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A REVISION OF THE EASTERN PACIFIC SNAKE-EEL GENUS  
*OPHICHTHUS* (ANGUILLIFORMES: OPHICHTHIDAE) WITH  
THE DESCRIPTION OF SIX NEW SPECIES

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The eastern Pacific species of the tropical snake-eel genus *Ophichthus*, family Ophichthidae, subfamily Ophichthinae, are reviewed. An identification key, synonymies, diagnoses, and illustrations are provided for each of the 11 species recognized: *O. apachus* n. sp. (from México to Colombia), *O. arneutes* n. sp. (Galápagos Islands), *O. frontalis* (Gulf of California to Panamá), *O. longipenis* n. sp. (México to Panamá), *O. mecopterus* n. sp. (México to Costa Rica), *O. melope* n. sp. (Costa Rica to Colombia), *O. remiger* (Nicaragua to Chile), *O. rugifer* (Galápagos and Cocos islands), *O. tetratrema* n. sp. (Costa Rica to Ecuador), *O. triserialis* (California to Peru), and *O. zophochir* (California to Peru). The Galápagos and Cocos islands endemic *O. rugifer* is recognized as distinct from *O. triserialis*. The status of all nominal eastern Pacific species of *Ophichthus* is discussed. Characters useful for the study of ophichthid phylogeny are compared and discussed. The following new synonymies are proposed: *Ophichthys* (*Herpetoichthys*) *ater*, *Ophichthys callaensis*, *Ophisurus dicellurus*, *Ophichthys exilis*, and *Ophichthys uniserialis* = *O. remiger*; *Ophichthys biserialis* = *O. rugifer*; *Ophisurus Californiensis* and *Ophichthys grandimaculatus* = *O. triserialis*; *Ophichthus chamensis* = *O. zophochir*. Lectotypes for the following species are designated: *O. frontalis*, *O. pacifici*, *O. remiger* and *O. zophochir*.

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The snake-eels and worm-eels (family Ophichthidae) of the eastern Pacific Ocean constitute a rich and diverse assemblage. At least 40 species distributed among 21 genera occupy benthic habitats ranging from the shallow intertidal to depths of 975 m or more (McCosker and Rosenblatt 1995, and our unpublished data). Although the eastern Pacific lacks coral reefs and its tropical band is restricted, the eastern Pacific diversity of this primarily tropical eel family is comparable to that of the western Atlantic which has 25 genera and 54 species (McCosker et al.

1989). By far the most speciose genus of eastern Pacific ophichthids is *Ophichthus* with 11 species, six of which are new and described here.

In this work we have attempted to reference all of the eastern Pacific ophichthids that have been described either as *Ophichthus* or *Ophichthys*. Besides the recognized species and their synonyms that occur in our species accounts, we list the following: *Ophichthys miurus* Jordan and Gilbert (1882), described from Cape San Lucas, is now known as *Scytalichthys miurus*; *Ophichthus evionthas* Jordan and Bollman (1890), de-

scribed from the Galápagos Islands, and *Ophichthys nothochir* Gilbert (1890), described from the Gulf of California, are placed in *Quassiremus*; *Ophichthys quincunciatus* Günther (1870), locality unknown, and *Ophichthys xysturus* Jordan and Gilbert (1882), from México, are synonyms of *Myrichthys tigrinus* Girard (1859); and *Ophichthys afueræ* Hildebrand (1946) from Peru is a junior synonym of *Herpetoichthys fossatus* (Myers and Wade 1941).

#### MATERIALS AND METHODS

Measurements are straight-line, made either with a 300 mm ruler with 0.5 mm gradations (for total length, trunk length, and tail length), and recorded to the nearest 0.5 mm, or a 1 m ruler with 1 mm gradations and recorded to the nearest 1 mm. All other measurements are made with dial calipers or dividers and recorded to the nearest 0.1 mm. Body length is head and trunk length. Head length is measured from the snout tip to the posterodorsal margin of the gill opening; trunk length is taken from the end of the head to mid-anus; maximum body depth does not include the median fins. Head pore terminology follows that of McCosker et al. (1989:257): such that the supraorbital pores are expressed as the ethmoid pore + pores in supraorbital canal, e.g., 1 + 3, the infraorbital pores are expressed as pores along the upper jaw + those in vertical part of canal behind eye (the "postorbital pores"), e.g., 4 + 2, in that frequently the last pore included along the upper jaw is part of the postorbital series. Gill arch examination was accomplished after removal and clearing and counterstaining with alcian blue and alizarin red dyes (Dingerkus and Uhler 1977). Vertebral counts (which include the hypural) were taken from radiographs. Vertebral notation and definitions are described in Böhlke (1982). The mean vertebral formula (MVF) is expressed as the average of predorsal, preanal, and total vertebrae. Galápagos island names follow those of Woram (1989). Institutional abbreviations follow Leviton et al. (1985) except specimens identified by the acronym "W." These specimens now reside at the Los Angeles County Museum of Natural History (LACM).

#### Genus *Ophichthus* Ahl, 1789

*Ophichthus* Ahl, 1789:5 (type species *Muraena ophis* Linnaeus 1758, by original designation).

DIAGNOSIS. — Body moderately to very elongate, cylindrical, laterally compressed posteriorly; body stouter and shorter than tail. Snout moderately developed, subconical. Eye moderate to large. Anterior nostril tubular, posterior nostril just above lip or opening into mouth. Dorsal fin above or behind gill opening; pectoral fin well developed. Dentition variable, from numerous, small and multiserial to few, large, and uniserial or biserial; teeth never caniniform. Coloration usually uniform, although some species may be banded or spotted.

ETYMOLOGY. — From the Greek ὄφις (snake) and ἰχθύς (more properly ἰχθυός, fish), masculine.

REMARKS. — A complete generic synonymy of *Ophichthus* is available in McCosker et al. (1989). Pending a worldwide revision, we treat *Ophichthus* broadly, recognizing that several subgenera and lineages exist.

#### KEY TO THE EASTERN PACIFIC SPECIES OF *OPHICHTHUS*

- 1a. Body ground color yellow to tan, with a series of prominent, subcircular brown blotches or saddles centered above midline on sides; head with smaller spots and speckles . . . . . 2
- 1b. Body ground color brown, gray or blackish; plain or with spots or darker bars, not as above . . . . . 3
- 2a. Vertebrae 145–152 . . . . . *O. triserialis* (California to Peru)
- 2b. Vertebrae 157–162 . . . . . *O. rugifer* (Galápagos and Cocos islands)
- 3a. Posterior nostril in a tube above upper lip . . . . . 4
- 3b. Posterior nostril opening just above edge of upper lip, covered by a flap (lower margin of opening with a thickened or raised rim, but flap attached to lip, rather than to lower margin of nostril) . . . . . 6
- 4a. Preopercular (PO) pores 4; teeth in mandible in a single row, vomerine teeth biserial *O. tetratrema* n. sp. (Costa Rica to Ecuador)

- 4b. PO pores 2 or 3; teeth in mandible in two rows, vomerine teeth uniserial. . . . . 5
- 5a. Pectoral fin pointed; a series of pale spots, about a snout length apart, along lateral line: body not banded . . . . . *O. remiger* (Nicaragua to Chile)
- 5b. Pectoral fin rounded; no pale spots on head or body, body with pale brown bands or saddles (often fading in older preserved specimens), at least posteriorly . . . . . *O. frontalis* (Gulf of California to Panamá)
- 6a. Tail 74–80% of TL; anterior lateral line pores of body in brown spots or unmarked . . . . . 7
- 6b. Tail 56–70% of TL; lateral line pores on body unmarked . . . . . 8
- 7a. Teeth in jaws uniserial, long, slender, recurved and widely spaced; intermaxillary teeth enlarged and recurved; snout long and pointed when viewed from above; head pores and anterior lateral line pores in brown spots . . . . . *O. longipenis* n. sp. (México to Panamá)
- 7b. Jaw teeth in two rows, small and close set, intermaxillary teeth little enlarged; snout short and blunt, rounded when viewed from above; lateral line pores on body unmarked, head pores with at most a narrow melanophore ring. . . . . *O. apachus* n. sp. (México to Colombia)
- 8a. A barbel between nostrils, and (usually) two behind posterior nostril; pectorals long and pointed, their tips well-behind dorsal origin. . . . . 9
- 8b. No barbels on snout between or behind nostrils; pectorals short and rounded, their tips about a fin-length before dorsal origin . . . . . 10
- 9a. Vertebrae 149–162; vomerine teeth biserial, at least anteriorly; mandibular teeth biserial; color plain brown above, fins dark in large juveniles and adults . . . . . *O. zophochir* (California to Peru)
- 9b. Vertebrae 139–146; vomerine teeth strictly uniserial; mandibular teeth in a single row; body of adults with faint bands, fins colorless, head pores in black rings . . . . . *O. mecopterus* n. sp. (México to Costa Rica)
- 10a. Head pores in black rings; vomerine tooth-row ending below mid-eye to posterior third of eye; teeth relatively large, 10–12

- in inner maxillary row; body with a series of faint bands; anterior nostrils not conspicuously lighter than snout . . . . . *O. melope* n. sp. (Costa Rica to Colombia)
- 10b. Head pores not so marked; vomerine tooth-row ending under posterior nostril; teeth small, 25 in inner maxillary row; back and upper sides evenly colored, without bands; anterior nostrils white, conspicuously lighter than snout . . . . . *O. arneutes* n. sp. (Galápagos Islands)

## SPECIES DESCRIPTIONS AND DIAGNOSES

***Ophichthus apachus* new species**  
(Figs. 1, 3a, 15; Tables 1, 3)

DIAGNOSIS. — An elongate, slender species of *Ophichthus* with tail 75–76% and head 6.7–8% of total length; dorsal fin origin above, slightly before, or slightly behind appressed pectoral tips; pectoral fins long and slender; posterior nostril a hole above upper lip, covered by a flap extending below edge of mouth; a small tentacle between anterior and posterior nostrils; most head pores obvious, SO 1 + 4, IO 4 + 2, POM 6 + 2; teeth small and numerous, uniserial on vomer, biserial on maxillary and mandible; coloration uniform tan, paler ventrally, sides evenly sprinkled with melanophores, more densely dorsally, pores on snout within dark brown spots; and mean vertebral formula 12.3-41.8-182.8, total vertebrae 180–186 (n = 6).

COUNTS AND MEASUREMENTS OF HOLOTYPE (in mm). — Total length 230; head 15.5; trunk 40.5; tail 174; predorsal distance 20.0; pectoral fin length 5.2; pectoral fin base 1.0; body depth ~3.2 at gill openings; body width ~2.8 at gill openings; snout 2.1; tip of snout to rictus 5.2; eye diameter ~0.9; interorbital distance ~0.8; gill opening height ~0.9; isthmus width ~0.8. Vertebral formula 12-42-186. Ten lateral line pores in branchial region; 45 pores before the anus.

DESCRIPTION. — Body very slender and elongate, compressed throughout, depth at gill openings 62–71 in TL. Branchial basket wider and deeper than body. Head and trunk short, 4–4.2 in TL; head 13–15 in TL, 2.4 in trunk. Snout rounded, blunt when viewed from above. Snout not bisected on underside by a groove. Lower jaw slightly included, upper and lower lips almost meeting when mouth is closed. Mouth moder-



ately elongate, rictus about 2 eye lengths behind rear margin of eye. Eye 4.7–5.8 in upper jaw and 14–18 in head, its center behind middle of upper jaw. Tube of anterior nostril short, hardly capable of being deflected forward. A small barbel beneath 2nd infraorbital pore, midway between anterior and posterior nostrils. Posterior nostril a hole above upper lip, covered by a flap that extends well below edge of mouth; lower margin with a thickened rim, but distal flap attaches to lip rather than to lower rim of nostril. Dorsal fin origin above, slightly behind, or slightly before tip of appressed pectoral fin. Dorsal fin low, in a groove that deepens posteriorly for its entire length. Anal fin higher, in a groove similar to that of dorsal. Pectoral fins pointed, elongate, about equal to jaw in length. Pectoral fin base in upper half of gill opening.

Head pores (Fig. 1) small, inconspicuous. Single median interorbital and temporal pores. Supraorbital pores 1 + 4, infraorbital pores 4 + 2, lower jaw pores 6, preopercular pores usually 2 (CAS 97856 has 3 on its left side). Lateral line pores present but difficult to enumerate, 10 before gill opening, 45 before anus.

Teeth (Fig. 3a) mostly small, conical. Intermaxillary with a rosette of 3 small teeth, then 3 irregular pairs of erect, pointed teeth, an interspace and an irregular row of 14 teeth on the vomer, becoming smaller posteriorly. Maxillary dentition biserial. An inner row of about 20 pointed, slightly recurved teeth begins behind level of posterior nostril. An outer row of about 18 smaller, erect teeth, commences about at anterior margin of eye. Mandibular teeth small, close set, pointed, about 30 in a single row.

Color in isopropanol uniform tan over head and body. Sides dusted with melanophores, most dense dorsally. Chin with a dark smudge followed by a few melanophores. SO and IO pores within dark spots. Fins pale.

SIZE. — The adult size is unknown, as the available specimens are immature.

ETYMOLOGY. — From the Greek  $\alpha$  (without)  $\pi\acute{\alpha}\chi\omicron\varsigma$  (thickness).

DISTRIBUTION. — Known from México and Colombia (Fig. 15), over sand bottoms between 0–8 m.

REMARKS. — The new species is most similar to the eastern Pacific *O. longipennis* n. sp. and *O. melanoporus* of the western Atlantic in having high vertebral numbers and a long tail. It differs

from both in its coloration and in its smaller and more numerous teeth and biserial maxillary dentition. It further differs from the Atlantic species in having two rather than three preopercular pores.

MATERIAL EXAMINED. — HOLOTYPE: SIO 62-25, 231 mm, male, Islas Tres Marias, NE side of Isla Maria Magdalena, 21°26.5'N, 106°22.0'W, collected with rotenone by scuba divers in 0–8 m, Donald Dockins and party on 16 Aug. 1961. PARATYPES: ANSP 126077, 16 (92–198 mm) and CAS 97856, 2 (196–199 mm), Colombia, Bahía Utria, 06°59'30"N, 77°21'20"W, collected with rotenone in 0–2 m, by Leslie Knapp on 13 Nov. 1970.

***Ophichthus arneutes* new species**  
(Figs. 2, 3c, 15; Table 1)

DIAGNOSIS. — A moderately elongate species of *Ophichthus* with tail 60% and head 13% of total length; dorsal fin origin behind pectoral tips; posterior nostril a hole above the upper lip, covered by a flap that extends to or below the edge of the mouth; pores small but conspicuous, SO 1 + 4, IO 4 + 2, POM 6 + 2; teeth small and numerous, uniserial on vomer and mandible, biserial anteriorly on maxillary; coloration brown dorsally, pale ventrally, anterior nostrils white; mean vertebral formula 22-55-158.5.

COUNTS AND MEASUREMENTS OF HOLOTYPE (in mm). — Total length 306; head 39.5; trunk 83.5; tail 183; predorsal distance 60.1; pectoral fin length 11.5; pectoral fin base 5.0; body depth 9.8 at gill openings; body width 8.2 at gill openings; snout 7.2; tip of snout to rictus 9.6; eye diameter 5.3; interorbital width 4.8; gill opening height 6.3; isthmus width 4.4. Vertebral formula 24-56-159. Twelve lateral line pores in left branchial region; 45 pores before anus; the remainder small and difficult to discern.

DESCRIPTION. — Body moderately elongate, subcircular to level of anus, then becoming more compressed, its depth at gill openings 31 in TL. Head and branchial basket bulbous, about 1.5 times depth of trunk. Head and trunk 2.5 and head 7.7 in TL. Snout rounded, blunt when viewed from above; a short groove bisecting underside of snout nearly to tip of upper jaw. Lower jaw included, its tip reaching anterior base of tube of anterior nostril. Upper jaw short, rictus before a vertical from posterior margin of eye. Eye large,



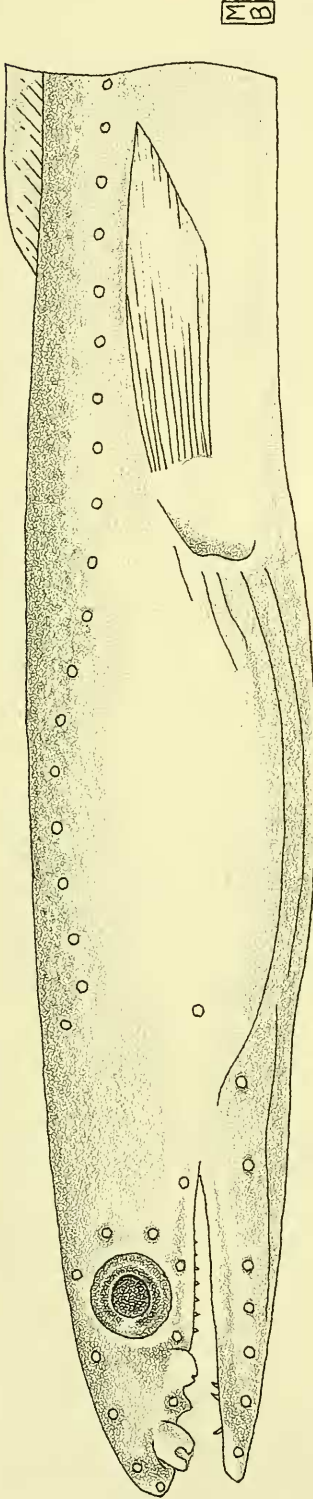


FIGURE 1. Head region of holotype of *Ophichthys apachus* n. sp., SIO 62-25, 231 mm.

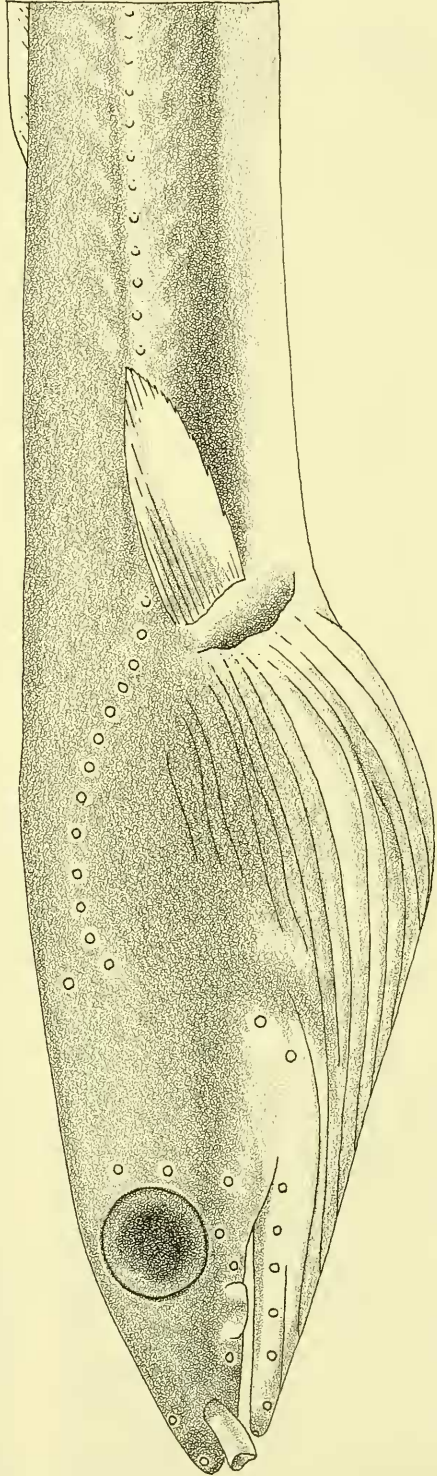


FIGURE 2. Head region of holotype of *Ophichthys arnetex* n. sp., CAS 88004, 306 mm.

TABLE 1. Vertebral counts of holotypes of valid species of eastern Pacific *Ophichthus* and their synonyms.

Species	Predorsal	Preal	Total
<i>Ophichthus apachus</i>	12	42	186
<i>Ophichthus arneutes</i>	24	56	159
<i>Ophichthys frontalis</i> <sup>1</sup>	20	56	155
<i>Ophichthus longipenis</i>	12	40	184
<i>Ophichthus mecopterus</i>	14	43	142
<i>Ophichthus melope</i>	19	56	148
<i>Ophichthys remiger</i> <sup>1</sup>	18	55	155
<i>Ophichthys ater</i>	23	55	156
<i>Ophichthys callaensis</i>	20	53	155
<i>Ophisurus dicellurus</i>	17	53	154
<i>Ophichthys exilis</i>	21	53	156
<i>Ophichthys pacifici</i> <sup>1</sup>	18	54	153
<i>Ophichthys uniserialis</i>	21	53	153
<i>Ophichthus rugifer</i>	14	56	161
<i>Ophichthys biserialis</i>	13	56	161
<i>Ophichthus tetratrema</i>	12	55	155
<i>Muraenopsis triserialis</i>	12	54	146
<i>Ophichthys grandimaculatus</i>	12	54	157
<i>Ophichthys zopochir</i> <sup>1</sup>	14	43	155
<i>Ophichthus chamensis</i>	15	45	149

<sup>1</sup> Lectotype

1.8 in upper jaw and 7.5 in head. Anterior nostrils tubular, extending laterally from snout at ca. 45°, nearly reaching tip of snout when directed forward. Posterior nostril a hole above upper lip, covered by a flap that extends to, or below, the edge of mouth; lower margin with a thickened rim, but the flap attaches to lip rather than to rim of nostril. Dorsal fin origin behind pectoral fins by about their own length. Median fins low but obvious, ending in a shallow groove about an eye diameter before the pointed tail tip. Pectoral fins moderately elongate, but not lanceolate.

Head pores small but apparent (Fig. 2). Single median interorbital and temporal pores. Supraorbital pores 1 + 4, infraorbital pores 4 + 2, lower jaw pores 6, preopercular pores 2. Lateral line pores present but difficult to discern, 12 before gill opening, 45 before anus.

Teeth (Fig. 3c) small, conical, slightly retrorse. Three on each side at tip of snout, followed by an intermaxillary rosette of 6 teeth arranged as 3, a pair, and 1 central tooth, followed by a short gap and a row of 5 vomerine teeth. Maxillary with 25 teeth in a close set row, 1st–14th flanking vomer-

ine row, the remainder behind; 4 slightly larger teeth as an inner row between outer and vomerine row. Lower jaw with 42 teeth in a close-set row.

Color in ethanol uniform brown over dorsal surface and entire tail; throat, chin, cheeks, anterior nostrils, tail tip, branchial basket and median fins yellow. Pectoral fins yellow posteriorly, with a roughly triangular dark area basally. Color in life brown dorsally; anterior nostrils, throat and ventral surface to anus white; a pale white spot, about equal in size to eye, behind rictus. Chin and lower edge of mandible dusky.

SIZE. — Known from the 306 mm holotype and the 101 mm paratype.

ETYMOLOGY. — From the Greek ἀρνευτήρ, a diver, in reference to both the depth and means of capture.

DISTRIBUTION. — Galápagos Islands (Fig. 15), between depths of 434–557 m.

REMARKS. — The paratype of *Ophichthus arneutes* is a small, recently transformed juvenile. It has a freckling of fine brown pigmentation along its chin, flanks and dorsal surface. The fins are colorless. There are obvious, larger, stellate

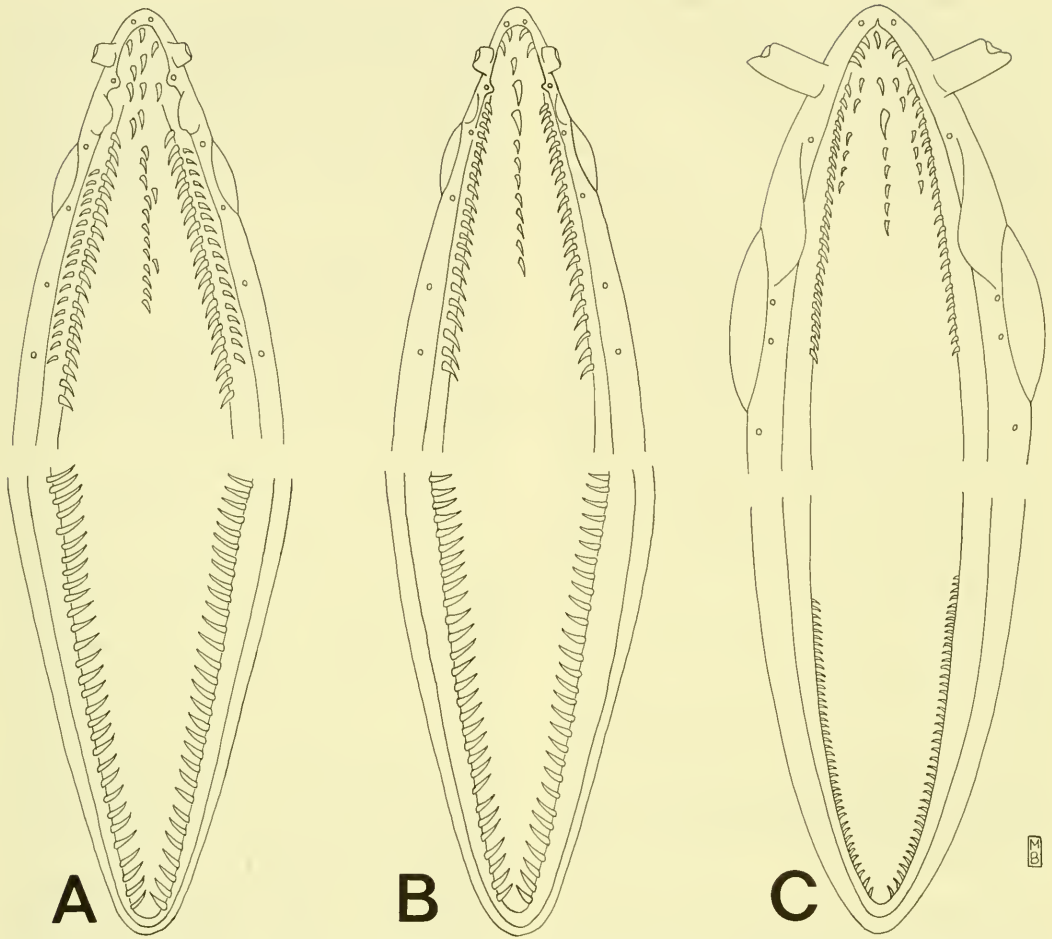


FIGURE 3. Dentition of: A) *Ophichthus apachus* n. sp., SIO 62-25, 231 mm, holotype; B) *Ophichthus longipenis* n. sp., ANSP 175793, 367 mm, paratype; C) *Ophichthus arneutes* n. sp., CAS 88004, 306 mm, holotype.

patches of pigment equally spaced along the ventral surface behind the head that gradually become elevated so that the last patch is along the lateral mid-line. There are six patches in the trunk region, one overlying the anus, and 15 in the tail region. The specimen is small and fragile, so we have included its vertebral count (20-54-158) but not its body proportions in our diagnosis and description. It has, however, the diagnostic characteristics of the holotype, including: nearly identical head, trunk and tail proportions; its dorsal fin arises slightly behind the pectoral tips; and it appears to have the same dentition.

*Ophichthus arneutes* is easily distinguishable from other eastern Pacific *Ophichthus* species by the location of its dorsal fin origin, pore pattern,

dentition, and coloration. Fowler (1938:21) described a leptocephalus (*Leptocephalus alternatus*) from Tagus Cove, Galápagos, which appears to be an ophichthid. We have not examined his specimen, but it was described as having 152 myomeres. Neither *O. arneutes* (158–159 vertebrae) nor *O. rugifer* (157–162 vertebrae), the other Galápagos species of *Ophichthus*, could be Fowler's species. The Galápagos ophichthid most likely to be the adult of *Leptocephalus alternatus* is *Quassiremus evionthas* (Jordan and Bollman 1890), which has 149–153 vertebrae (Castle 1996; and our data).

The holotype was observed and ultimately captured during a survey of the deep-reef ichthyofauna of the Galápagos Islands aboard the



submersible *Johnson Sea-Link*. The species was seen on three occasions: Roca Redonda, 00°15.9'S, 91°36.5'W, one seen head-out from the sand at 557 m; Wolf Island, 01°22.9'N, 91°51.4'W, four individuals (one of which was collected) in a patch approximately 1 m<sup>2</sup> were observed and filmed, their heads exposed from a sand slope at 485 m; and north shore of Tower Island, 00°21.8'S, 89°58.2'W, two individuals photographed at 434 m and 450 m, their heads and trunks protruding from a 60° sand slope.

MATERIAL EXAMINED. — HOLOTYPE: CAS 88004, 306 mm, a female with developing eggs, Islas Galápagos, Isla Wolf, 01°22.9'N, 91°51.4'W, suction-captured from the submersible *Johnson Sea-Link* (JSL Dive 3970) at 485 m by J. E. McCosker and party on 23 Nov. 1995. PARATYPE: CAS 94485, 101 mm, Islas Galápagos, Isla Hood, 01°30.5'S, 89°35'W, *Albatross* Station 4642, captured by tangle net in 300 fm (549 m) on 7 Nov. 1904.

***Ophichthus frontalis*** Garman 1899  
(Figs. 4, 15; Tables 1, 2)

*Ophichthus (Cryptopterus) frontalis* Garman 1899:309 (type locality: 07°16'45"N, 79°17'15"W; lectotype USNM 57899).

*Ophichthus* sp. nov. B, Bussing and Lopez S. 1994:42.  
*Ophichthus* sp. nov. B, Bussing and Lopez S. 1994: unnumbered figure, 43.

DIAGNOSIS. — A robust species of *Ophichthus* with tail 54–59% and head 12–15% of TL; dorsal fin arising in advance of end of pectoral fins; pectoral fins rounded, about 2.5–3.4 times in head; tube of anterior nostril, when directed forward, extending beyond tip of lower jaw and nearly reaching snout tip; posterior nostril in a tube above lip, its distal portion expanded and flaplike, extending ventrally to but not reaching mouth; eye large, about 6.6–9.2 times in head; head pores (Fig. 4) small, inconspicuous, SO 1 + 3, IO 4 + 2, POM 5/6 + 3; free sensory neuromasts visible on nape of adults; teeth (very similar to those of *O. remiger*, Fig. 13a) conical, not enlarged, uniserial on vomer and biserial in jaws, outer row of mandible notably larger, outer row of maxillary slightly larger; coloration brown in preservative, slightly paler beneath, with a series of faint dark bars or saddles (often fading in preservative) extending from base of dorsal fin

to mid-flank in trunk and tail region, the bars slightly broader than their pale interspaces and about equal to jaw in width; dorsal fin with fine punctations; tail tip, anal fin and margin of pectoral fin pale, the inner and outer faces of pectoral fin brown; anterior nostrils pale, strongly contrasting with brown snout; and mean vertebral formula 16-56.8-147.5, total vertebrae 143–155 ( $n = 12$ ).

SIZE. — Largest an 860 mm specimen captured in the Gulf of California NW of Isla Angel de la Guarda (SIO 69-204).

DISTRIBUTION. — Known from the central Gulf of California to Panamá (Fig. 15), captured by hook-and-line, trawl, and traps at depths of 35–760 m.

ETYMOLOGY. — Presumably from the Latin *frons*, forehead, the allusion not obvious.

REMARKS. — Smith (1994:34) noted that “Garman’s description was based on at least three specimens, from three *Albatross* stations. Seven specimens are listed in the MCZ collections under catalog numbers 28455, 28456, and 28457, but none of these can be located.” In 1971, JMc discovered USNM 57899, labelled “3386A,” in the non-type collection of the National Museum of Natural History, and it subsequently proved to be the only extant syntype of *O. frontalis*. We designate that specimen as the lectotype of the species.

*Ophichthus frontalis* is most similar to the eastern Pacific *O. remiger*, from which it differs in coloration and mean vertebral number. The two species overlap in depth distribution and occupy a similar habitat, and are sympatric as well in the respective northern and southern ranges. They share a nearly identical dentition and condition of the posterior nostrils.

The late C. L. Hubbs trapped and trawled numerous specimens of *O. frontalis* in the Gulf of California in 1968. His color notes from SIO 68-79 were as follows: “almost uniform in life showing very weak darker bars and lighter below. After being killed in freshwater, rather irregular cross-bars of deep olive to purplish brown and alternating with bars of whitish, pale lemon or light gray. Anal fin red.”

TYPE MATERIAL EXAMINED. — USNM 57899, 371 mm, Panamá, 07°33'12"N, 79°17'15"W, 443 m, *Albatross* 3386, the extant syntype of *Ophichthus (Cryptopterus) frontalis*, here designated as the lectotype.

OTHER MATERIAL EXAMINED. — **México, Gulf of California:** SIO 68-110, 452 mm, E. of Isla Carmen. SIO 68-115, 16(460–740 mm), Sinaloa. Farallon Basin. SIO 68-124, 620 mm, off Isla Santa Catalina. SIO 65-247, 390 mm, Bahía de la Ventana, 24°04.9'N, 109°54.8'W. SIO 69-203, 2(544–574 mm), SIO 69-204, 8(505–860 mm), and SIO 69-205, 3(495–820 mm), NW of Isla Angel de la Guarda. SIO 68-79, 10(500–780 mm), off Bahía Concepcion. SIO 65-293, 443 mm, NW of Isla Monserrate. SIO 68-113, 31(365–655 mm) and SIO 68-114, 5(640–855 mm), off Fuerte Delta, Farallon Basin. SIO 84-67, 454 mm, Isla Espiritu Santo. CAS 38566, 595 mm, Guaymas. **Costa Rica:** SIO 73-281, 500 mm, W. of Cabo Santa Elena. LACM 33827-41, 515 mm; LACM 33827-42, 2(515–690 mm), Golfo de Nicoya.

***Ophichthus longipenis* new species**

(Figs. 3b, 5, 15; Tables 1, 3)

*Ophichthus* sp. nov. A, Bussing and Lopez S. 1994:42.

*Ophichthus* sp. nov. A, Bussing and Lopez S. 1994: unnumbered figure, 43.

DIAGNOSIS. — An elongate, slender species of *Ophichthus* with tail 74–80% and head 7–9% of total length; dorsal fin origin slightly before pectoral tips; pectoral fins long and slender; posterior nostril a hole above the upper lip, covered by a flap that extends to or below edge of mouth; a small tentacle between anterior and posterior nostrils; most head pores obvious, SO 1 + 4, IO 4 + 2, POM 6 + 2; teeth small and numerous, uniserial on jaws and vomer; coloration uniform tan, paler ventrally, head pores (except mandible) and anterior lateral line in dark brown spots; and mean vertebral formula 12.8-40.7-181, total vertebrae 176–184 ( $n = 11$ ).

COUNTS AND MEASUREMENTS OF HOLOTYPE (in mm). — Total length 423; head 33.5; trunk 81.0; tail 308.5; predorsal distance 43; pectoral fin length 9.4; pectoral fin base 2.5; body depth 12 at gill openings; body width 9.0 at gill openings; snout 5.4; tip of snout to rictus 12.7; eye diameter 3.5; interorbital distance 1.8; gill opening height 5.3; isthmus width 4.6. Vertebral formula 12-40-184. Ten lateral line pores over branchial region; ~42 pores before anus.

DESCRIPTION. — Body elongate, depth at gill openings 35–48 in TL. Head and trunk short,

3.8–5 and head 11.5–14 in TL. Snout acute, pointed when viewed from above. Lower jaw included, its tip reaches from just behind to just before anterior nostril tube. Snout not bisected on underside by a groove. Upper jaw moderately elongate, rictus well behind posterior margin of eye. Eye large, entering upper profile of head, 2.8–3.7 in upper jaw and 7.3–9.6 in head, its center at or behind middle of upper jaw. Anterior nostrils in short, widely-flared tubes, directed nearly downward. A small barbel immediately beneath first infraorbital pore, midway between anterior and posterior nostrils. Posterior nostril a hole above the upper lip, covered by a flap that extends to or below edge of mouth; lower margin has a thickened rim, but distal flap attaches to lip rather than to lower rim of nostril. Dorsal fin origin over tips of pectoral fins. Median fins low, ending in a groove less than an eye diameter before the tail tip. Tail tip covered with a fine mat of minute hairlike projections. Pectoral fins elongate, slender, about equal to jaw in length. Pectoral fin base in upper half of gill opening.

Head pores obvious (except mandibular and preopercular) (Fig. 5). Single median interorbital and temporal pores. Supraorbital pores 1 + 4, infraorbital pores 4 + 2, lower jaw pores 6, the first 4 closely-spaced and in anterior 1/2 of jaw, preopercular pores 2. Lateral line pores present but difficult to enumerate, 10 before gill opening, ~42 before anus.

Teeth (Fig. 3b) mostly small, conical, widely separated at their bases. An anterior intermaxillary rosette of 4–6 small teeth, serially followed by a gap, then 1 small and 2 large intermaxillary teeth, followed by a gap and a row of 8–10 vomerine teeth, that decrease in size posteriorly. Maxillary teeth small, subequal and uniserial, about 21–22. Mandibular teeth like those of maxilla, about 28–30.

Color in isopropyl alcohol tan, slightly paler ventrally, overlain on head, chin, inside of mouth, flanks, and dorsal surface with a distinct fine brown speckling. Cephalic and anterior lateral line pores within dark brown spots. Fins pale.

SIZE. — To 587 mm.

ETYMOLOGY. — From the Latin *longus* (long) and *penis* (tail).

DISTRIBUTION. — From México to Panamá (Fig. 15), over sand bottoms between 0–69 m.

REMARKS. — The new species is closely related to the eastern Pacific *Ophichthus apachus*,

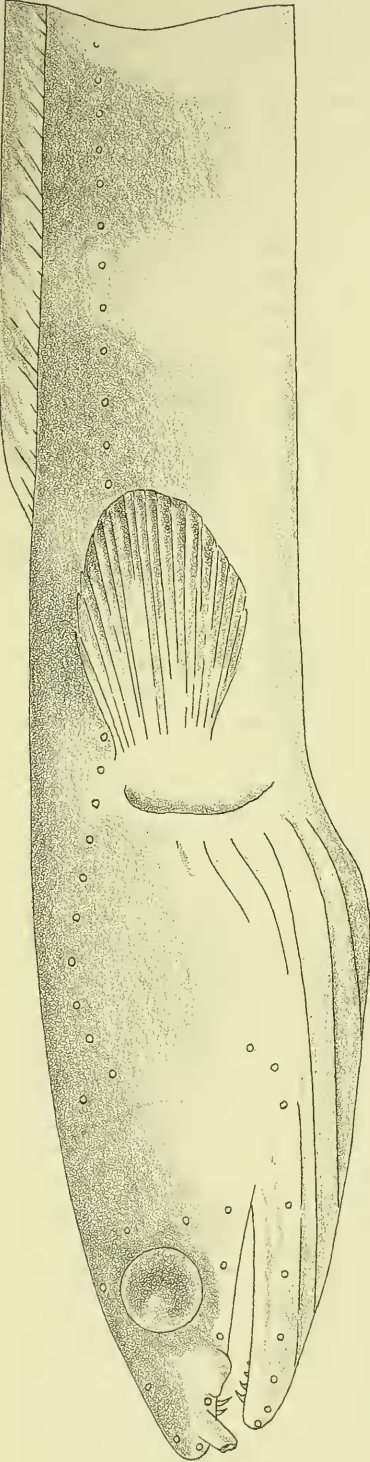


FIGURE 4. Head region of *Ophichthus frontalis*, CAS 38566, 595 mm.

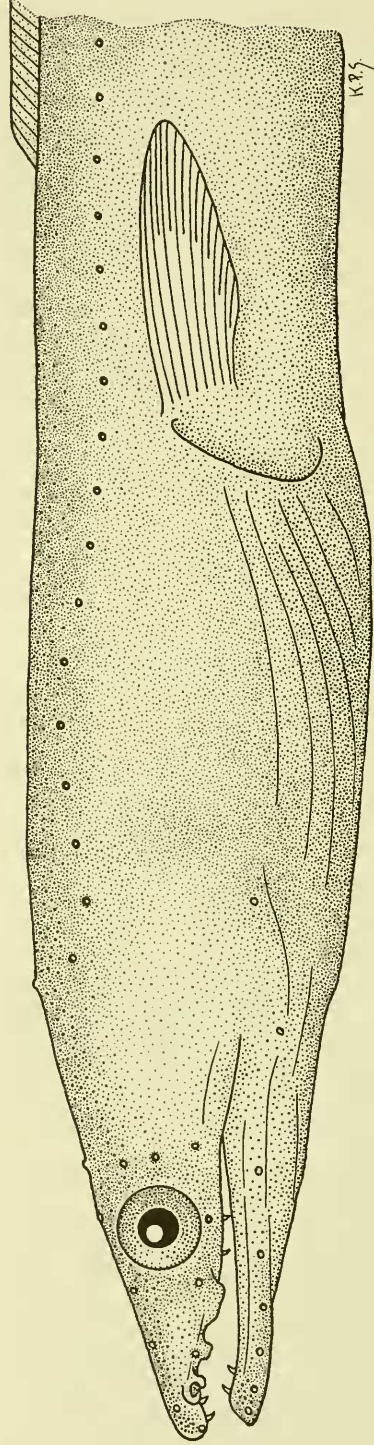


FIGURE 5. Head region of holotype of *Ophichthus longipennis* n. sp., SIO 63-295, 423 mm.



but differs in having uniserial rather than biserial jaw teeth. We do not consider the minor differences in morphometry between the two species as diagnostic since we lack adult specimens of *O. apachus*. *Ophichthus longipennis* has the same cephalic pore pattern as that of *O. apachus* and *O. arneutes*, but differs considerably from the last species in its morphometry and meristics.

*Ophichthus longipennis* is similar to *O. melanoporus* Kanazawa (1963), a western Atlantic species known from the Gulf of México and the Carolinas to the Florida Straits. *Ophichthus melanoporus* is also an elongate deepwater species with similar uniserial dentition, brown cephalic and lateral line pores, an elongate tail, and 177–186 vertebrae. It differs from *O. longipennis* in having three, rather than two, preopercular pores, a shorter tail (69–71% vs. 74–80%), and pore spotting continuous throughout its length.

**MATERIAL EXAMINED.** — **HOLOTYPE:** SIO 63-295, 423 mm, a male, from Panamá (Pacific), La Vieja, 09°00'N, 79°29'W, collected by benthic trawl, IATTC Cruise FB 62, Sta. FB 62-42, by F. H. Berry in 1961. **PARATYPES:** **México:** SIO 65-160, 389 mm, male, Bahía de Banderas 20°44.0'N, 105°24.6'W, collected by 20' otter trawl over 27–32 m bottom, El Golfo II Cruise, Sta. BT 150, by T. Matsui on 2 June 1965. **El Salvador:** SIO 73-276, 3 (337–356 mm), SW of Punta Amapala, 13°05.8'N, 87°58.6'W, collected by 40' otter trawl over 24–29 m, Cruise MV 73-1, Sta. MV 73-I-65, by C. L. Hubbs on 17 Apr. 1973. **Costa Rica:** LACM 32554-11, 418 mm, Isla del Caño, 08°43'55"N, 83°54'15"W, collected by 30' otter trawl over 69 m, by W. Bussing on 16 Mar. 1972. CAS 97894 (previously LACM 32559, originally UCR 686.010), 3(312–323 mm), Isla del Caño, 08°44'20" N, 83°53'20" W, collected by 30' otter trawl over 62 m, by W. Bussing on 17 Mar. 1972. LACM 32575-11, 7(213–273 mm), mouth of Golfo de Dulce, 08°28'30" N, 83°12'45" W, collected by 30' otter trawl over 55 m by W. Bussing on 21 March 1972. **Panamá:** SIO 63-295, 5(127–165 mm), collected with the holotype. SIO 64-744, 430 mm, male, off Rio Juan Diaz, 09°00.0'N, 79°00.0'W, collected by trawl by F. H. Berry, 4 Feb. 1960. MCZ 44173, 2(584–587 mm), Bella Vista, collected with rotenone by I. Rubinoff, 10 Mar. 1961. ANSP 152296, 443 mm, Gulf of Panamá, E. of San Carlos, 08°26'12"N, 79°43'12"W, collected by

10' otter trawl over 15 m, Pillsbury Sta. 485, 1 May 1967. ANSP 175793, 367 mm, SW of Ciudad Panamá, 08°45'12"N, 79°10'18"W, collected by 10' otter trawl over 33–37 m, Pillsbury Sta. 533, 6 May 1967.

***Ophichthus mecopterus* new species**  
(Figs. 6, 8a, 15; Tables 1, 2)

**DIAGNOSIS.** — A moderately elongate species of *Ophichthus* with tail 63–65% and head 11–13.5% of TL; a conspicuous barbel between nostrils; dorsal fin origin above pectoral fins; pectoral fins elongate, longer than jaw; posterior nostril opens by a tube into mouth; head pores inconspicuous, SO 1 + 3, IO 4 + 2, POM 6–7 + 3; teeth conical, numerous, uniserial on vomer and mandible, biserial posteriorly on maxillary; coloration brown dorsally, pale ventrally; mean vertebral formula 14.6-46-143.4, total vertebrae 139–146 (n = 5).

**COUNTS AND MEASUREMENTS OF HOLOTYPE** (in mm). — Total length 274; head 37.1; trunk 99; tail 175; predorsal distance 41.8; pectoral fin length 17.9; pectoral fin base 3.6; body depth 10.4 at gill openings; body width 8.2 at gill openings; body depth at anus 10.3; body width at anus 8.5; snout 5.5; tip of snout to rictus 14.2; eye diameter 3.9; interorbital width 4.2; gill opening height 4.2; isthmus width 4.8. Vertebral formula 14-43-142.

**DESCRIPTION.** — Body moderately elongate, subcircular to level of anus, then becoming more compressed, its depth at gill openings 30–34 in TL. Head and trunk 2.7–2.9 and head 7.4–9.1 in TL. Snout moderately acute, rounded when viewed from above; a groove bisects underside of snout nearly to tip of upper jaw. Lower jaw included, its tip nearly reaches anterior base of tube of anterior nostril. Mouth elongate, rictus well behind posterior margin of eye. Eye large, center of orbit in middle of upper jaw, its hind margin well ahead of rictus. Anterior nostrils tubular, extending ventro-laterally from snout. Posterior nostril opening near edge of lip; its lower rim joins with the distal flap to form a tube directed into mouth, the flap incised at the middle of its margin. A conspicuous elongate slender barbel midway between nostrils, followed by the posterior nostril, then a smaller barbel at level of mid-orbit, and a third, even smaller barbel just before level of hind edge of orbit. Dorsal fin

TABLE 2. Counts and proportions (in thousandths) of *Ophichthus frontalis* (n = 15), *O. remiger* (n = 10; vertebrae, n = 44), *O. rugifer* (n = 11)<sup>1</sup>, *O. triserialis* (n = 12; vertebrae, n = 21)<sup>1</sup>, *O. mecopterus* new species (holotype and 4 paratypes), and *O. zophochir* (n = 16; vertebrae, n = 31). TL = total length, HL = head length.

	<i>O. frontalis</i>		<i>O. remiger</i>	
	Mean	Range	Mean	Range
TL (mm)	—	371–805	—	374–672
HL/TL	132	119–145	144	139–150
Head and trunk/TL	444	414–462	420	376–438
Tail/TL	558	538–586	580	562–624
Depth at gill opening/TL	52	45–62	44	35–52
Depth at gill opening/HL	320	186–399	306	233–367
Depth at anus/HL	333	282–382	278	227–319
Dorsal fin origin/TL	172	164–191	199	188–223
Pectoral fin length/HL	360	294–403	375	352–406
Upper jaw/HL	414	366–500	399	347–449
Snout/HL	172	161–196	172	157–193
Eye/HL	121	109–152	105	91–119
Predorsal vertebrae	16	14–20	19.5	17–23
Preanal vertebrae	56.8	54–58	53.7	52–57
Total vertebrae	147.5	143–155	154.4	150–160

<sup>1</sup> When comparing data of *O. rugifer* with those of *O. triserialis* it is important to recognize the size differential of specimens examined.

arises above anterior to posterior 1/3 of appressed pectoral fin. Median fins low, inconspicuous, ending in a shallow groove before the pointed tail tip. Pectoral fins elongate, slender.

Head pores (Fig. 6) either encircled by melanophores or, if not, inconspicuous. Single median interorbital and temporal pores. Supraorbital pores 1 + 3, infraorbital pores 4 + 2, lower jaw pores of holotype 6 right/7 left (those of paratypes 7/6 and 7/7), the first 3 near jaw tip, the remainder widely spaced, preopercular pores 3. Lateral line pores present but difficult to discern and enumerate, 9 before gill opening, 44 before anus.

Teeth (Fig. 8a) conical, slightly retrorse. Those of holotype similar to but more numerous than those of paratypes. Five teeth in intermaxillary region, followed by a row of 21 (paratypes 10–12) widely-spaced teeth on vomer. Maxillary dentition begins as a single row of 7 (5) small, close-set teeth, followed by two rows which

flank the vomerine teeth; inner row has 18 (8–10), larger, widely-spaced teeth, outer row has 22 (12–16) smaller, more closely-spaced teeth. Mandible has 2–3 pairs at symphysis, followed by a single row of 30 (22–24) teeth descending in size posteriorly.

Color in isopropyl alcohol pale, overlain on dorsal surface to below lateral line with a dense peppering of fine brown punctations. Brown coloration of flanks of holotype in trunk region interrupted by about 10 irregularly-spaced narrow pale bands. Snout, forehead and nape with fine brown punctations like dorsal surface of body. Gular region pale. Head pores encircled by fine brown melanophores. Dorsal fin with a faint dark margin, its base colorless; anal fin colorless except for faint dark margin in posterior 1/5. Pectoral fins colorless except for fine spotting in axil.

SIZE. — Largest known is the 274 mm holotype, a mature male.

TABLE 2. (continued) Counts and proportions (in thousandths) of *Ophichthus frontalis* (n = 15), *O. remiger* (n = 10; vertebrae, n = 44), *O. rugifer* (n = 11)<sup>1</sup>, *O. triserialis* (n = 12; vertebrae, n = 21)<sup>1</sup>, *O. mecopterus* new species (holotype and 4 paratypes), and *O. zophochir* (n = 16; vertebrae, n = 31). TL = total length, HL = head length.

<i>O. rugifer</i> <sup>1</sup>		<i>O. triserialis</i> <sup>1</sup>		<i>O. mecopterus</i>		<i>O. zophochir</i>	
Mean	Range	Mean	Range	Mean	Range	Mean	Range
333	197-680	718	379-1011	—	174-274	—	174-571
107	99-114	112	93-119	123	110-135	120	100-151
398	376-435	441	421-473	361	351-371	346	301-370
602	565-624	559	527-579	639	629-649	654	630-699
29	25-33	40	35-45	33	29-36	34	31-41
276	234-303	353	300-396	263	237-283	321	253-380
249	207-312	376	322-472	269	254-288	324	222-385
133	124-151	142	131-150	149	121-168	145	104-164
302	250-390	368	291-440	420	367-482	441	385-567
359	307-407	386	303-418	364	330-383	366	334-471
188	176-204	202	178-227	149	134-148	171	154-205
112	82-124	111	88-148	86	71-105	91	79-113
13.8	13-15	12.7	11-15	14.6	14-15	14	11-16
56.2	54-59	54.5	52-56	46	43-48	45.6	43-52
159.5	157-162	147	145-152	143.4	139-146	153	149-162

ETYMOLOGY. — From the Greek μήχος (long) and πτερός (fin), in recognition of its elongate pectorals.

DISTRIBUTION. — Known from México to Costa Rica (Fig. 15) at depths between 24–79 m.

REMARKS. — Although they are similar in general appearance, the new species is easily differentiated from *O. zophochir* by its strictly uniserial vomerine dentition (mostly or entirely biserial in *O. zophochir*) and its low vertebral number (149–162 in *O. zophochir*). The general appearance of the snout and the coloration of the holotype, the largest specimen, are also unique among eastern Pacific *Ophichthus*.

We have not made a specimen of *O. mecopterus* formerly from the Stanford University ichthyology collection (SU 46978) a paratype; it was collected by W. Beebe aboard the *Zaca* but lacks other data. It agrees with *O. mecopterus* in its morphology and meristics (16-46-143 vertebrae). Other data in the SU catalogue confirm that it came from the 1937/1938 *Zaca* expedition,

somewhere between Baja California, México, and Isla Gorgona, Colombia.

MATERIAL EXAMINED. — HOLOTYPE: SIO 62-76, 274 mm, a male, México, Nayarit, W of Laguna de Agua Brava, 22°13.0'N, 106°10.0'W, captured in 74–79 m using 16' otter trawl by F. H. Berry on 25 August 1961. PARATYPES: El Salvador: SIO 73-276, 182.5 mm, male, SW of Punta Ampala, 13°05.8'N, 87°58.6'W, collected in 24–29 m using 40' otter trawl by C. L. Hubbs and party on 17 April 1973. Costa Rica: CAS 58340, 182 mm, male, Golfo de Nicoya, off Bahía Ballena, 09°42'N, 84°56'W, dredged in 64 m, ZACA station 213, 25 Feb. 1938. LACM 47325-1 (originally UCR 2352.001), 175 mm, immature female, captured by dredge at 43 m depth, Golfo de Nicoya, due east of Bahía Ballena, by M. I. Lopez and W. A. Bussing on 14 December 1993. LACM 32575 (formerly UCR 702.008), 174 mm, sex undetermined, mouth of Golfo de Dulce, 08°28'30"N, 83°12'45"W, captured by 30' otter trawl at 55 m by W. A. Bussing et al., 21 March 1972. NON-PARATYPE: SU 46978,



TABLE 3. Counts and proportions (in thousandths) of the holotypes and paratypes of *Ophichthus apachus*<sup>1</sup> new species, *O. longipenis*<sup>2</sup> new species, *O. melope*<sup>3</sup> new species, and *O. tetratrema*<sup>3</sup> new species. TL = total length, HL = head length.

	<i>O. apachus</i>		<i>O. longipenis</i>		<i>O. melope</i>		<i>O. tetratrema</i>	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
TL (mm)	—	178–230	—	199–443	—	218–270	—	337–556
HL/TL	72	67–78	78	65–87	117	110–125	110	108–111
Head and trunk/TL	243	240–250	246	200–270	389	381–404	407	401–415
Tail/TL	757	750–760	754	730–800	611	596–619	593	585–599
Depth at gill opening/TL	15	14–16	206	175–252	37	32–41	38	36–39
Dorsal fin origin/TL	92	87–96	94	84–114	179	170–183	119	119–120
Pectoral fin length/HL	332	320–350	334	281–380	273	268–282	260	234–286
Upper jaw/HL	342	320–360	399	380–443	365	338–381	287	262–312
Snout/HL	134	123–146	157	140–164	184	167–217	161	148–169
Eye/HL	64	56–71	126	104–151	110	107–113	80	70–93
Predorsal vertebrae	12.3	11–13	12.7	12–13	19	19	11.7	11–12
Preanal vertebrae	41.8	41–43	40.6	39–43	54	51–56	55	55
Total vertebrae	182.6	180–186	181.2	176–184	149	146–154	156	156–157

<sup>1</sup>Based on holotype and 6 paratypes. When comparing the data of *O. apachus* with those of *O. longipenis* it is important to recognize the size differential of specimens examined.

<sup>2</sup>Based on holotype and 11 paratypes. Head and trunk of smaller specimens is shorter: for <200 mm TL, mean = 225, range = 200–250; for >325 mm TL, mean = 260, range = 250–270.

<sup>3</sup>Based on holotype and 2 paratypes.

203 mm, male, eastern Pacific, lacking additional data, collected by W. Beebe aboard the *Zaca*.

### *Ophichthus melope* new species (Figs. 7, 8b, 15; Tables 1, 3)

DIAGNOSIS. — A moderately robust species of *Ophichthus* with tail 60–62% and head 11–12% of TL; lips without barbels; dorsal fin origin well behind pectoral fin tips; pectoral fins rounded, paddle-shaped; posterior nostril a hole above the upper lip, covered by a flap that extends to or below edge of mouth; head pores conspicuous, SO 1 + 3, IO 4 + 2, POM 6 + 2; teeth conical, uniserial on vomer and mandible, biserial on maxillary; coloration brown dorsally, pale ven-

trally, with irregular asymmetrical banding; head pores conspicuously surrounded by melanophores; and mean vertebral formula 19-54-149, total vertebrae 146–154 (n = 3).

COUNTS AND MEASUREMENTS OF HOLOTYPE (in mm): Total length 270; head 31; trunk 72; tail 167; predorsal distance 49.3; pectoral fin length 8.4; pectoral fin base 2.9; body depth at gill openings 8.6; body width at gill openings 6.9; body depth at anus 7.9; body width at anus 7.2; snout 5.2; tip of snout to rictus 11.9; eye diameter 3.4; interorbital width 3.9; gill opening height 4.9; isthmus width 5.1. Vertebral formula 19-56-148.

DESCRIPTION. — Body moderately robust, becoming compressed posteriorly, its depth at gill openings 24–31 in TL. Head and trunk 2.5–2.6

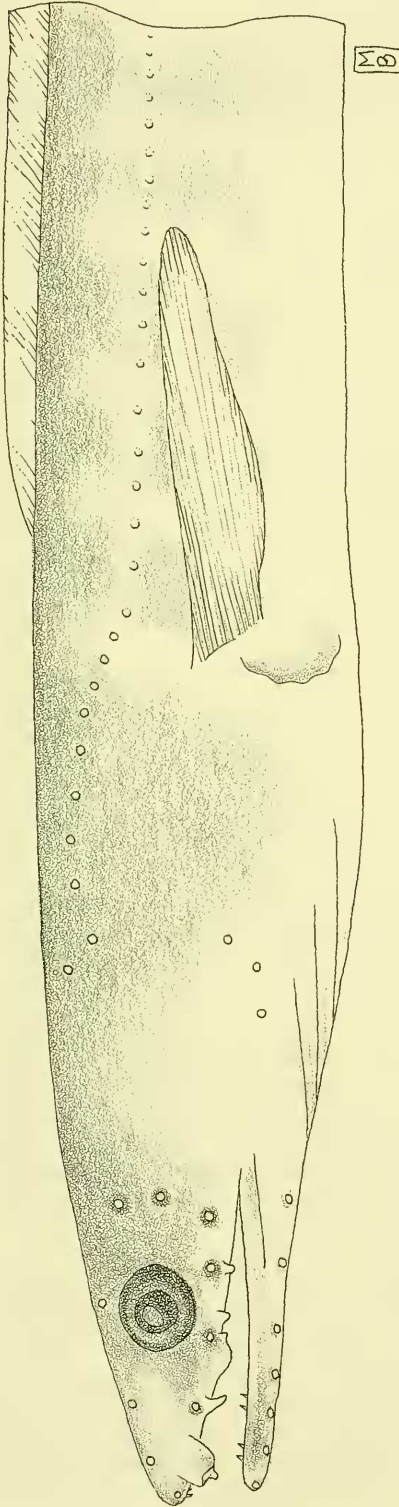


FIGURE 6. Head region of holotype of *Ophichthus mecoplerus* n. sp., SIO 62-72, 274 mm.

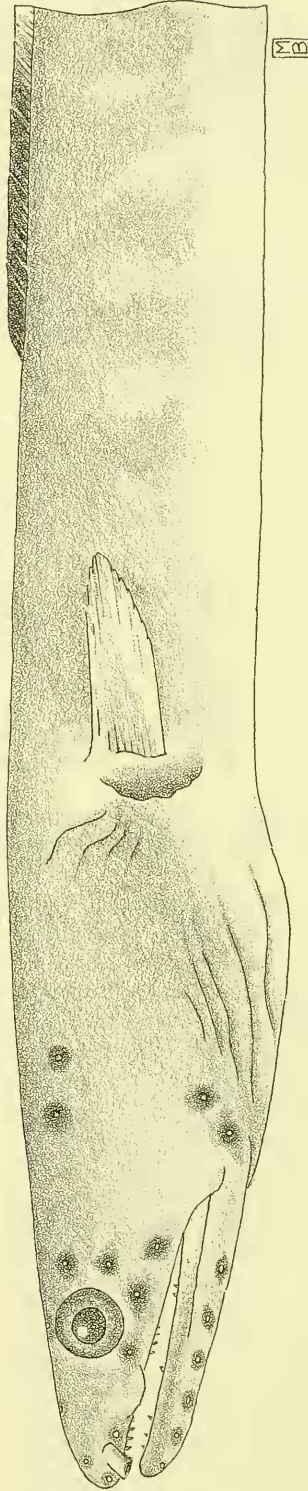


FIGURE 7. Head region of holotype of *Ophichthus melope* n. sp., LACM 47311-1, 270 mm.

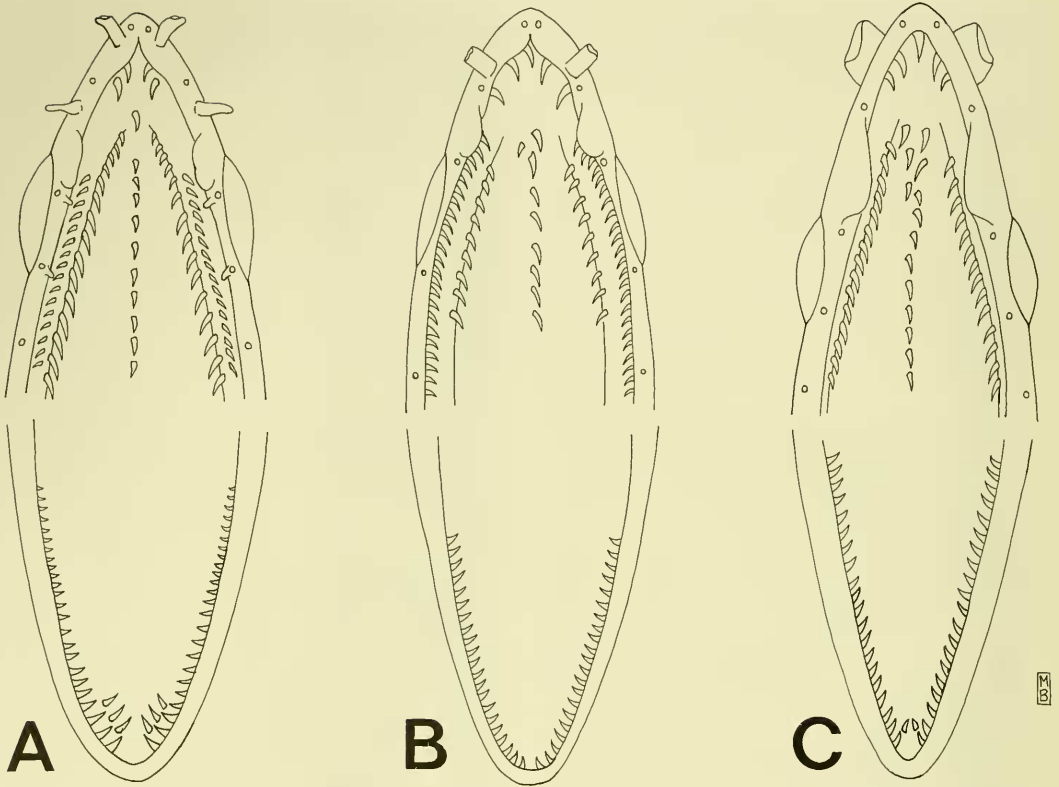


FIGURE 8. Dentition of: A) *Ophichthus mecopterus* n. sp., LACM 47325-1, 175 mm, paratype; B) *Ophichthus melope* n. sp., LACM 47311-1, 270 mm, holotype; C) *Ophichthus tetratrema* n. sp., SIO 73-294, 421 mm, holotype.

and head 8.0–9.1 in TL. Snout blunt, rounded when viewed from above; a short groove bisects underside of snout nearly to tip of upper jaw. Lower jaw included, its tip nearly reaches center of base of tube of anterior nostril. Upper jaw not elongate, rictus behind posterior margin of eye. Eye moderate, center of orbit behind middle of upper jaw. Anterior nostrils tubular, extending ventro-laterally from snout and beyond level of lip. Posterior nostril a hole above the upper lip, covered by a flap that extends to or below edge of mouth; lower margin has a thickened rim, but distal flap attaches to lip rather than to lower rim of nostril. Dorsal fin arises twice length of appressed pectoral fin behind pectoral base. Median fins low, inconspicuous, ending in a shallow groove before the pointed tail tip. Pectoral fins not elongate, longest in upper third.

Head pores (Fig. 7) conspicuous. Single median interorbital and temporal pores. Supraorbital pores 1 + 3, infraorbital pores 4 + 2, 6 lower

jaw pores, 2 preopercular pores. Lateral line pores present but difficult to discern and enumerate, at least 11 before gill opening and 57 before anus.

Teeth (Fig. 8b) conical, stout and slightly retrorse. Five intermaxillary teeth, followed by a row of 8 teeth on vomer. Maxillary teeth biserial, an inner row of 9–10 larger teeth, flanked by an outer row of 22–23 smaller, more closely set teeth. Mandible with a pair of teeth at symphysis, followed by a single row of 18–20 teeth decreasing in size posteriorly.

Color in isopropyl alcohol pale white to yellow, overlain on dorsal surface to below lateral line with a dense peppering of fine brown to gray punctations. Darker coloration of flanks and dorsum in trunk and tail is interrupted by irregularly spaced, narrow, pale bands, giving the appearance of saddles. Head covered with fine brown or gray punctations like dorsal surface, except for pale gular region. Cephalic, preopercular, tempo-



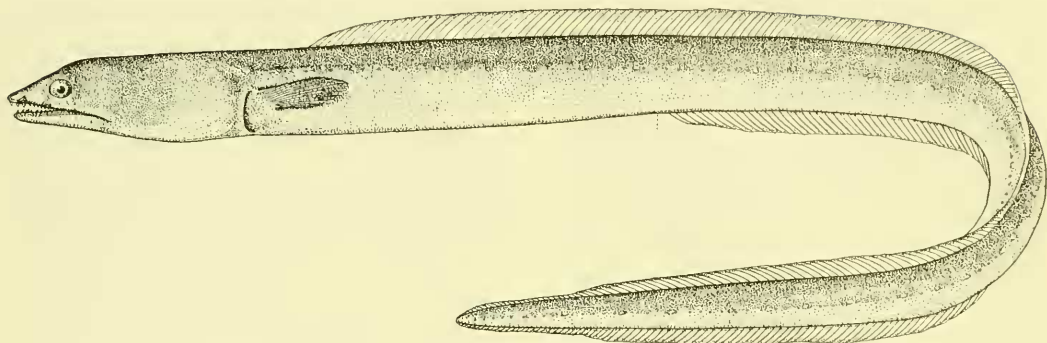


FIGURE 9. *Ophichthus remiger*, USNM 77687, 680 mm (based on Hildebrand 1946, fig. 33).

ral and first lateral line pores prominently encircled by dark melanophores. Margin of anterior portion of dorsal fin black for about 1/2 head length, the remainder with a thin dark margin. Anal fin and base of dorsal fin colorless. Pectoral fins colorless except for fine spotting in axil.

SIZE. — To 270 mm, a male.

DISTRIBUTION. — Known from Costa Rica to Colombia (Fig. 15), captured by trawl in 100–224 m depth.

ETYMOLOGY. — From the Greek μέλας (black) and ὄπη (a hole or cavity, in reference to the rings around the pores). A noun in apposition.

REMARKS. — Unfaded specimens of *O. melope* would not be mistaken for any other *Ophichthus* on the basis of head coloration alone. The striking coloration of the anterior cephalic pores suggests that, like many ophichthids, *O. melope* occupies a burrow with only the anterior portion of the head protruding. It is morphologically similar to several generalized species of *Ophichthus* but shares obvious synapomorphies with none. It is unique in its coloration and cephalic pore condition, and the combination of its dentition, posterior nostril condition, and fin shape and development.

The 264 mm paratype (CAS 97857) was extremely swollen and had within its gut a partially digested adult specimen of the myrophine eel *Pseudomyrophis* sp. The meal was taken head-first and is approximately half the length of the diner.

MATERIAL EXAMINED. — HOLOTYPE: LACM 47311-1 (originally UCR 2350.002), 270 mm, male, Costa Rica, center of mouth of Golfo de Nicoya, off Puntarenas, captured by 3 m dredge

in 224 m depth by M. I. Lopez and W. A. Bussing on 14 Dec. 1993. PARATYPES: CAS 97857 (originally UCR 2377.002), 264 mm, female, Costa Rica, center of mouth of Golfo de Nicoya, off Puntarenas, captured by 3 m dredge in 100–125 m depth by M. I. Lopez and W. A. Bussing on 13 Feb. 1994. ANSP 176292 (originally UMML 31933), 218 mm, male, Colombia, 06°23.8'N, 77°30'W, collected in 216 m by 10' otter trawl by the crew of the R/V *Gillis* on 16 Jan. 1972.

***Ophichthus remiger* (Valenciennes)**  
(Figs. 9, 13a, 16; Tables 1, 2)

*Ophisurus remiger* Valenciennes in d'Orbigny 1837, pl. 12, fig. 2 (type locality: Port Rame, Chile; lectotype MNHN B. 2748).

*Ophisurus dicellurus* Richardson 1845:106, pl. 48, figs. 2–4 (no locality given; type BMNH 1848.3.18.94).

*Ophisurus ramiger* Valenciennes 1847:11 (improper emendation of *Ophisurus remiger*).

*Muraenopsis discellurus*, Kaup 1856a:46 (errata pro *Ophisurus dicellurus* Richardson 1845).

*Ophichthys (Herpetoichthys) ater* Peters 1866:525 (type locality: Chile; holotype ZMB 3978).

*Ophichthys pacifici* Günther 1870:76 (type locality: Chile, and Tambo River, Peru; lectotype BMNH 1866.12.27.5).

*Ophichthys callaensis* Günther 1873:92 (type locality: Callao, Peru; type BMNH 1873.6.23.7).

*Ophichthys uniserialis* Cope, 1877:47 (type locality: Pacasmayo, Peru; holotype ANSP 21152).

*Ophichthys exilis* Seale, 1917:86 (type locality said to be Santiago, Chile; holotype MCZ 28401).

DIAGNOSIS. — A robust species of *Ophichthus* with tail 56–62% and head 14–15% of TL; dorsal fin arising in advance of end of pectoral fins; pectoral fins elongate, about 2.5–3.0 times in head; posterior nostril in a tube above lip, its distal portion expanded and flaplike, extending ventrally to but not reaching mouth; eye large, about 8.4–11 times in head; head pores (Fig. 9) small, inconspicuous, SO 1 + 3, IO 4 + 2, POM 6 + 3; free sensory neuromasts visible on nape of adults; teeth (Fig. 13a) conical, not enlarged, uniserial on vomer and biserial in jaws, outer row of mandible notably larger, outer row of maxillary slightly larger; coloration grayish brown in preservative, paler beneath, with a series of prominent white spots (often fading in preservative) along and between approximately each 5 lateral line pores from above pectoral base to the tail region, their distribution and extent variable; dorsal fin and inner edge of pectoral with fine punctations, anal fin colorless; and mean vertebral formula 18.9-53.8-154.6, total vertebrae 152–160 (n = 30).

SIZE. — The largest specimen reported is 825 mm, from Peru (Hildebrand 1946). The largest we examined was 678 mm, from Viña del Mar, Chile (SIO 87-137).

DISTRIBUTION. — From Nicaragua to Chile (Fig. 16), captured by trawl, trap and hook-and-line at depths of 15–277 m.

ETYMOLOGY. — Named for Port Rame, Chile, the type locality. We have been unable to find a contemporary locality with that name, and assume that it is currently known as Estero Rama (34°33'S, 70°56'W), south of Valparaíso.

REMARKS. — The convoluted taxonomy of this species has resulted in a plethora of names throughout the 19th and 20th centuries. The first name, *O. remiger* of Valenciennes, was applied to the illustration that appeared in d'Orbigny (Valenciennes 1837). In 1847, Valenciennes described *Ophisurus ramiger*, "L'OPHISURE PORTE-RAME," invalidly emending the name to agree with the location of capture. Richardson (1845) described *Ophisurus dicellurus* from a specimen obtained during the voyage of *HMS Sulphur*; we consider it to be a synonym of *O. remiger* (see below). Peters (1866) described *Ophichthus ater* on the basis of a Chilean specimen which we have examined and consider to be *O. remiger*. Kaup's (1856b:11) synonymy of *O. remiger* with Richardson's *Ophisurus ocellatus*

(not of Lesueur, but *Cryptopterus puncticeps* Kaup), an Atlantic species, probably led to Günther's (1870) description of *Ophichthus pacifici*, the name used by most 20th century authors. Subsequently, Günther (1873) described *Ophichthus callaensis* from Peru, Cope (1877) described *Ophichthus uniserialis* from Peru, and Seale (1917) described *Ophichthus exilis* from Chile. (Seale cited "Santiago" as the location — it seems likely that it came from a market since Santiago is well inland.) We have examined the holotypes of those taxa and find them to be referable to *O. remiger*.

Richardson's (1845:106) description of *Ophisurus dicellurus* lacked a locality. The 247 mm specimen, obtained during the voyage of *HMS Sulphur*, was examined by JMc who found that although it is emaciated, flabby and colorless, its morphology otherwise agrees in every way with that of *O. remiger*. Within the jar is a label that states "Yang-tze-kiang Richardson," as was reported by Günther (1870:59). We presume that the label is erroneous for two reasons. First, we are unfamiliar with any species of *Ophichthus* from China that resembles *dicellurus*. And second, the vessel *Sulphur* spent the vast majority (1836–1839) of her voyage along the coast of South America between Chile and México, dredging and sampling fishes and visiting harbors in *O. remiger*-habitats including Valparaíso, Callao, Guayaquil, Panamá, and the gulfs of Fonseca and Nicoya. Only during her western leg did the *Sulphur* reach China, where she stayed only a fortnight in November, 1841 (Hinds 1844). Thus she had ample opportunity to collect *O. remiger* and far less to sample Chinese *Ophichthus*. Furthermore, questionable localities occur elsewhere in Richardson (1844–45), such as in his description (p. 96) of *Calloptilum mirum*, which states "Inhab. The fish was probably taken in the China seas, but this habitat is by no means certain."

There are six syntypes of *Ophisurus remiger* in the Paris Museum (Bauchot et al. 1993:111). Three (MNHN B. 2748) were collected by d'Orbigny and three, questionably considered syntypes (MNHN A. 9955), were collected by Gay. The species is based upon Valenciennes' (1837) illustrated specimen, but it is not clear from either the description, or the faded coloration and poor condition of d'Orbigny's specimens, which of the three, if not all, were the basis of the illustra-

tion. We therefore have selected the largest specimen to be the lectotype.

Günther based his description of *O. pacifici* on four specimens, one from Chile and three from Peru. Although we consider *O. pacifici* to be a junior synonym of *O. remiger*, we feel it appropriate to designate a lectotype to fix the name. We have examined all the syntypes and find the specimen from Chile (BMNH 1866.12.27.5) to best serve as the lectotype.

*Ophichthus remiger* appears most similar to the eastern Pacific *O. frontalis*, from which it differs primarily in coloration and mean vertebral number. The ranges of the two species overlap between Nicaragua and Panamá, where they also overlap in depth and occupy a similar habitat. The species share a nearly identical dentition and the condition of their posterior nostrils, specializations not seen in other eastern Pacific *Ophichthus*. *Ophichthus remiger* also appears similar in appearance and morphology to the Atlantic *O. puncticeps* (Kaup) (previously known as *O. ocellatus*), and on that basis, several early authors (e.g., Jordan and Davis 1891; Delfin 1901; Fowler 1916), followed Günther (1870) in including the Atlantic species *Ophichthus ocellatus* in Chilean faunal lists. Those records are all based on *O. remiger*. *Ophichthus puncticeps* shares the dentition and posterior nostril location above the lip with its eastern Pacific cognates, however it differs in having fewer vertebrae (127–141) and a shorter tail (51–56% of TL).

TYPE MATERIAL EXAMINED. — MNHN B. 2748, 605 mm, Valparaiso, Chile, collected by d'Orbigny, the lectotype of *Ophisurus remiger*. MNHN 1997-732, 2(540–595 mm), paralectotypes of *Ophisurus remiger*, collected with the lectotype. MNHN A. 9955, 3(574–668 mm), Valparaiso, Chile, collected by Gay, questionable paralectotypes of *Ophisurus remiger*. ZMB 3978, 609 mm, Chile, holotype of *Ophichthys ater*. BMNH 1866.12.27.5, 614 mm, Chile, syntype of *Ophichthys pacifici*, here designated the lectotype. BMNH 1868.1.11.16–18, 3 (395–430 mm), Peru, paralectotypes of *Ophichthys pacifici*. BMNH 1873.6.23.7, 265 mm, Callao, Peru, the type of *Ophichthys callaensis*. ANSP 21152, 330 mm, Peru, holotype of *Ophichthys uniseri- alis*. MCZ 28401, 506 mm, Santiago (sic.), Chile, holotype of *Ophichthys exilis*. USNM

153611, 423 mm, Santiago, Chile, "cotype" (= paratype) of *O. exilis*.

OTHER MATERIAL EXAMINED. — **Nicaragua:** SIO 73-264, 5 (220–375 mm). SIO 73-279, 9(232–360 mm). **Costa Rica:** CAS 33288, 3(350–535 mm), SE of Cabo Blanco. LACM 33818-16, 7(330–345 mm), Cabo Blanco. LACM 33802-17, 350 mm, Punta Arenas. LACM 32498-9, 535 mm, SW of Cabo Santa Elena. CAS 51120, 2(505–525 mm), 09°34'N, 84°53'W. CAS 33283, 323 mm, off Quepos. CAS 35085, 425 mm, off Quepos. CAS 35086, 498 mm, off Quepos. CAS 33290, 410 mm, Golfo de Nicoya. **Panamá:** SIO 71-81, 318.5 mm, SE of Bahía de Panamá. UP 305, 298.5 mm, SE of Bahía de Panamá. ANSP 175794, 335 mm, SW of Ciudad Panamá, 08°45'12"N, 79°10'18"W. W 58-220, 336 mm, Bahía de Panamá, off Chame Point. W 58-305, 110 mm, Panamá. **Ecuador:** CAS 109290, 460 mm, Guayaquil. CAS 164258, 425 mm, Manta. **Peru:** ANSP 126119, 412 mm, 06°03'S, 81°09'W. MCZ 9203, 13(250–355 mm), Callao. MCZ 9204, 12(253–345 mm), Callao. USNM 77687, 670 mm, Paita. SIO 83-138, 280 mm, Puerto Pizarro. SIO 58-64, 174 mm, 17°38.0'S, 71°21.0'W. IMARPE 55c, 603 mm, 03°31.2'S, 81°08.4'W. SU 37373, 2(195 mm and head only), Bahía Independencia. AMNH 07960, 370 mm, Bahía Independencia. W 59-48, 115 mm, Peru. W 59-63, 4(220–250 mm), 08°14'S, 78°58'W. **Chile:** SIO 87-137, 16 (402–678 mm), N. of Viña del Mar. MCZ 9206, 4(350–510 mm), Valparaiso. USNM 39796, 381 mm, Valparaiso. BMNH 71.9.13.150, 186 mm, Valparaiso. USNM 36931, 480 mm, Coquimbo. ANSP 126122, 2(432–512 mm), La Serena. BMNH 1936.8.7.46, 365 mm, "*Ophichthys ater*, Chile."

***Ophichthus rugifer*** Jordan and Bollman (Figs. 10, 15; Tables 1, 2)

*Ophichthus rugifer* Jordan and Bollman 1890:155 (type locality: Galápagos, Charles Island; holotype USNM 41428).

*Ophichthys biserialis* Garman 1899:311 (type locality: Galápagos, Chatham Island; holotype MCZ 28454).

DIAGNOSIS. — A robust species of *Ophichthys* with tail 56–62% and head 10–11.5% of TL; body of large individuals conspicuously etched



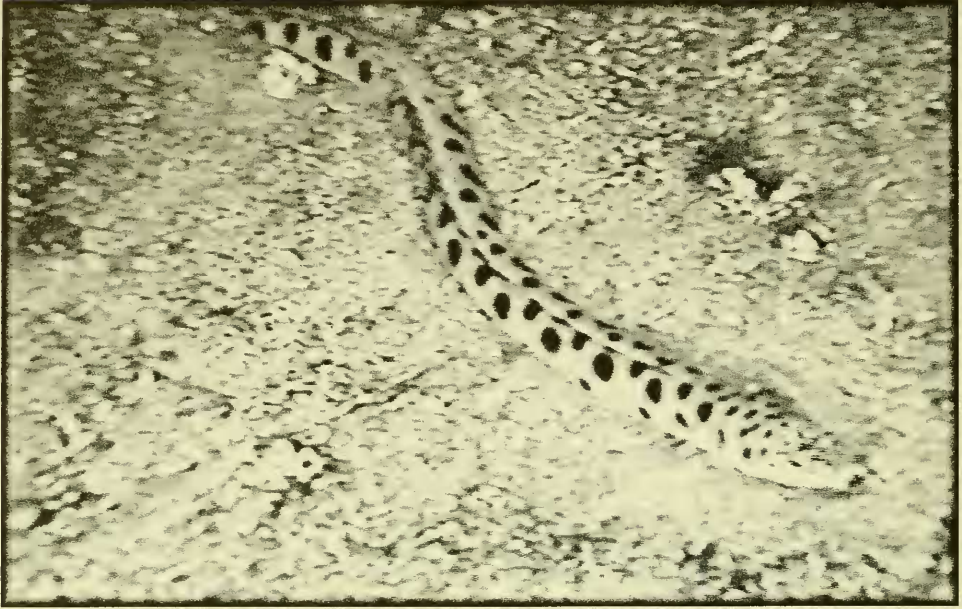


FIGURE 10. Underwater photograph of an adult *Ophichthus rugifer*, taken from the submersible *Johnson Sea-Link* at 200 m off Isla Floreana, Galápagos.

with fine longitudinal striations; dorsal fin arises above mid-pectoral fin; median fins well developed; pectoral fin spatulate, about 2.5–4 in HL; posterior nostril within a large flat tube, opening outside of upper lip; a small lip barbel (a protuberance in larger individuals) just anterior to base of posterior nostril; eye large, about 8–12 in HL; head pores small but apparent, SO 1 + 3, IO 4 + 2, POM 6 + 3; free sensory neuromasts visible on nape of adults; teeth very similar to those of *O. triserialis* (Fig. 13b), conical and strong but not enlarged, strictly uniserial on vomer and biserial in jaws, maxillary teeth nearly subequal, the outer row of the mandible notably larger; coloration in preservative yellow, slightly browner dorsally, a series of brown spots from mid-flank to dorsal base, irregularly paired along the dorsal midline, the largest spots about 1–1.3 eye diameters; dorsal fin margin with a series of brown streaks and pale interspaces; anal fin in anterior half of tail yellowish, posteriorly becoming darker basally, the entire fin flanked by reddish stripes; median fins black posteriorly (about the length of the jaw) as they enter a deep groove; most of pectoral fin of larger individuals with a black smudge; head and throat covered with smaller brown spots; anterior nostrils and tail tip

yellow; mean vertebral formula 13.7-56-159.2, total vertebrae 154–162 ( $n = 23$ ).

SIZE. — The two largest specimens we have examined are 680 mm, from Cocos Island.

DISTRIBUTION. — Known from the Galápagos and Cocos islands (Fig. 15), from a few to 200 m depth. Most of the specimens we have examined were captured at the surface by dipnetting under lights, and a few were taken using rotenone-based ichthyocides. A large adult was observed at 200 m off Isla Floreana swimming slowly over a sand bottom and photographed (Fig. 10) by S. Pomponi from the submersible *Johnson Sea-Link*.

ETYMOLOGY. — From the Latin *rugose*, in reference to the longitudinal striations that are obvious on larger specimens.

REMARKS. — Most 20th century authors have synonymized the nominal Galápagos species *O. rugifer* and *O. biserialis* with *O. triserialis*. On the basis of the non-overlapping difference in total vertebrae (158–162 and 145–152, respectively), we consider the Galápagos and Cocos islands *populations* to be distinct from the mainland species *O. triserialis*.

*Ophichthus rugifer* appears to exhibit geographic variation in color pattern, however we

lack enough material to determine its significance. Only four specimens larger than 400 mm are available, and only one is from the Galápagos. That specimen agrees in color pattern with similarly-sized specimens of *O. triserialis*. That is, there is a series of 21 midlateral circular spots about 1.5 eye diameters in size, alternating with a series of smaller spots on either side of the dorsal midline. The head has a number of regular round spots dorsally. The three large specimens from Cocos Island differ in that the head is profusely spotted with smaller, less regular spots and the body has many small spots, the largest 0.7–1.0 eye diameters in size. The larger spots are mostly arranged in a series of 18–30 just above the lateral midline, and there are as many as 40 more-or-less paired smaller spots on either side of the dorsal midline. The overall impression is of spotting that is much more profuse and less regular. Small specimens (less than 400 mm) from Galápagos are similar in coloration to that of *O. triserialis*.

TYPE MATERIAL EXAMINED. — USNM 41428, 536 mm, an ovigerous female, Charles Island (Isla Floreana), Galápagos, the holotype of *Ophichthus rugifer*. MCZ 28454, 158 mm, Chatham Island (Isla San Cristobal), Galápagos, the holotype of *Ophichthus biserialis*.

OTHER MATERIAL EXAMINED. — **Isla del Coco:** CAS 35956, 680 mm, Chatham Bay. LACM 33647-4, 423 mm. LACM 37656-1, 680 mm. **Galápagos:** W 53-150, 193 mm; CAS 33687, 85 mm, James. LACM 8140, 157 mm, Barrington. SU 37374, 218 mm, Hood. FMNH 75733, 165 mm; LACM 24474, 2(108–114 mm); SU 6283, 208 mm; SU 6284, 212 mm; W 67-42, 215 mm, Floreana. SU 236, 2(268–285 mm), San Cristobal. CAS 47053, 2(87–189 mm); LACM 23844, 3(86–150 mm); SU 37375, 3(94–135 mm), Isabela. CAS 5285, 236 mm; CAS 5286, 151 mm, Bolivar Channel. CAS 23737, 222 mm; SIO 64-1010, 2(132–225 mm); SIO 64-1017, 2(230–285 mm); SIO 64-1018 (W 64-40), 275 mm; LACM 8087, 180 mm; LACM 30360, 8(78–260 mm), Santa Cruz. LACM 44025-1, 640 mm, Jervis.

***Ophichthus tetratrema*, new species**  
(Figs. 8c, 11, 15; Tables 1, 3)

DIAGNOSIS. — A robust species of *Ophichthus* with tail 58.5–60% and head 11% of TL;

dorsal fin origin above pectoral fin; pectoral fin paddle-shaped; posterior nostril a hole in lip covered by a flap; cephalic pores conspicuous, SO 1 + 4, IO 4 + 2, PO 7 + 4; teeth uniserial on mandible, uniserial or biserial on maxillary and biserial on vomer; coloration tan to chocolate brown, darker on throat and belly; mean vertebral formula 11.7-55-156, total vertebrae 155–157 (n = 3).

COUNTS AND MEASUREMENTS OF THE HOLOTYPE (in mm). — Total length 421; head 45.5; trunk 125; tail 250.5; predorsal distance 50; pectoral length 13.0; pectoral base 4.7; body depth 15.2 at gill opening; body width 12.4 at gill opening; body depth 14.8 at anus; body width 12.0 at anus; snout 7.7; tip of snout to rictus 13.1; eye diameter 3.5; interorbital distance 4.8; gill opening height 6.8; isthmus width 6.4. Vertebral formula 12-55-155. Total left lateral-line pores 141.

DESCRIPTION. — Body elongate, depth at anus 25–28 in TL. Head and trunk 2.4–2.5 and head 9.0–9.3 in TL. Snout rounded, conical when viewed from above. Lower jaw included, its tip beneath base of tubular anterior nostrils. Eye well developed, 3.3–3.7 in upper jaw, its center behind midpoint of upper jaw. Anterior nostrils tubular, about 3 in eye diameter. Posterior nostril in a tube above lip, its distal portion expanded and flaplike, often extending ventrally to the mouth. Dorsal fin origin slightly behind pectoral fin base. Median fins low but distinct, expanded in posterior tail region and ending within a groove about an eye diameter before fleshy tail tip. Pectoral fin well developed, paddle-shaped but longer than broad, the base extending across dorsal half of gill opening.

Head and lateral line pores (Fig. 11) conspicuous, well developed for an ophichthid. Single median interorbital and temporal pores. Supraorbital pores 1 + 4, infraorbital pores 4 + 2, lower jaw pores 7, preopercular pores 4. Lateral-line pores continue to nearly 1/2 HL of tail tip; 11 before gill opening, 48–50 before anus, 141–144 total pores.

Teeth (Fig. 8c) pointed and depressible. An anterior rosette of 4–7 intermaxillary teeth, followed by 2–3 pairs on vomer, then 7–10 uniserial teeth posteriorly. Maxillary teeth 12–14, either uniserial or regularly biserial (see Remarks below). Mandibular teeth 15–19, uniserial. Intermaxillary and anterior vomerine teeth slightly



larger than jaw teeth. Gill arches of holotype (removed and cleared and stained) are typical for *Ophichthus* (cf. McCosker 1977:32) with small biserial conical teeth on lower tooth plate and triserial on upper.

Coloration in isopropyl alcohol tan to chocolate brown, darker along throat and belly. Median fins darker basally with a light margin. Pectoral fins colored like body. Caudal tip tan. Holotype, when collected by the late C. L. Hubbs, was described as "blackish."

SIZE. — To 556 mm, a female with undeveloped eggs.

DISTRIBUTION. — Known from Costa Rica to Ecuador (Fig. 15), trapped or trawled at depths between approximately 700–1000 m.

ETYMOLOGY. — From the Greek τετρα (four) and ῥήμα (a hole), in reference to the unique presence of four preopercular pores in this species. Here considered a noun in apposition.

REMARKS. — The new species falls within the generic limits of *Ophichthus* (sensu lato) in all characters except the presence of four rather than two or three preopercular pores. The numerous, oversized head and body pores are probably related to the depth at which this eel lives. Most ophichthids have been taken at depths shallower than 100 m, although this may represent sampling more than depth preference. The Gulf of Panamá paratype (P 32692) had a partially-digested myctophid (*Lampanyctus* sp., ca. 55 mm SL) in its stomach.

The maxillary teeth of the two smaller specimens (the holotype and CAS 57864, female and male, respectively) are regularly uniserial, whereas those of P 32692, a female, are biserial. It is not uncommon in certain muraenids for tooth number and rows to increase with age (Hatooka 1986), yet we do not know of another ophichthid species in which there is so marked a difference in dentition at so similar a size.

MATERIAL EXAMINED. — HOLOTYPE: SIO 73–294, 421 mm, a female with undeveloped eggs, captured in a benthic trap set overnight at 900 m depth, 12 km S of Isla Blanca, Costa Rica, 09°24.5'N, 85°06.0'W, by R. R. McConnaughey and C. L. Hubbs on 20 Apr. 1973. PARATYPES: ZMUC P.32692, 556 mm, a female with undeveloped eggs, captured in a herring trawl over a green clay bottom, 915–975 m depth, Galathea Sta. 739, Gulf of Panamá, 07°22'N, 79°32'W, on 15 May 1952. CAS 57864, 337 mm, male, Gulf

of Guayaquil, Ecuador, 02°25'S, 81°10'W, trawled at 700–1000 m, *Te Vega* Exped. Cruise 19, Sta. 148, by M. Bradbury on 1 Sep. 1968.

***Ophichthus triserialis* (Kaup)**  
(Figs. 12, 13b, 16; Tables 1, 2)

*Muraenopsis triserialis* Kaup 1856a:46 (type locality: "Pacific"; holotype BMNH 1855.9.19.1276).

*Ophisurus Californiensis* Garrett 1863:66 (type locality: Margarita Bay, Lower California; holotype destroyed by the 1906 San Francisco earthquake).

*Ophichthus grandimaculata* Kner and Steindachner 1867:389, pl. 5, fig. 13 (type locality: coast of Peru; holotype BMNH 1866.12.27.9).

DIAGNOSIS. — A robust species of *Ophichthus* with tail 53–58% and head 9–12% of TL; body of large individuals conspicuously etched with fine longitudinal striations; dorsal fin arises above mid-pectoral fin; median fins well developed; pectoral fin spatulate, about 2.3–3.4 in HL; posterior nostril within a large flat tube, opening outside of upper lip; a small but noticeable lip protuberance just anterior to base of posterior nostril; eye large, about 7–11 in HL; head pores (Fig. 12) small but apparent, SO 1 + 3, IO 4 + 2, POM 6 + 3; free sensory neuromasts visible on nape of adults; teeth (Fig. 13b) conical and strong but not enlarged, strictly uniserial on vomer and biserial in jaws, maxillary teeth subequal, those of outer row of mandible notably larger; coloration in preservative yellow, slightly browner dorsally, a series of large brown spots from mid-flank to dorsal base, irregularly paired along the dorsal midline and (in individuals larger than 30 cm) alternating with large brown spots across dorsal midline including fin, the largest spots about twice eye diameter; anterior half of anal fin yellowish, posteriorly becoming darker basally, the entire fin flanked by reddish stripes; median fins black posteriorly (about the length of the jaw) as they enter a deep groove; most of pectoral fin of larger individuals covered by a black smudge; head and throat covered with smaller brown spots; anterior nostrils and tail tip yellow; mean vertebral formula 12.7-54.5-147, total vertebrae 145–152 (n = 19).

SIZE. — The largest specimen we examined is 1035 mm (CAS 40255). Quirollo and Dinnel (1975) described a 900 mm immature female from northern California as having five winter zones on its otoliths.



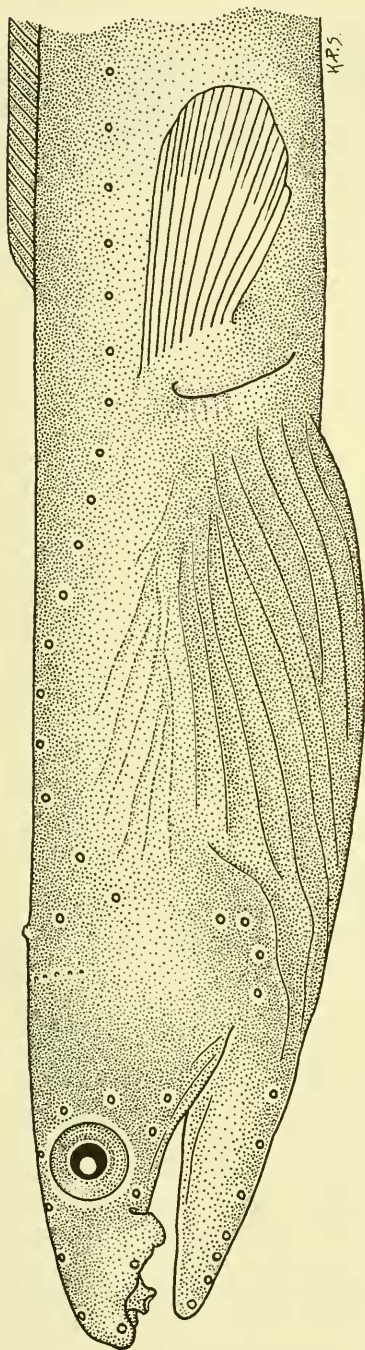


FIGURE 11. Head region of holotype of *Ophichthus tetratrema*, n. sp., SIO 73-294, 421 mm.

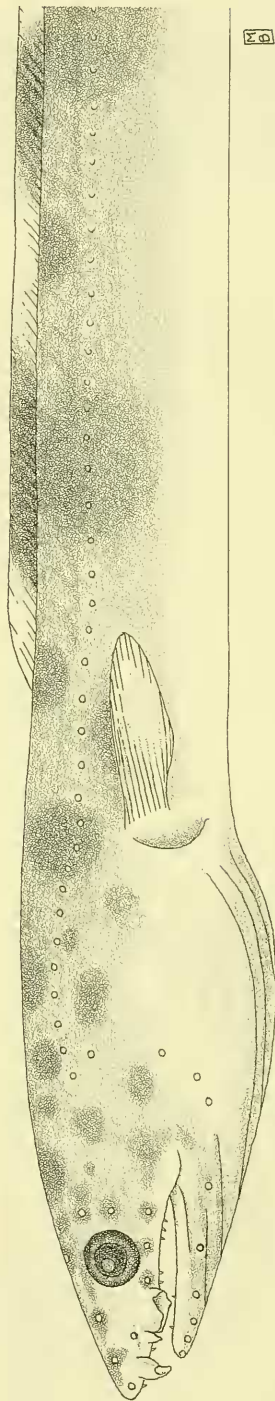


FIGURE 12. Head region of *Ophichthus triserialis*, SIO 63-524, 436 mm.

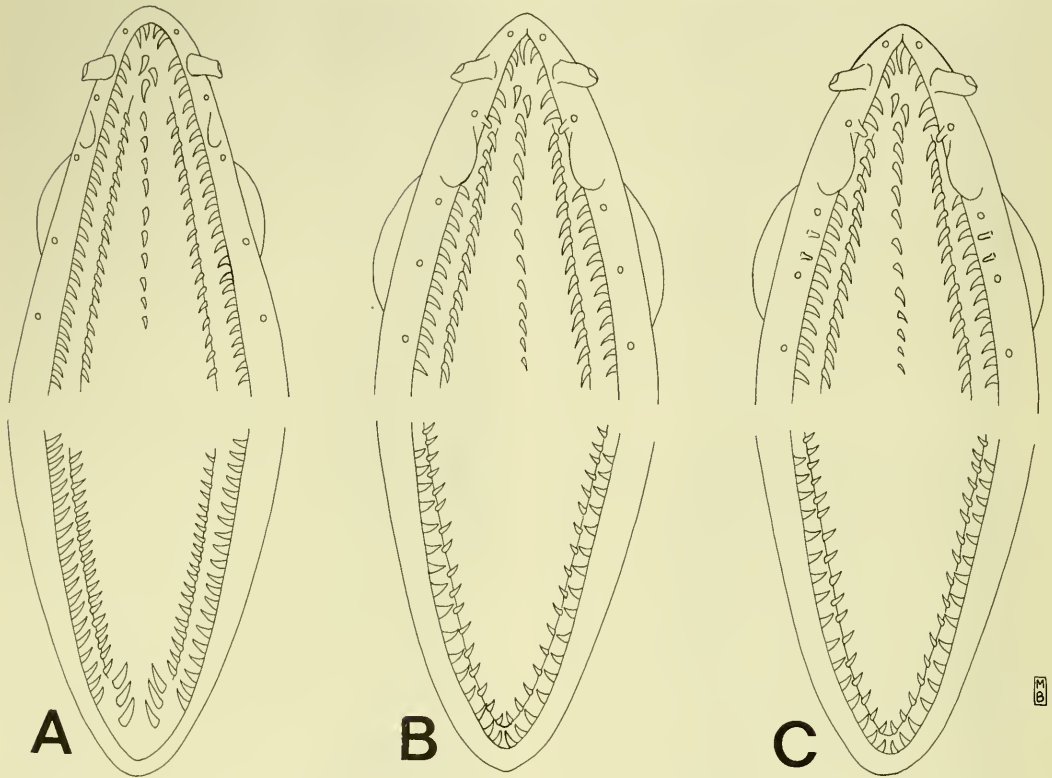


FIGURE 13. Dentition of: A) *Ophichthus remiger*, SIO 87-137, 665 mm; B) *Ophichthus triserialis*, SIO 79-15, 313 mm; C) *Ophichthus zophochir*, SIO 62-342, 334 mm.

ETYMOLOGY. — From the Latin, *triserialis*, three-rowed, in reference to the pattern of spots.

DISTRIBUTION. — From off the Klamath River, northern California (Quirollo and Dinnel 1975), to Peru (Fig. 16), generally caught with hook-and-line or trawled, from tidepool depths to 155 m.

REMARKS. — Kaup twice described *Muraenopsis triserialis* in 1856. In *Uebersicht der Aale* (1856a:46) he cited the capture as “Süd-Amerika oder stiller Ocean. Haslar Mus.” In the *Catalogue of apodal fish in the collection of the British Museum* (1856b:12) he stated “Pacific (discovered by Dr. Goodridge, on the voyage of the *Herald*. Brit. Mus.)” There is nothing associated with the label of the holotype that would clarify this discrepancy.

McCosker et al. (1989:399) placed *Herpeichthys callisoma* Abbott (1861) in the synonymy of the Atlantic species *Ophichthus ophis*. The type locality of the holotype (ANSP 38148)

is unknown. Although Abbott suggested in his original description of the holotype of *H. callisoma* that “. . . various circumstances induce me to suspect it is a species belonging to the Pacific fauna,” McCosker et al. found that it agreed in all characters, including vertebrae (166), with *O. ophis* (total vertebrae 161–167).

Charter (1996:96) gave the total vertebrae of *O. triserialis* as ranging from 144–160. We have reexamined the four specimens that she reported on and found three to have 147 vertebrae and the fourth, with 160, to be a specimen of *O. rugifer*. McCosker (1977:115) reported on two *O. triserialis* as having 145 and 160 vertebrae; the first specimen is *O. triserialis* and the second is *O. rugifer*.

Jordan and Evermann (1896:384) erred in their description of *O. triserialis* by stating “teeth in both jaws uniserial.” However, in their key (p. 381) they correctly included it among those spe-

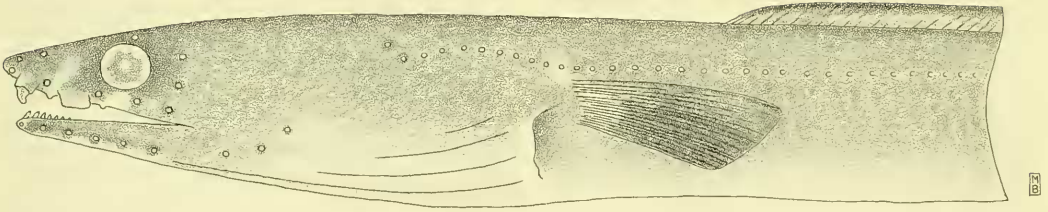


FIGURE 14. Head region of *Ophichthus zophochir*, SIO 65-158, 572 mm.

cies with “teeth of upper jaw in 2 or 3 series” and “teeth of lower jaw in 2 to 4 series.”

The mainland species *O. triserialis* differs from the Galápagos and Cocos islands species *O. rugifer* in having fewer vertebrae (145–152 vs. 158–162).

**TYPE MATERIAL EXAMINED.** — BMNH 1855.9.19.1276, 930 mm, Goodridge, Pacific, the holotype of *Muraenopsis triserialis*. BMNH 1866.12.27.9, 597 mm, coast of Peru, holotype of *Ophichthys grandimaculata*.

**OTHER MATERIAL EXAMINED.** — **California:** CAS 40255, 1035 mm, off Bodega Bay. SU 24130, 545 mm, San Francisco Bay. CAS 23715, 890 mm, San Francisco Bay. SU 4359, 2(655–715 mm), Pacific Grove. LACM 37042-1, 600 mm, Malibu Pt. SU 22510, 670 mm, San Pedro. SIO 70-258, 910 mm, Santa Catalina Island. LACM 32703-1, 820 mm, Seal Beach. SIO H49-47, 661 mm, Solana Beach. SIO H50-121, 980 mm, Torrey Pines. SIO 48-16, 1215 mm, La Jolla. SIO 64-324, 900 mm, Coronado Islands. **Baja California:** SIO 65-316, 730 mm, Punta Pulpito. SIO 64-645, 2(165–242 mm); SIO 91-48, 720 mm; CAS 54889, 382 mm, Bahía Magdalena. SIO 79-15, 313 mm, Boca de la Trinidad. SIO 68-55, 550 mm, Gorda Bank. **Gulf of California:** LACM 8822-2, 750 mm; LACM 30356-1, 485 mm, Bahía de Los Angeles. W 53-68, 880 mm, Isla Angel del la Guarda. W 53-59, 960 mm, Bahía San Pedro. SU 60312, 496 mm, Bahía Concepción. W 53-118, 2(680–915 mm), Sinaloa. LACM 24449, Isla San Pedro Nolasco, 3(151–179 mm). W 53-59, Bahía San Pedro, 760 mm. SIO 69-252, 800 mm (skeletonized), Mulege. SIO 70-91, 1035 mm, Cerro Colorado. LACM 35737-72, 560 mm, Guaymas. SIO 79-15, 313 mm, Boca de la Trinidad. W 53-218, 240 mm; W 55-118, 870 mm; AC 94 (1-1934), 770 mm, Cabo San Lucas. CAS 39541, 775 mm; SU 32086, 593 mm, La Paz. SU 21197, 610 mm,

Punta Abreojos. CAS 36595, 2(525–975 mm); SIO 64-1068, 181 mm; CAS 27518, 2(67–71 mm), Los Frailes. CAS 119095, 123 mm, Bahía Santa Maria. **México:** SIO 63-515, 661 mm; SIO 63-524, 436 mm, Golfo de Tehuantepec. **Guatemala:** CAS 98444, 108 mm, off San Jeronimo. **Panamá:** SIO 72-379, 90 mm, Panamá Bay, Farfan Pt. **Peru:** IMARPE 556, 510 mm, Caleta San Jose. USNM 77635, 375 mm, Isla Lobos de Tierra. USNM 127837, 941 mm, Bahía Sechura. W 53-421, Cabo Blanco, 720 mm.

***Ophichthus zophochir* Jordan and Gilbert**  
(Figs. 13c, 14, 16; Tables 1, 2)

*Ophichthys zophochir* Jordan and Gilbert, 1882:347  
(type locality: México, Mazatlan; lectotype USNM 28277).

*Ophichthus zophochir*, Jordan and Davis 1891:633.

*Ophichthus chamensis* Meek and Hildebrand 1923:155, pl. 8, fig. 2 (type locality: Panamá, Chame Point; holotype USNM 82216).

*Ophichthus Gisenchelys zophochir*, Fowler 1944:188  
(type of the new subgenus *Gisenchelys*).

**DIAGNOSIS.** — A moderately elongate species of *Ophichthus* with tail 63–70% and head 10–15% of TL; dorsal fin origin above pectoral fin; pectoral fin moderately rounded, variable in length, 38–57% of HL; posterior nostril opening near edge of lip, its lower rim joins with the distal flap to form a tube directed into mouth; a small but conspicuous barbel usually present on upper lip midway between nostrils; head pores (Fig. 14) small, inconspicuous, SO 1 + 3, IO 4 + 2, POM 7 + 3; teeth (Fig. 13c) small, conical, none enlarged, irregularly biserial (see Remarks) in jaws and on vomer (becoming multiserial in large adults); coloration gray dorsally and on flanks to lateral line, pale beneath, median fins and occasionally pectoral fins of adults (>40 cm) black;



mean vertebral formula 14-45.6-153, total vertebrae 149-162 (n = 31).

SIZE. — The largest we have examined is an 822 mm male specimen (SIO 78-105) with moderately-developed testes that was captured at the San Onofre, California, Nuclear Generating Station. Hopkirk (1965) reported on another 822 mm specimen that had been captured in a suction dredge in 10 m of water in Long Beach Harbor, California. Almost all large specimens (>60 cm) of *O. zophochir* in museum collections are from California. The SIO collection contains 101 transformed individuals of *O. zophochir* from south of California, collected by a variety of methods. The largest of these is 57.2 cm, and only four others exceed 50 cm in length. The eight California specimens in the SIO collection range from 41.4 cm to 82.2 cm. Four are larger than 70 cm and the remainder range from 41.4-68.4 cm. It seems unlikely that the large size of the California specimens can be attributed to the circumstance of expatriates putting energy into growth rather than reproduction, as both ripe males and females are represented. It may be that the California individuals, living in colder water, mature later and are longer lived.

ETYMOLOGY. — From the Greek ζόφος (black) and χεῖρ (hand), in reference to the pectoral fin coloration.

DISTRIBUTION. — From Humboldt Bay, northern California (Quirollo and Dinnel 1975; Wintersteen 1975), to Huacho, Peru (Chirichigno 1974) (Fig. 16), over sand and mud bottoms, from 1 m to a depth of 110 m.

REMARKS. — Several characters (including but not limited to dentition, coloration, barbels, and pectoral fin shape) of *Ophichthus zophochir* are so variable that only after the examination of a large series have we been able to characterize the species. The number and rows of teeth of *O. zophochir* is particularly variable with growth and among individuals of the same size. Meek and Hildebrand (1923) differentiated *O. chamensis* from *O. zophochir* on the basis of uniserial vomerine teeth in the former. The vomerine teeth of the holotype of *O. chamensis* are in a single row, whereas the two similar-sized paratypes collected with the holotype have partially and mostly biserial dentition, respectively. The mandibular dentition of the holotype of *O. chamensis* is biserial but partially uniserial in the other two specimens. The majority of specimens

of *O. zophochir* examined have strictly biserial vomerine teeth or they are at least biserial anteriorly; a few individuals have uniserial dentition. A conspicuous barbel between the anterior and posterior nostrils is present in all individuals, however, upon closer examination many specimens will be seen to have either one or two, much smaller barbels along the lip margin behind the posterior nostril. The pectoral fin shape is quite variable, ranging from a moderately-developed, paddle-shaped fin to a more slender, elongate condition. The median and pectoral fins of large individuals (>40 cm TL) are usually but not always black; we are unable to ascribe this to sexual state or reproductive condition.

We have examined the remaining syntypes of *O. zophochir* and designate USNM 28277, 697 mm, as lectotype. Two paralectotypes (USNM 28280 and USNM 29239) are extant, however USNM 29220 was not found during the 1980 inventory of the USNM type collection, and Smith (1994:35) stated that "possibly it was lost in the 1884 fire at Indiana University."

Charter (1996:98) recorded a specimen of *O. zophochir* as having 144 total vertebrae, below the vertebral range that we recognize. We have examined that specimen (SIO 73-276) and determined that it is *O. mecopterus*.

TYPE MATERIAL EXAMINED. — USNM 28277, the lectotype of *Ophichthus zophochir*, 697 mm, México, Mazatlan. USNM 28280, 606 mm and USNM 29239, 425 mm, paralectotypes, collected with the lectotype. USNM 82216, 265 mm, the holotype of *Ophichthus chamensis*, from Panamá, Chame Point. USNM 82217, 2(210-242 mm), paratypes of *O. chamensis*, collected with the holotype.

OTHER MATERIAL EXAMINED. — **California:** W 51-98, 780 mm; W 55-208, 745 mm, Santa Monica. W 61-55, 530 mm, Huntington Beach. W 61-134, 700 mm, Alamitos Bay. SIO 76-332, 684 mm, Redondo Beach. W 60-276, 2(575-628 mm), Newport Beach. CAS 122511, 2(448-502 mm), Playa del Rey. W 61-54, 490 mm, El Segundo. SIO 78-105, 822 mm; W 54-164, 810 mm; W 61-135, 580 mm, Long Beach. SIO 76-268, 2(743-793 mm), San Onofre. SIO 78-105, 822 mm, San Onofre. SIO 60-162, 414 mm, Del Mar. SIO 82-66, 628 mm, La Jolla. SIO 75-461, 645 mm, Mission Bay. SIO 48-133A, 813.5 mm, San Diego Bay. **Baja California:** SIO 59-25, 2(93-107 mm), Turtle Bay. SU 66882, 417 mm.

Thurloe Bay. SIO 52-140, 535 mm, Scammon's Lagoon. SIO 54-245, 238 mm, Magdalena Bay. **Gulf of California:** CAS 119094, 10(94-198 mm), Santa Maria Bay. CAS 95055, 209 mm, Punta Abreojos. SU 19216, 5(103-154 mm), Asuncion Bay. SU 288, 455 mm; SU 19215, 2(544-571 mm); W 50-43, 695 mm; LACM 35736-17, 2(532-700 mm), Guaymas. SIO 62-342, 334 mm; SIO 65-158, 4(323-572 mm), Isla Altamura. SIO 62-701, 8(275-531 mm), WNW of Marquis Point. **México:** W 58-26, 695 mm, San Blas. CAS 38945, 2(98-107 mm); SU 68555, 106 mm, Tangola-Tangola Bay, 15°43'15"N, 95°04'15"W. SU 57315, 2(81-102 mm), Puerto Guatulco. SIO 63-514, 3(352-508 mm); SIO 63-517, 11(294-417 mm); SIO 63-523, 2(379-524 mm); SIO 63-526, 6(330-548 mm); SIO 73-258, 296 mm, Gulf of Tehuantepec. SIO 73-276, 181 mm, Pta. Ampala. **Guatemala:** CAS 58339, 237 mm, Champerico. LACM 24164, 2 (106-111), 13°52'N, 91°01'W. **El Salvador:** SIO 73-276, 181 mm, SW of Punta Ampala. **Costa Rica:** UCR 702.008, 174 mm, Puntarenas, S. of Golfo de Dulce. **Panamá:** USNM 128420, 143 mm, Venado Beach. SIO 64-744, 425 mm, Rio Juan Diaz. ANSP 152297, 2(209-212 mm), E. of San Carlos, 08°26'12"N, 79°43'12"W, 14.7 m. ANSP 175795, 312 mm, SW of Ciudad Panamá, 08°45'12"N, 79°10'18"W, 33-37 m. MCZ 44192, 3(385-520 mm), Panamá Bay, Bella Vista. W 58-305, 105 mm. **Ecuador:** MNHN 1997-4160, 496 mm; MNHN 1997-4161, 497 mm, Puerto Lopez. **Peru:** IMARPE 55d, 515 mm, Paita.

#### CHARACTERS

The morphological reduction that is the essence of eelness has resulted in a paucity of characters useful in other fishes for determining species. Scales are generally absent, or so small as to be uncountable, gill rakers are poorly developed and inaccessible, paired fins are reduced or absent, and median fins have such a large number of fine fin rays that accurate enumeration, even from radiographs, is impractical at best and often impossible. This leaves vertebral number as the only accessible meristic feature. Mensurable characters are likewise few. The eel shape presents few landmarks for measurements on the body; gill openings, the anus, and dorsal and anal origins exhaust the list. Almost all the definable

measurements involve the head and its parts. The condition of preservation introduces much variability and further confounds the use of measurements. Specimens are usually bent, and often distorted, greatly affecting accuracy. In general, it is a fair statement that measurements on eels may be made with great precision but without much accuracy. Nevertheless, it has proved possible to distinguish 11 species of *Ophichthus* in the eastern Pacific using a combination of vertebral number, dentition, proportions, pore patterns and coloration. The most useful characters are discussed below.

1. Body shape: The species vary more or less continuously in form from slender or elongate (*O. longipenis*) to robust (*O. frontalis*, *O. triserialis*, et al.). The difference in relative elongation is difficult to quantify because in none is body depth a large percentage of total length. Thus, body depth at the gill openings is about 2.5% of total length at one extreme and 5% at the other. This seemingly small difference of 2.5% is nevertheless twofold and, integrated over the length of the body, translates into eels of markedly-different appearance. We will use the terms slender for one extreme and robust for the other, with the caveat that small individuals are typically more slender than large ones.

Although there are interspecific difference in other body proportions, the species for the most part exhibit considerable uniformity, perhaps dictated by similarities in habitat and lifestyle. Most body proportions are generally similar across species. There are exceptions to this generality: *O. longipenis* and *O. apachus* have notably long tails and short heads (and concomitantly short predorsal distances), and *O. arneutes* and *O. tetratrema* have short mouths (24 and 29% of the head length, respectively, vs. 35-40% in other species). Both *O. melope* and *O. tetratrema* have short pectoral fins, but given the inherent variability in the measurements and the small number of available specimens, it would be difficult to demonstrate significant differences.

2. Vertebrae: Vertebral number is one of the most useful characters for separation. It is, for example, the only way in which the Galápagos species *O. rugifer* can be distinguished from the mainland *O. triserialis*. Although it has become the convention (Böhlke 1982) to separate vertebral counts into predorsal and pre- and post-anal origin, we have found total vertebral number to

be the most useful, as well as the most determinable, on radiographs of varying quality. Predorsal-fin and preanal-fin counts are, however, critical in linking leptocephali and adults. And we caution that anomalous vertebral counts can be obtained from individuals with amputated and healed-over tail tips.

3. Dentition: The teeth are pointed in all species, and there are few remarkable interspecific differences in size. There are, however, differences in arrangement and conformation of the teeth. The teeth on the vomer may be uniserial or biserial, although there is considerable variation in *O. zophochir*, so that in a few individuals only the first of the first two or three positions are paired, and the jaw teeth of larger individuals progress from biserial to nearly multiserial (not unlike the condition in certain Atlantic species, cf. McCosker et al. 1989). We have infrequently observed individual variation in the arrangement of jaw teeth in *Ophichthus*: they are usually invariably either bi- or uniserial.

4. Nostrils: The anterior nostrils of all *Ophichthus* species are in a tube. Although there are interspecific differences in the relative development of the tube, they are obscured by artifacts of preservation, so that the nostril-tubes of conspecifics can appear to differ considerably in length and shape. There are three conditions of the posterior nostril in the eastern Pacific species. In the first condition (*O. arneutes*, *O. melope* and *O. longipenis*) the posterior nostril is a hole just above the upper lip, covered by a distal flap that extends to or below the edge of the mouth. The lower margin of the nostril has a thickened rim, but the distal flap attaches to the lip rather than to the lower rim of the nostril. In another condition (*O. zophochir*, *O. mecopterus*, *O. triserialis* and *O. rugifer*) the nostril opening is near the edge of the lip, but the lower rim of the nostril is elaborated, so that it joins with the distal flap to form a tube directed into the mouth. In both of these conformations the nostril opens into the mouth. In *O. frontalis*, *O. remiger*, and *O. tetratrema* the posterior nostril is in a tube well above the lip. The distal portion of the tube is expanded and flaplike, often extending ventrally to the mouth, but if the edge is raised it can be seen that it is a part of a tube that opens just above the mouth. A feature associated with the nostrils is the presence of barbels on the lip. In *O. longipenis*, *O. triserialis* and *O. rugifer* there is a

barbel midway between the anterior and posterior nostrils. In large individuals of the latter two species the barbel thickens and eventually becomes a prominence. In *O. zophochir* and *O. mecopterus* there is a barbel (which may be flaplike) just anterior to the posterior nostril and one or (usually) two shorter, finer barbels behind the posterior nostril.

5. Pectoral fin shape: Although there is considerable individual variation in detail, there are two basic pectoral shapes. The pectorals are rounded and paddle-shaped in *O. arneutes* and *O. melope*. Correlated with this, the pectorals fall short of or barely reach the origin of the dorsal. In the other species they are pointed and extend back beyond the dorsal origin.

6. Coloration: *Ophichthus triserialis* and *O. rugifer* stand out because of their strongly-contrasted, spotted color pattern. There is ontogenetic variation; small individuals have a row of spots on the side and sparse spotting on the head, and in larger individuals the spots become more numerous. The coloration of the other species is more somber, as tones of gray or brown, often with subtle bars or mottlings. A notable exception is provided by the species that have the lateral line pores of the head (and in one case the body) variously outlined in dark, ranging from the black rings of *O. melope* to the brown spots of *O. longipenis*. Some judgment must be employed in using this character; time brings fading, and in probably all species some or all of the head pores are ringed by chromatophores in small individuals. We do not know whether bars or mottlings represent the usual life coloration in those species. It is known that freshly caught *O. frontalis* are plain reddish brown and that darker bands, which often persist in preservative, appear as they die. This seems unlikely in *O. melope* and *O. mecopterus*, for example, which have darker bars on a lighter background, but we have no information about their coloration in life. Only *O. zophochir* has a completely plain body, although in large juveniles and adults the pectoral is dark and the fins are dark-edged.

7. Cephalic pores: The number and arrangement of cephalic pores of species of *Ophichthus* provide useful characters. The lateral line pores, particularly those of the tail region, of many ophichthids are nearly impossible to discern and provide information that is better available through vertebral number. The cephalic pores



however are usually constant in number and position. Minor variation is observed primarily in the total number of mandibular pores, which rarely vary by more than a single pore on one side of the lower jaw, and on rare occasions the preopercular pore condition is anomalously two rather than three. Most eastern Pacific *Ophichthus* (*O. frontalis*, *O. mecopterus*, *O. remiger*, *O. rugifer*, *O. triserialis* and *O. zophochir*) possess SO 1 + 3, IO 4 + 2, and PO 5–7 (usually 6) + 3; *O. melope* agrees with that pattern but lacks the third preopercular pore. *Ophichthus arneutes* and *O. longipenis* have an additional SO and one fewer preopercular pore (SO 1 + 4, IO 4 + 2, and PO 6 + 2). *Ophichthus tetratrema* is unique within *Ophichthus* in having a fourth preopercular pore.

8. Free sensory neuromasts: Large individuals of species of *Ophichthus* that attain a large size (viz. *O. frontalis*, *O. remiger*, *O. rugifer* and *O. triserialis*) have free sensory neuromasts along the sides and top of their head (McCosker 1977:38, fig. 24). They appear as minute papillae and are often difficult to discern due to skin rugosity and a waxy precipitate that often forms on preserved specimens. Neuromast development appears to be related to the soft bottom habitats occupied by certain eels and has not yet been shown to be a useful indicator of anguilliform phylogeny (McCosker 1977; Rosenblatt and Rubinoff 1972).

#### RELATIONSHIPS

As discussed earlier, the species of *Ophichthus* do not present many characters allowing precise and persuasive arguments as to relationships. The difficulty is compounded in a regional study such as this, particularly considering the poorly known status of the Indo-Pacific ophichthid fauna. Those factors, and the scarcity of material prevent us from producing a satisfactory phylogeny. However, we are able to make some observations as to relationships of some of the eastern Pacific species.

There is an obvious pair of spotted eastern Pacific species, viz., the mainland *O. triserialis* and the Galápagos/Cocos insular species *O. rugifer*. They differ only in vertebral number and both are very similar to the Atlantic *ophis* with their bold patterning of spots on the body and speckling on the head. Although roughly similar

color patterns occur in related *Ophichthus* (cf. the species of the subgenus *Microdonophis*, McCosker 1977, and McCosker and Randall 1982), we consider them to be independently evolved and consider this coloration to be a synapomorphy of these three New World species. The three further agree in that there is a barbel between the nostrils and the posterior nostril is a tube opening into the mouth, although these are not unique character states. *Ophichthus ophis* is most similar to *O. rugifer* in its vertebral number (161–167 vs. 158–162, respectively), but we would not venture to say that this signifies a closer phyletic relationship.

There are other amphi-American species pairs and groups. The similarity in appearance of the two pale-spotted species, *Ophichthus remiger* and the wide-ranging Atlantic *O. puncticeps* (previously known as *O. ocellatus*, cf. McCosker et al. 1989), has resulted in historic assumptions of conspecificity (see Remarks in *O. remiger* section). The two species also share similar body proportions, pectoral fin size and shape, nostrils, dentition, and cephalic pore conditions, but differ in vertebral counts. They also occupy similar deep-water habitats. There does not appear to be a comparable species in the Indo-Pacific. Related to this pair are the other deep-water New World species, *O. frontalis* in the Pacific and *hyposagmatus*, *rex*, and *spinicauda* in the Atlantic. All six species share a posterior nostril in a tube that opens outside the mouth and a rounded and relatively short pectoral fin, and *O. frontalis* is similar in coloration to that of the Atlantic triad. *Ophichthus hyposagmatus* and *O. frontalis* further agree in having a relatively short and broad snout, and a relatively large eye that enters the profile of the head. And, in contrast to *rex* and *spinicauda*, the dorsal fin origin is over rather than behind the pectorals. Although *O. frontalis* is most like *hyposagmatus* in overall similarity, we have not been able to identify any synapomorphies that would enable us to establish them as sister species.

The eastern Pacific *O. zophochir* and *O. mecopterus* are most similar to each other but share their similarities with the western Atlantic *O. cylindroideus* and *gomesii*. All have barbels on their lips, dark fins as adults, similar pectoral fin and dorsal fin conditions, and similar (although variable in detail) biserial jaw teeth. Differences include: the tentacle attached to the inner edge of

the anterior nostril tube in all species is exaggerated in *cylindroideus*; *gomesii* has two rather than three preopercular pores; and *O. mecopterus* has uniserial vomerine dentition. Although there is an overall similarity among these New World species, the differences are significant enough to prevent the discrimination of species pairs.

No known Indo-Pacific species approaches *O. longipennis* and *O. apachus* in slenderness, shortness of head, length of tail, or in their coloration. Only *O. rhytidodermatoides* exceeds them in vertebral number (190 vs. 176–186), and it differs in many other characters including dentition and physiognomy. *Ophichthus longipennis* appears mostly closely related to the western Atlantic species *O. melanoporus*, particularly in its meristics, coloration, dentition, slenderness and head and tail proportions. Based on those presumed synapomorphies, we regard this amphioceanic pair as sister species.

#### DISTRIBUTION

The ranges of the eastern Pacific species of *Ophichthus* are shown in Figures 15 and 16. Only two species, *O. triserialis* and *O. zophochir*, are long-ranging; they span the entire tropical area and extend well into the north temperate zone (41st and 37th parallels, respectively). However, the numerous northern records do not seem to represent self-sustaining populations, as ophichthid leptocephali have never been taken north of Punta San Juanico, Baja California (26°N) (Charter 1996; Butler et al. 1997). Those species and *O. frontalis* are the only ones known from as far north as the Gulf of California. Of the remaining six (excluding the two island-endemic species), three (*O. apachus*, *O. longipennis* and *O. mecopterus*) have been taken as far north as Nayarit, México. However, undetermined leptocephali of seven species of *Ophichthus* have been taken in the vicinity of the mouth of the Gulf of California (Butler et al. 1997; S. R. Charter, National Marine Fisheries Service, pers. comm.). All of the mainland species may be found within the coastal zone from Nicaragua south to Panamá. Only *O. remiger* has a predominantly southern distribution, ranging from Guatemala to temperate central Chile (33°S). There is no temperate analog to the north, although the distribution of the genus extends to 41°30'N, with numerous records north of 32°N. The two north-

ward-ranging species, *O. triserialis* and *O. zophochir*, are not known from south of 7°S. This disparity may be explained by the occasional northern transport of larvae via the Davidson Current, which has no direct analogue in the Southern Hemisphere, as well as the colder temperatures in central Chile (Wooster and Sievers 1970; Brandhorst 1971; Viviani 1979).

There are two island-endemic species of *Ophichthus*, *O. arneutes* and *O. rugifer*. The non-overlapping meristic counts of the Galápagos and Cocos islands populations of *O. rugifer* and the mainland *O. triserialis* demonstrate a limited if not complete isolation of genetic interchange. (Neither has been collected at the Revillagigedo or Clipperton islands.) There can be little doubt that they are most closely related to each other (see Relationships, above); although separated by vertebral number, the two are virtually identical in external morphology and coloration. The circumstance of species found only at the Galápagos and Cocos (and some also at Malpelo) is not limited to *Ophichthus*. Coastal fishes including *Mycteroperca olfax*, *Apogon atradorsatus*, *Stegastes arcifrons* and *Quassiremus evionthas* (McCosker and Rosenblatt 1975b, and our unpublished data) have such a distribution. Rosenblatt and Walker (1963) noted such distributions and concluded that the species must have originated at Cocos, as current patterns allowed only transport to the south (Wyrteki 1965). Gene flow between the Galápagos and Cocos populations of *O. rugifer* would seem to be limited as there is a difference in adult color pattern.

The endemic nature of the deep-water species *O. arneutes*, described here from two Galápagos specimens, may be an artifact of the unique sampling opportunity provided by the deep-submersible. Submersible-aided collections have not been made along the mainland. There is a broad range of differences between other Galápagos ophichthids and their mainland congeners, ranging from: the species of *Paraetharchus* (McCosker 1974) and *Quassiremus* (which are also at Cocos), which have mainland congeners that differ trenchantly in meristics and coloration; to the *Caltechelys* which is most closely related to a Hawaiian species (McCosker and Rosenblatt 1972; McCosker 1979); to those ophichthids that do not significantly differ in meristics or coloration from mainland speci-



FIGURE 15. Distribution of eight eastern Pacific species of *Ophichthus*. Abbreviations are: a = *O. apachus*; ar = *O. arnantes*; f = *O. frontalis*; l = *O. longipenis*; m = *O. mecopterus*; ml = *O. melope*; r = *O. rugifer*; t = *O. tetratrema*.



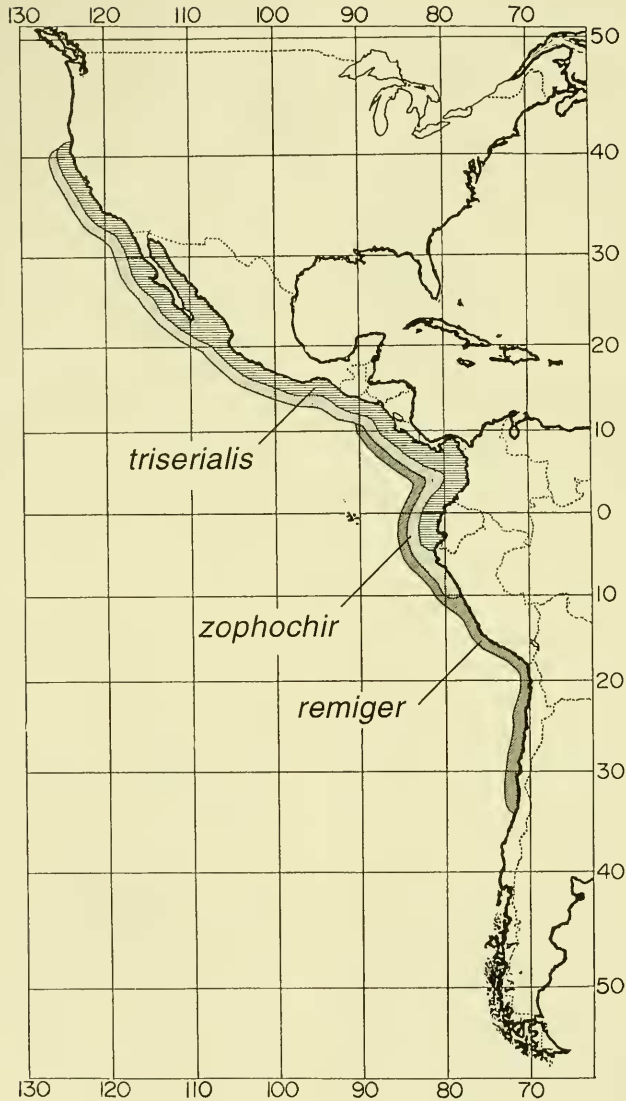


FIGURE 16. Latitudinal distribution of wide-ranging eastern Pacific species of *Ophichthus*. (The boundaries drawn delineate latitudinal distribution; the species do not replace each other in a seaward direction.)

mens, including *Apterichtus*, *Herpetoichthys*, *Ichthyapus*, *Myrichthys*, *Phaenomonas* and *Scytalichthys* (McCosker 1975; McCosker and Rosenblatt 1993).

Endemism of Galápagos ophichthid species (including *O. rugifer*) stands at 45% (5/11). This contrasts strongly with the family Muraenidae, in which none of the 19 species at Galápagos is endemic and 11 also occur in the Indo-west Pacific (Rosenblatt et al. 1972; McCosker and

Rosenblatt 1975a; McCosker and Humann 1996). This distribution parallels that of the genera of the two families. Of the 20 genera of eastern Pacific ophichthids, four are endemic and five are amphi-American, but all of the eastern Pacific genera of muraenids are also in the Indo-west Pacific.

It is curious that so few ophichthids are known from the southeastern Pacific. Within *Ophichthus*, only *O. triserialis* and *O. remiger* extend to

Peru, and only *O. remiger* enters Chilean waters. The paucity of species might reflect the restricted amount of subtropical habitat and/or the limited sampling using rotenone-based ichthyocides and extensive trawl surveys south of Ecuador.

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