John E. Fitch and one of the authors (RWH) collected and initiated the first research on the Chalk Hill ichthyofauna. We acknowledge his friendship, assistance, and contributions to the study of fossil and Recent fishes.

Diagnosis.—*Seriphus lavenbergi*, is distinguished from *S. politus* in the following combination of characters for the saccular otolith: 1) a more elongate overall

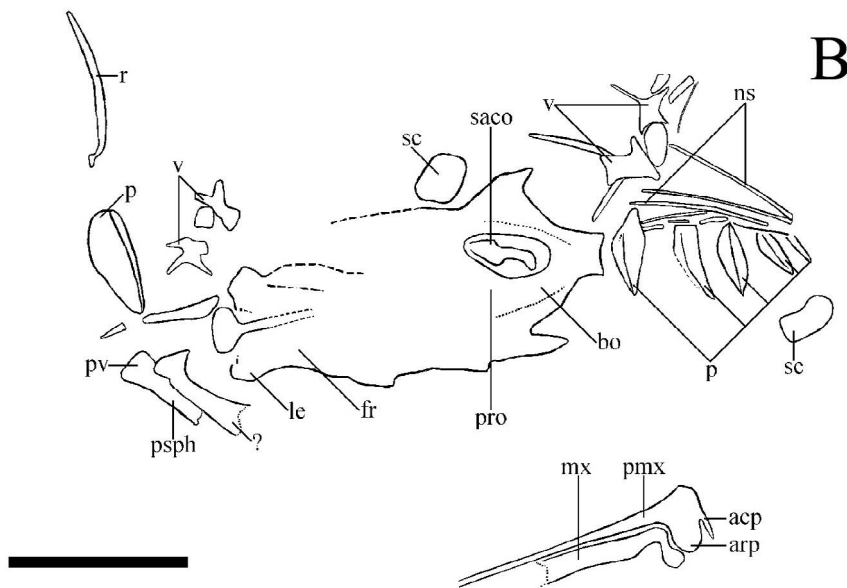
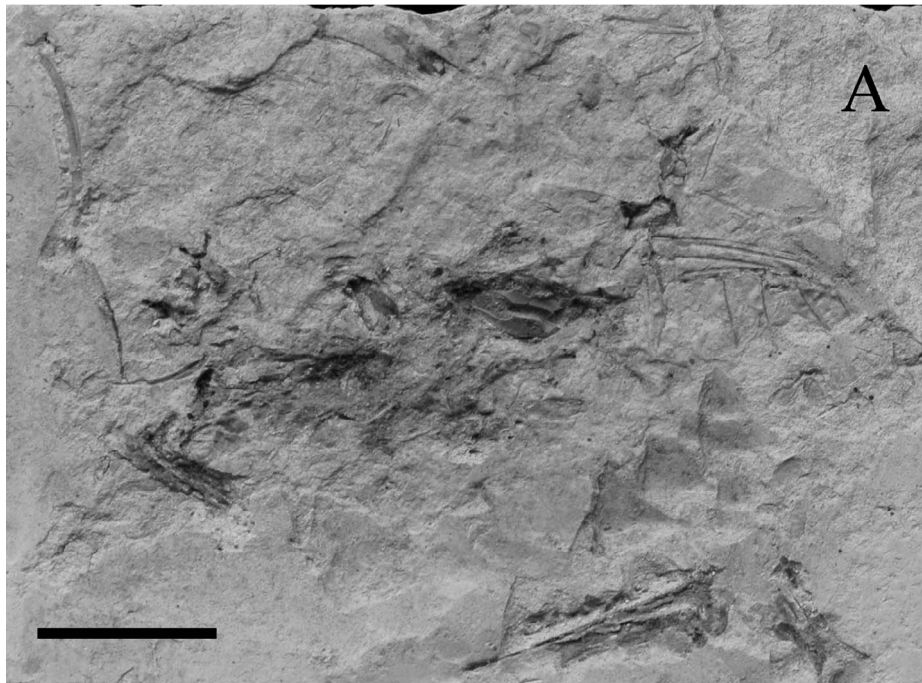


Fig. 3. Photograph (A) and illustration (B) of disarticulated skull with right saccular otolith *in situ* of *Seriphus lavenbergi*, sp. nov. (LACM 55484), holotype, late Miocene, Yorba Member of the Puente Formation, California. **Abbreviations:** **acp**, ascending process; **arp**, articular process; **bo**, basioccipital; **fr**, frontal; **le**, lateral ethmoid; **mx**, maxilla; **ns**, neural spine; **p**, pterygiophore; **pmx**, premaxilla; **pro**, prootic; **psph**, parasphenoid; **pv**, prevomer; **rb**, rib; **saco**, saccular otolith; **sc**, scale; **v**, vertebra. Scale bar equals 2 cm.

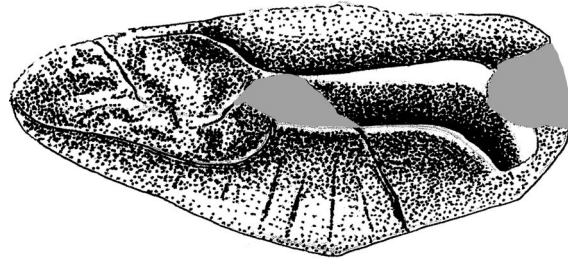


Fig. 4. Drawing of right saccular otolith of *Seriphus lavenbergi*, sp. nov. (LACM 55484), holotype, late Miocene, Yorba Member of the Puente Formation, California. Gray areas represent missing portions of the otolith. Scale bar equals 5 mm.

shape (Fig. 4); 2) a low, nearly horizontal dorsal rim (Fig. 4); 3) a more blunted, nearly vertical posterior rim (Fig. 4); 4) a longer more anteriorly tapering ostium (Fig. 4); 5) a lower caudal curvature index (2.2 vs. 3.7 in *S. politus*; Table 2); and 6) the posterior cauda is more gently flexed posteroventrally (Fig. 4). The new species also differs from *S. politus* in the following: a premaxilla with a much longer alveolar process; and a maxilla that is strongly constricted between the anterior condyle and the posterior extension of the maxillary.

Discussion.—The most diagnostic feature of the holotype is the saccular otolith, which has a broad, flat, shallow ostium. The cauda is narrow and horizontal with a curved posterior section. The sulcus is strongly homosulcoid with both the rostrum and antirostrum absent. These features are sufficient to place this specimen within the family Sciaenidae. The sub-ovate otolith with a subangular ventral margin, elliptical ostium, and posteroventrally-bent posterior cauda is characteristic of the genus *Seriphus*.

Description.—The holotype of *Seriphus lavenbergi* (Fig. 3–4) is a disarticulated incomplete skull with the right saccular otolith *in situ*. The specimen is preserved as brown bone in white diatomaceous shale.

The neurocranium measures 48.20 mm in length and 21.24 mm at greatest width. The preserved elements of the skull are difficult to interpret because of damage. The frontals and lateral ethmoids appear to be preserved in ventral view. The paired triangular frontals are by far the largest bone in the skull roof and account for the anterior half of the neural cranium. The lateral ethmoids are paired, moderately thick and projecting lateroanteriorly, forming the anterior wall of the orbits. The edentulous prevomer is short and expands laterally. It is detached and preserved lateroanteriorly of the neurocranium. The nasals do not appear to be preserved in the holotype. The thick, flattened parasphenoid is detached and preserved in ventral view anteriorly of the neurocranium. The anterior parasphenoid is attached to the prevomer. The paired prootics are large and broken, attached posteroventrally to the incomplete enlarged basioccipitals.

The upper jaw consists of a maxilla and a premaxilla. The bone surfaces are all smooth without noticeable ornamentation. The premaxilla bears well-developed ascending, articular, and postmaxillary processes. The ascending process is a thin blade-like structure and is higher than the articular process. The articular

Table 2. Comparison of measurements and proportional ratios of the saccular otolith between species of *Seriphus*. **Abbreviations:** l, otolith length; h, otolith height; t, otolith thickness; ol, ostium length; oh, ostium height; cl, caudal length; x, horizontal portion of cauda; y, down turned portion of cauda; xy, caudal curvature index (cci). See text and Fig. 2 for definition of abbreviations. Measurements are in mm.

	l	h	t	ol	oh	cl	x	y	l:h	h:t	cl:ol	ol:oh	cci
<i>S. laevenbergi</i>													
Holotype (LACM 55484)	10.3	5.1	—	4.8	2.6	4.8	2.9	1.3	2.0	—	1.0	1.8	2.2
<i>S. politus</i>													
Mean	9.61	5.48	2.21	4.43	2.64	5.03	3.31	0.9	1.75	2.49	1.13	1.67	3.77
Standard Deviation	0.85	0.13	0.24	0.25	0.09	0.53	0.22	0.15	0.14	0.23	0.08	0.05	0.67
Coefficient of Variation	8.85	2.45	10.88	5.64	3.69	10.63	6.84	16.97	8.12	9.34	7.37	2.76	17.79
Maximum	10.9	5.7	2.7	4.9	2.8	5.7	3.5	1.1	1.9	2.8	1.2	1.8	4.7
Minimum	8.1	5.3	2.0	4.2	2.5	4.0	3.0	0.7	1.4	2.1	1.0	1.6	3.0
Number = 7													

process is large and rounded, while the alveolar process is narrow and incomplete. The postmaxilla process is also incomplete. The ventral edge of the alveolar process has a narrow row of small, uniform conical teeth.

The maxilla is incomplete, and only the anterior portion is exposed. The maxilla has a distinct head with two condyles and a laterally flattened shaft. The dorsal-ventral width of the shaft is strongly constricted just posterior of the condyles.

Other associated skeletal material includes four disarticulated abdominal vertebral centra with the parapophysis either poorly preserved or broken. Neural spines are either obscured by matrix or incomplete. Two pleural ribs are present. An isolated partially articulated segment of four dorsal fin pterygiophores are preserved near the posterior end of the neurocranium. The pterygiophores are bisegmental with well-ossified stays. Pterygiophores are broad, blade-like, and increase in size posteriorly. Two additional detached pterygiophores are present, anterior and posterior of the neurocranium.

Numerous isolated scales and scale impressions on the slab are scattered around the neurocranium and are of the typical sciaenid type. They are ctenoid with the focus positioned posterior to the center of the scale. There are 12–13 anterior (basal) radii.

The right saccular otolith (Fig. 4) is moderately elongate with a total length of 10.3 mm and a greatest height of 5.1 mm. Measurements and proportional ratios of the otolith are given in Table 2 and Fig. 2. The dorsal rim is low, flat, and nearly horizontal with a slight undulation. The anterior end is sharply rounded, lacking both rostrum and antirostrum, and the ventral rim is deep and strongly angular, reaching greatest depth just posterior of the vertical midline of the otolith. The posteroventral margin is short and angled posterodorsally, with the posterior margin blunted. The ostium is large, broad, shallow, subelliptical, and elongated, tapering anteriorly. The area of the precaudal depression is not adequately preserved for description. The cauda is narrow, with its anterior long and nearly horizontal. The posterior cauda is greatly flexed posteroventrally and terminates near the posteroventral margin.

Discussion and Conclusions

The genus *Seriphus* is generally acknowledged as monospecific, with *S. politus* as the only included species. Recently, Schwarzhans (1993) incorporated an additional extant species, *Cynoscion striatus*, within *Seriphus*. This assignment was based solely on similarities in otolith morphology and excluded the differences in osteology and soft body anatomy upon which the relationships of the modern sciaenids are based. A phylogenetic analysis for the Sciaenidae by Sasaki (1989) that used morphological, osteological, and myological evidence concluded that *Seriphus* is broadly separated from *Cynoscion* by possessing the following characters: an enlarged and anteriorly located toothplate on the pharyngobranchial 2, the flexor ventralis externus fades into the flexor ventralis, the basiphenoid is separate from the parasphenoid ventrally, a dentary foramen is present, there is a secondary reversal from an enlarged and anteriorly located tooth plate on pharyngobranchial 2, the posterior dorsal fin spines are not exposed, and the soft dorsal and anal fin bases are of equal length. Sasaki's (1989) phylogenetic analysis placed *Seriphus* and related genera near *Cheilotrema* and *Cillus*.

The saccular otolith of *S. politus* and *Cynoscion striatus* display some super-

ficial similarities, however, a closer examination as part of this study revealed significant differences. The otoliths of *C. striatus* differ from *Seriphus* by being more elongate and subrectangular. They are considerably thicker with a small, more elliptical ostium. The anterior cauda is relatively longer, and the posterior cauda is extremely short and sharply curved. These features are more consistent with the interspecific variation seen in the species of *Cynoscion*. Based on these observations and the differences in the osteological and soft-bodied anatomy, we consider the placement of *C. striatus* within *Seriphus* untenable. Thus, we recognize only a single extant species within *Seriphus*.

The occurrence of *S. lavenbergi* in the late Miocene Yorba Member of the Puente Formation suggests that *Seriphus* appears to have evolved entirely in the subtropical eastern Pacific during, or prior to, the late Miocene. The Sciaenidae display pronounced provincialism with most genera confined to a specific bioprovince. The greatest diversity and highest number of species within the Sciaenidae primarily concentrate in two distinct areas of the world: Tropical America (on both Pacific and Atlantic sides) and the Indo-West Pacific, particularly along the coasts from India to China. A third more isolated endemic bioprovince occurs along the tropic West Africa coast. These areas may represent the evolutionary centers for sciaenid radiation and dispersal (Schwarzhan 1993). In his analysis of the monophyletic groups within the Sciaenidae, Sasaki (1989) noted that the family possibly originated in a restricted area of the New World (= eastern Pacific and western Atlantic) with successive dispersals extending the range of the family and increasing the diversity of the genera and species.

The North American fossil record of the Sciaenidae strongly suggests that Tropical America was the possible major evolutionary center for this family. The earliest geologic occurrence of the family is from the middle to late Eocene Gulf Coast region of North America (Koken 1888; Frizzell and Dante 1965; Breard and Stringer 1999; Nolf 2003; Nolf and Stringer 2003). Eight fossil sciaenid species have been described with an additional specimen assigned to a Recent species. Of these, five have been recognized as valid by Schwarzhan (1993). The fauna is dominated by very plesiomorphic genera that includes *?Umbrina pseudoradians*, *Frizzellithus gemma*, *Eokokenia epporrecta*, *Jefitchia claybornensis*, and *Jefitchia copelandi*. None of the sciaenids from the Eocene through Miocene Gulf Coast region display any ancestral relationship to *Seriphus*. Dispersal of the family into the eastern Pacific from the Gulf Coast region occurred by way of the Panama Seaway sometime prior to the early Miocene. Assuming fossil sciaenids had similar ecological preferences as extant sciaenids, they probably used the existing coastline of North America to radiate into the eastern Pacific. Final closure of the Panama Seaway with the uplift of the Isthmus of Panama occurred about 3.5 Ma (Coates et al. 1992) and divided a former single bioprovince in two.

Otolith-rich Eocene deposits along the eastern Pacific of North America show a conspicuous absence of sciaenids. They first appear in the early Miocene (ca 23 Ma) of the west coast of North America within the Jewett Sand Formation in central California (Huddleston, pers. obs.). This small poorly preserved fauna includes several undescribed sciaenids. By the late early Miocene (ca 16.7 Ma), the family was well established in the eastern Pacific, and this is reflected in the occurrence of several thousand sciaenid otoliths representing more than a dozen different taxa from the late early Miocene Olcese Sand of central California

(Clarke and Fitch 1979). This is the largest and most diverse sciaenid population known from the fossil record, yet none of the taxa display any ancestral relationship to *Seriphus*. This strongly suggests that *Seriphus* evolved sometime between the early and late Miocene.

Until recently, otoliths *in situ* were considered an extremely rare occurrence. Nolf (1985) noted only 23 fossil taxa of otoliths associated with skeletal material in which the otoliths were sufficiently preserved to be taxonomically useful. The fossil fish record in California is restricted to either the numerous faunas based on isolated otoliths or the relatively few faunas based solely on skeletal material. Recent work in southern California by the authors has revealed a surprising number of localities with skeletal remains associated with otoliths. These occurrences appear to be more frequent than previously reported. The reason for this is not known at this time, but it has opened up possibilities that will help provide a more complete picture of California Cenozoic fishes for future studies. At present, three localities are known within California that have at least some specimens preserved with otoliths. These include the Chino Hills, Puente Hills (this paper), and the northern Los Angeles basin. Of these, the Chalk Hill locality is unique in being the only North American diatomaceous deposit where otoliths are preserved with skeletal remains (Huddleston and Takeuchi 2002). Specimens with otoliths *in situ* provide an invaluable bridge in the dichotomy that currently exists in the nomenclatural taxonomy between taxa based entirely on isolated otoliths and skeletal material lacking otoliths.

Acknowledgments

We thank M. Caskey, former Associate Professor of Geology, Rio Hondo College, California, who brought to the attention of one of the authors (RWH) the specimen described in this paper. R. F. Feeney and J. A. Seigel (Department of Ichthyology, LACM) provided access to osteological specimens and otoliths of extant sciaenids. We greatly benefited from discussions with L. G. Barnes and J. D. Stewart (Department of Vertebrate Paleontology, LACM). Comments by C. A. Shaw, and reviews by H. L. Fierstine and G. L. Stringer greatly improved the clarity of this paper. K. E. Nakashima assisted with figure 3. Preliminary results of this project were presented at the 62nd Annual Meeting of the Society of Vertebrate Paleontology and previously published in abstract form (Huddleston and Takeuchi 2002).

Literature Cited

- Ayres, W. O. 1860. [Description of fishes.] Proc. Calif. Acad. Sci. (Ser. 1), 77–81, 81–86.
- Breard, S., and G. L. Stringer. 1999. Integrated paleoecology and marine vertebrate fauna of the Stone City Formation (middle Eocene), Brazos River section, Texas. Trans. Gulf Coast Assoc. Geol. Soc., 49:132–142.
- Clarke, M. E., and J. E. Fitch. 1979. Statoliths of Cenozoic teuthoid cephalopods from North America. Palaeontology, 22:479–511.
- Coates, A. G., J. B. C. Jackson, L. S. Collins, T. M. Cronin, H. J. Dowsett, L. M. Bybell, P. Jung, and J. A. Obando. 1992. Closure of the Isthmus of Panama: the near-shore marine record of Costa Rica and western Panama. Geol. Soc. of Amer. Bull., 104:814–828.
- Critelli, S., P. E. Rumelhart, and R. V. Ingersoll. 1995. Petrofacies and provenance of the Puente Formation (Middle to Upper Miocene), Los Angeles Basin, southern California: implications for rapid uplift and accumulation rates. J. Sed. Res., A65(4):656–667.
- Cuvier, G. L. C. F. D. 1829. Le Règne Animal, distribué d'après son organisation, pour servir de base

- à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée, Nouvelle édition. Paris, 2:122–406.
- Daviess, S. N., and A. O. Woodford. 1949. Geology of the northwestern Puente Hills, Los Angeles County, California. USGS Oil and Gas Inv. Prelim. Map 83.
- Dibblee, T. W., Jr. 1995. Tectonic and depositional environment of the middle and upper Cenozoic sequences of the coastal southern California region. Pp. 212–245 in *Cenozoic paleogeography of the western United States—II*. (A. E. Fritsche, ed.), Society for Sedimentary Geology, Pacific Section Book 75.
- . 2001. Geologic Map of the Whittier and La Habra quadrangles (western Puente Hills), Los Angeles and Orange Counties, California. Dibblee Geological Foundation map DF- 74.
- Durham, D. L., and R. F. Yerkes. 1964. Geology and oil resources of the eastern Puente Hills area, southern California. US Geol. Surv. Prof. Paper, 420-B:1B–62B.
- Eldridge, G. H., and R. Arnold. 1907. The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California. US Geol. Surv. Bull., 309:103–106.
- Fitch, J. E. 1964. The fish fauna of the Playa Del Rey locality, a southern California marine Pleistocene deposit. Los Angeles County Mus. Contrib. Sci., 82:1–35.
- . 1966. Additional fish remains, mostly otoliths, from a Pleistocene deposit at Playa del Rey, California. Los Angeles County Mus. Contrib. Sci., 119:1–16.
- . 1967. The marine fish fauna, based primarily on otoliths, of a lower Pleistocene deposit at San Pedro, California (LACMIP 332, San Pedro Sand). Los Angeles County Mus. Contrib. Sci., 128:1–23.
- . 1968. Otoliths and other fish remains from the Timms Point Silt (early Pleistocene) at San Pedro, California. Los Angeles County Mus. Contrib. Sci., 146:1–25.
- . 1969. Fossil lanternfish otoliths of California, with notes on fossil Myctophidae of North America. Los Angeles County Mus. Contrib. Sci., 173:1–20.
- . 1970. Fish remains, mostly otoliths and teeth, from the Palos Verdes Sand (Late Pleistocene) of California. Los Angeles County Mus. Contrib. Sci., 199:1–41.
- , and R. Reimer. 1967. Otoliths and other fish remains from a Long Beach, California, Pliocene deposit. Bull. Southern California Acad. Sci., 66:77–91.
- Frizzell, D., and J. Dante. 1965. Otoliths of some early Cenozoic fishes of the Gulf Coast. J. Paleontol., 39:687–718.
- Gill, T. 1861. Revision of the genera of North American Sciaeninae. Proc. Acad. Nat. Sci. Phila., 13: 79–89.
- Huddleston, R. W., and G. T. Takeuchi. 2002. First tertiary record of *Seriphus* (Perciformes: Sciaenidae) based on otoliths from the Late Miocene of California. J. Vert. Paleontol., 22(3):68a.
- Johnson, G. D., and C. Patterson. 1993. Percomorph phylogeny: a survey of the acanthomorphs and a new proposal. Pp. 554–626 in (G. D. Johnson and W. D. Anderson, Jr., eds.), Proceedings of the symposium on phylogeny of Percomorpha, June 15–17, held in Charleston, South Carolina at the 70th annual meeting of the American Society of Ichthyologists and Herpetologists, Bull. Marine Sci., 52:1–629.
- Jordan, D. S. 1925. The fossil fishes of the Miocene of California. Stanford Univ. Publ., Biol. Sci., 4(1):1–51.
- , and J. Z. Gilbert. 1919. Fossil fishes of southern California. Stanford Univ. Publ., 98 pp.
- Kanakoff, G. P. 1956. Fish records from the Pleistocene of southern California in the collection of the Los Angeles County Museum. Bull. Southern California Acad. Sci., 55:47–49.
- Koken, E. 1888. Neue untersuchungen an Tertiären fischotolithen. Z. deut. Geol. Ges., 40:274–305.
- Nelson, J. S. 1994. Fishes of the world, 3rd ed. John Wiley and Sons, Inc., New York, xvii + 600 pp.
- Nolf, D. 1985. Otolithi piscium. Pp. 1–145 in *Handbook of Paleoichthyology* Vol. 10. (H.-P. Schultze, ed.), Gustav Fischer Verlag, Stuttgart and New York.
- . 2003. Revision of the American otolith-based fish species described by Koken in 1888. Lou. Geol. Surv., 12:1–19.
- , and G. L. Stringer. 2003. Late Eocene (Priabonian) fish otoliths from the Yazoo Clay at Copenhagen, Louisiana. Lou. Geol. Surv., 13:1–23.
- Pietsch, T. W., and R. J. Lavenberg. 1980. A fossil ceratioid anglerfish from the late Miocene of California. Copeia, 1980(4):906–908.
- Pisciotto, K. A., and R. E. Garrison. 1981. Lithofacies and depositional environments of the Monterey Formation, California. Pp. 97–122 in *The Monterey Formation and related siliceous rocks of*

- California: Los Angeles, California. (Garrison, R. E. and R. G. Douglas, eds.), Pacific Section SEPM, Book 15.
- Prothero, D. R. 2001. Chronostratigraphic calibration of the Pacific Coast Cenozoic: a summary. Pp. 377–394 *in* Magnetic Stratigraphy of the Pacific Coast Cenozoic. (D. R. Prothero, ed.), Pacific Section SEPM, Book 91.
- Rafinesque, C. S. 1810. Caratteri di alcuni nuovi generi e nuove specie di animali e piante della sicilia, con varie osservazioni sopra i medesimi. Palermo, 105 pp.
- Regan, C. T. 1926. The pediculate fishes of the suborder Ceratioidea. Danish Dana Exped. 1920–22: 1–45.
- Sasaki, K. 1989. Phylogeny of the family Sciaenidae, with notes on its zoogeography (Teleostei, Perciformes). Mem. Faculty of Fisheries Hokkaido Univ., 36 (1/2):1–137.
- Schoellhamer, J. E., D. M. Kinney, R. F. Yerkes, and J. G. Vedder. 1954. Geologic map of the northern Santa Ana Mountains, Orange and Riverside counties, California. USGS Oil and Gas Inv. Map OM-154.
- Schwarzshans, W. 1993. Piscium catalogus: Part Otolithi Piscium, Vol. 1. A comparative morphological treatise of recent and fossil otoliths of the family Sciaenidae (Perciformes). Verlag Dr. Friedrich Pfeil, Munchen, 245 pp.
- Yerkes, R. F. 1972. Geology and oil resources of the western Puente Hills area, southern California. US Geol. Surv. Prof. Paper, 420-C:1C–63C.

Accepted for publication 16 March 2005.