

## Three New Species of Ophichthid Eels (Anguilliformes: Ophichthidae) from Japan

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**Abstract** Three new species of fishery research and fish market specimens of Japanese ophichthid eels are described and illustrated. *Scolecenchelys fuscipennis* sp. nov. is described on the basis of 21 specimens from 112–269 m depth from Tosa Bay and Niigata; it is unique in its vertebral number (157–162), dentition (jaw teeth bi- and triserial), dorsal-fin origin (1 head length before anus), and coloration (a prominent black spot on its posterior tail region). It is proposed that the melanistic tail pigment serves to strengthen the tail region of tail-burrowing eels. *Ophichthus machidai* sp. nov., subgenus *Coecilophis*, is described from 23 specimens from approximately 30–150 m depth from Tosa Bay, Uchinour Bay, and the Kii-suido channel. It is unique in its vertebral number (150–161), single (typically) labial barbel, 2 (typically) minute preopercular pores, and its small uniserial dentition. *Ophichthus obtusus* sp. nov., subgenus *Coecilophis*, is described from 21 specimens from approximately 30–150 m depth from Tosa Bay and the Kii-suido channel. It is unique in its blunt snout condition, its vertebral number (148–153), two labial barbels, 3 preopercular pores, and its small uniserial dentition. The vertebral numbers of Japanese *Ophichthus* are tabulated and a key to the species is provided.

**Key words:** Ophichthidae, new snake eels, *Ophichthus*, *Scolecenchelys*, Japan.

### Introduction

The snake eels of the tropical and subtropical eel family Ophichthidae are the most species rich of anguilliform fishes, comprising as many as 260 species worldwide (McCosker *et al.*, 1989, and unpublished data). Ophichthids occupy a variety of marine habitats, ranging from midwater to reefs to sand and mud substrates, usually at depths less than 100 m, although some species of the genus *Ophichthus* are found as deep as 1300 m. The Japanese Archipelago possess a large and diverse ophichthid fauna (Asano, 1984; Hatooka, 2002), with at least 40 valid described species and several more are likely to be discovered. To this assemblage we add three new spe-

cies collected from the Kii-suido channel, Niigata, Uchinour Bay, and from Tosa Bay, off the south coast of Kochi Prefecture in Shikoku Island, an area with an active trawl fishery, a history of ichthyological and academic researchers, and a rich ichthyofauna (Kamohara, 1964; Shinohara *et al.*, 2001; Ide *et al.*, 2003; Ide, 2004).

### Materials and methods

Measurements are straight-line, made either with a 300 mm ruler with 0.5 mm gradations (for total length, standard length, trunk length, and tail length) and recorded to the nearest 0.5 mm, or with dial calipers (all other measurements) and recorded to the nearest 0.1 mm. Body length

comprises head and trunk lengths. Head length is measured from the snout tip to the posterodorsal margin of the gill opening; trunk length is taken from the posterior 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 ethmoidal pore + pores in its supraorbital canal, i.e., 1 + 3, and the infraorbital pores are expressed as pores along the upper jaw + those in vertical part of the canal behind the eye (the “postorbital pores”), i.e., 4 + 2, in that frequently the last pore included along the upper jaw is part of the postorbital series. Vertebral counts (which include the hypural) were taken from radiographs. The mean vertebral formula (MVF) is expressed as the average of predorsal, preanal, and total vertebrae (Böhlke, 1982). Institutional abbreviations follow the Standard Symbolic Codes for Institutional Research Collections in Herpetology and Ichthyology (Leviton *et al.* 1985). The senior author has examined all of the holotypes of the ophichthid eels mentioned in this study except those of *Ophichthus habereri*, which was destroyed, and *O. ophis*. Information concerning those specimens is available in Eschmeyer (2012).

### Genus *Scolecenchelys* Ogilby, 1897

**Diagnosis.** Ophichthid eels, Subfamily Myrophinae, tribe Myrophini. Body elongate, laterally compressed posteriorly. Pectoral fin absent. Anterior nostril tubular; posterior nostril opens into mouth, covered by an exterior flap; 2 pores between nostrils. Jaw teeth conical, in 1–3 rows; intermaxillary teeth not in a broad patch.

**Remarks.** The genus *Scolecenchelys* was until recently considered to be a subgenus of *Muraenichthys* (Castle and McCosker, 1999). They separated the species of *Scolecenchelys* from those of *Muraenichthys* based on the number of labial pores (two vs. one) between the anterior and posterior nostrils, their dentition (conical vs. blunt), and the posterior nostril location (beneath upper

lip vs. outside of upper lip). There are at least 18–20 species within *Scolecenchelys* and 7–8 species within *Muraenichthys*. It is very likely that additional species will be discovered.

### *Scolecenchelys fuscapenis* sp. nov.

[New English name: Black tailed worm eel]

[New Japanese name: Tsumaguro-mimizu-anago]

(Figs. 1–3, Table 1)

*Scolecenchelys* sp.: Ide (2004: 12).

**Holotype.** NSMT-P 106570 (formerly BSKU 96046, photo), 337 mm SL, female, Tosa Bay, 33°14.70'N, 133°38.42'E–33°13.01'E, 133°36.55'E, 223–269 m, R/V *Kotaka-maru*, otter trawl, St. T5–1, coll. by K. Nashida and N. Nakayama, 26 Aug. 2008.

**Paratypes.** 20 specimens (19 specimens from Tosa Bay and 1 specimen from Sea of Japan). Tosa Bay, Japan (R/V *Kotaka-maru*, otter trawl): AMS I. 45671-001 (formerly BSKU 99523), 302 mm, 33°14.92'N, 133°38.02'E–33°13.59'E, 133°36.00'E, 213–202 m, coll. by K. Nashida and H. Sakaji, 6 July 2006; BSKU 64911, 365 mm, 33°12.6' N, 133°35.7'E–33°11.1'E, 133°33.7'E, 252–258 m, St. 6–2, coll. by K. Nashida and H. Sakaji, 16 June 2003; BSKU 76475, 236 mm, 33°14.81'N, 133°38.06'E–33°13.23'N, 133°35.67'E, 214–212 m, St. T5-1, by K. Nashida and H. Sakaji, 17 Nov. 2005; BSKU 77928, 2 (255–338 mm), 33°15.07'N, 133°38.36' E–33°16.30'N, 133°40.21'E, 207–201 m, St. T5-1, by K. Nashida and H. Sakaji, 17 Apr. 2006; BSKU 84462, 334 mm, BSKU 84463, 296 mm, ca. 250 m, 9 Mar. 1998 (the precise data are unknown); BSKU 85268, 306 mm, BSKU 85269, 325 mm, 33°13.2'N, 133°36.9'E–33°13.0'N, 133°36.2'E, 232–246 m, 8 June 1998; BSKU 98015, 260 mm, BSKU 98016, 302 + mm (tail damaged), 33°14.67'N, 133°37.83'E–33°15.72'E, 133°39.31'E, 205–207 m, St. T5-1, coll. by K. Nashida and N. Nakayama, 24 Feb. 2009; BSKU 99516, 285 mm, 33°14.82'N, 133°38.32'E–33°13.53'N, 133°35.30'E, 224–182 m, St. T5-1, coll. by K. Nashida and S. Yamamoto, 14 July 2009; BSKU 99524, 304 mm,



Fig. 1. Holotype of *Scolecnenchelys fuscipennis* sp. nov. in fresh condition, NSMT-P 106570, 337 mm SL. Photographed by N. Nakayama.

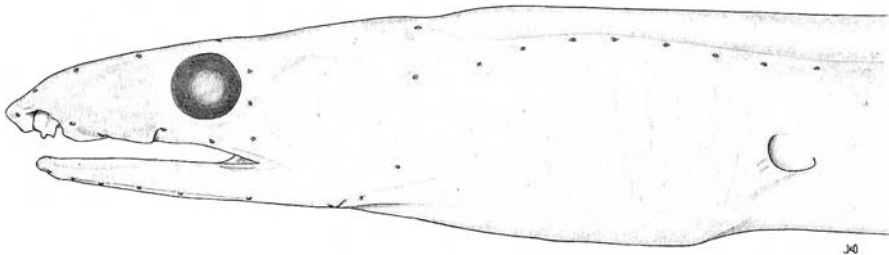


Fig. 2. Head of holotype of *Scolecnenchelys fuscipennis* sp. nov., NSMT-P 106570, 337 mm SL. Illustration by Juliana Olsson.

collected with AMS I. 45671-001; BSKU 99747, 318 mm, BSKU 99748, 283 mm, BSKU 99749, 330 mm, collected with BSKU 99516; BSKU 102889, 367 mm, 33°14.88'N, 133°38.12'E–33°13.26'N, 133°35.79'E, 212–215 m, St. T5-1, coll. by K. Nashida, 8 Mar. 2010; CAS 231945 (formerly BSKU 102890), 317 mm, collected with BSKU 102889; NSMT-P 106571 (formerly BSKU 99746), 357 mm, collected with BSKU

99747; USNM 404480 (formerly BSKU 77928, 1 of 3), 302 mm SL, collected with BSKU 77928. Sea of Japan: USNM 151440, 208 mm, Niigata, Sea of Japan (38°12'N, 138°52'E), 112 m, Albatross St. 4817, 18 July 1906.

*Diagnosis.* An elongate species of *Scolecnenchelys* with the following characteristics: tail 65–67% of TL; dorsal fin arising 1 HL before anus; 3 preopercular pores; teeth numerous, slen-

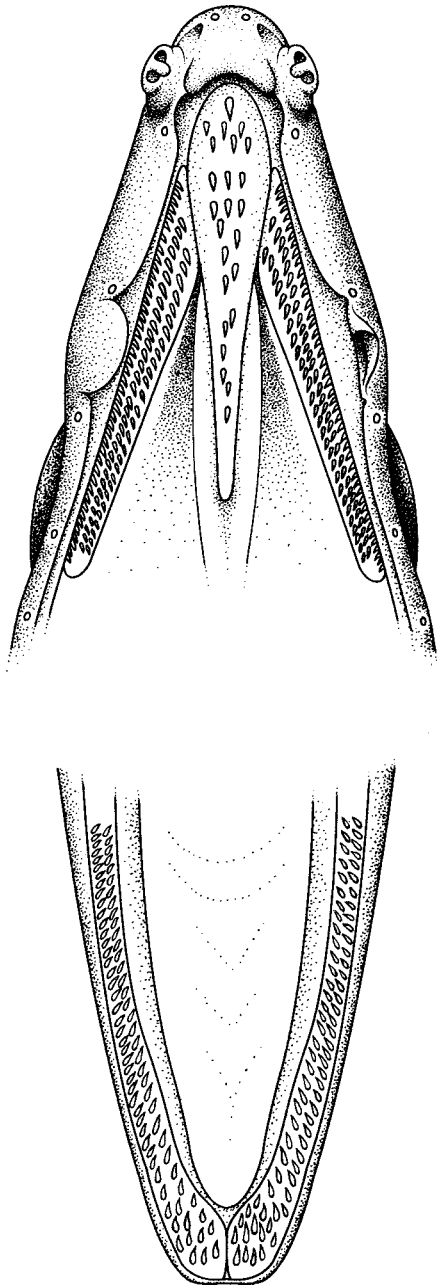


Fig. 3. Semi-diagrammatic illustration of dentition of holotype of *Scolecenchelys fuscipennis* sp. nov., NSMT-P 106570, 337 mm SL. Illustration by Claire Schneider.

der, small and conical, maxillary teeth triserial, mandibular teeth biserial, vomerine teeth uniserial posteriorly; total vertebrae 157–161; and

Table 1. Counts and proportions (in thousandths) of the holotype (NSMT-P 106570) and 9 paratypes of *Scolecenchelys fuscipennis* sp. nov. (AMS I.45671-001, BSKU 64911, BSKU 98015, BSKU 99516, BSKU 99524, BSKU 99748, BSKU 102889, CAS 231945, NSMT-P 106571 and USNM 404480). SL = Standard length. HL = head length.

	Mean	Range
SL (mm)	—	260–367
HL/SL	83	79–89
Head and trunk/SL	341	330–351
Tail/SL	659	649–670
Depth at gill opening/SL	22	19–26
Dorsal-fin origin/SL	250	231–270
Upper jaw/HL	311	290–347
Snout/HL	218	206–244
Eye/HL	105	79–116
Interorbital/HL	103	77–128
Gill opening/HL	52	41–65
Predorsal vertebrae	23.3	32–35
Preanal vertebrae	47.6	46–50
Total vertebrae	160	157–162

MVF 34/50/162 (n = 9).

*Counts and measurements (in mm) of the holotype.* Total length 341; standard length 337; head 27.4; trunk 89.6; tail 220; predorsal distance 87; body depth at gill openings 8.7; body width at gill openings 7.4; body depth at anus 7.9; body width at anus 7.3; snout 6.7; tip of snout to tip of lower jaw 1.5; tip of snout to rictus of jaw 9.5; eye diameter 2.6; interorbital distance 3.1; gill-opening length 1.5. Vertebral formula 33/48/160. Left lateral line pores minute, the majority uncountable, 8 in branchial region, 48 preanal.

*Description.* (Based on the holotype and 9 paratypes, see Table 1.) Body elongate (Fig. 1), depth at gill openings 41–65 in TL, tapering and laterally compressed posteriorly. Head and trunk short, 2.8–3.0 and head 11.2–12.6 in TL. Snout moderately acute; a short median ventral groove extends from a line across center of anterior nostrils forward to anterior edge of anterior nostrils. Lower jaw included, its tip reaching anterior edge of anterior nostrils. Anterior nostrils tubular, their length about one half eye diameter. Posterior nostril entirely inside upper lip, before anterior margin of eye, opening inward, appearing externally as a flap. Eye diameter about equal

to interorbital distance. Interorbital region flat. Rictus of jaw beneath posterior margin of eye. Median fins low. Dorsal fin arises 1 head length before level of anus origin. Paired fins absent. Median fins confluent with caudal.

Head pores minute (Fig. 2). Single temporal and interorbital pores. Supraorbital pores 1 + 3, infraorbital pores 4 + 2; two pores between anterior and posterior nostrils. Six pores along mandible, 3 overlying preopercle. Lateral-line pores difficult to discern posteriorly; 9 pores before right gill opening; approximately 130 pores along right side, approximately 60 before the anus. Last lateral-line pore occurs about a head length before tail tip.

Teeth (Fig. 3) numerous, slender, small and conical. Triserial on maxillary and biserial on mandible. A patch of 7 intermaxillary teeth, followed by 17–22 (17 in holotype) irregular teeth on vomer; 30–33 (30) irregular pairs of maxillary teeth flanked posteriorly by a third row of 40–45 (40) teeth, and approximately 35–40 (35) irregular pairs of mandibular teeth, largest at symphysis.

Body coloration of a freshly captured specimen is shown in Fig. 1. In ethanol, it is yellowish-brown, becoming darker on upper half due to small, closely spaced punctations, becoming uniform yellow-brown in posterior half of tail region. Median fins transparent except near caudal tip. Tail tip prominently blackened in posteriormost region for a length approximately equal to jaw length, extending onto median and caudal fins. Anterior nostril, upper lip, and inside of mouth pale. Dorsal surface of peritoneum freckled with fine dark punctations. Eye dark blue.

*Size.* The largest known specimen is 367 mm TL, a ripe male.

*Etymology.* From the Latin *fuscus* (dark) and *penis* (tail), in reference to its coloration.

*Distribution.* Known only from Tosa Bay and Niigata, Japan, collected from muddy and sandy bottoms between 112–269 m depth.

*Remarks.* The holotype of the new species is a gravid female with densely packed ova (~0.6 mm in diameter).

The depth of capture of the new species is extraordinary within *Scolecenchelys*. Except for *Scolecenchelys castlei* McCosker, 2006, a New Zealand and Australian species from 425–820 m depth, *Scolecenchelys puhioilo* (McCosker, 1979), a Hawaiian species known only from the holotype which was trapped in 275 m, and *Scolecenchelys profundorum* (McCosker and Parin, 1995), trawled at 310 m on the Nazca Ridge, most species of *Scolecenchelys* live in tidepools down to a few meters depth.

The new species appears to be most closely related to species of *Scolecenchelys* whose dorsal fin originates in advance of the anus, including: *S. breviceps* (Günther, 1876), *S. castlei*, *S. cookei* (Fowler, 1928), *S. godeffroyi* (Regan, 1909), *S. macroptera* (Bleeker, 1857), *S. puhioilo*, and *S. xorae* (Smith, 1962). Possessing 157–162 vertebrae, the new species has significantly more vertebrae than *S. cookei* (131–136), *S. godeffroyi* (~143), *S. macroptera* (127–135), and *S. xorae* (139–144), and fewer than *S. breviceps* (161–167) and *S. castlei* (180–186). The only known specimen of *S. puhioilo* has 160 vertebrae. The tail length of *S. fuscipennis* is longer than that of any of the above-mentioned congeners (65–67% vs. 55–63% of TL). All of those congeners have conical biserial maxillary dentition except *S. puhioilo* which has uniserial dentition.

All known species of *Scolecenchelys* are similar in having a nearly uniform tan coloration (although slightly darker dorsally) when in preservative. The two deepwater species, *S. fuscipennis* and *S. puhioilo*, differ in having black pigmentation along the posteriormost region of the tail. That of *S. puhioilo* is limited to the posterior portion of the anal fin approximately one head length before the tail tip. The black portion of the tail tip of *S. fuscipennis* is shorter in length but extends across the median and caudal fins. (The tail region and fins of their deepwater congeners *S. castlei* and *S. profundorum* are not blackened.) Several ophichthids, particularly some but not all deepwater species of *Ophichthus* (see McCosker, 2010), as well as the deepwater congrid *Congriscus megastomus*, also possess a darkened portion of



the anal fin and/or tail tip. No one has hypothesized a function for such a darkly pigmented fin. We discount the possibility that it would serve a signal function in such burrowing eels. We suspect, rather, that it might benefit those eels that dig into the substrate with their tails. It has been shown that eumelanin is a potent antioxidant and could serve to protect an organism that is in close contact with substrates that harbor toxic metals and/or peroxide ions (McGraw, 2005); the limited amount of blackened tissue on this eel's tail makes such a function less likely. It is well known that melanistic keratin in bird feathers and beaks is more effective than non-melanistic keratin in resisting abrasive wear (Bonser, 1955; Bonser and Witter, 1993). We propose that the melanistic pigment serves a similar purpose by structurally strengthening the tail of these eels which bury into the substrate tail-first. We are unaware of differences in the substrate composition of preferred habitats of different species of deepwater *Scolecenchelys* or *Ophichthus* but suspect that it may relate to the benefit of a hardened tail fin.

### Genus *Ophichthus* Ahl, 1789

*Diagnosis.* Ophichthid eels, Subfamily Ophichthinae, tribe Ophichthini. Body moderately to very elongate, cylindrical, and laterally compressed posteriorly. Head and trunk shorter than tail. Dorsal fin arises above or behind gill openings. Pectoral fin developed, ranging from paddle-shaped to elongate. Snout and jaws moderately elongate. Lips without numerous barbels or fringes. Anterior nostrils tubular; posterior nostrils open into mouth or along lower edge of lip. Eye moderately to well-developed. Teeth conical and numerous, never caniniform, from uniserial to multiserial on jaws and vomer. Coloration variable, often marked, but generally uniform and darker dorsally.

*Remarks.* The genus *Ophichthus* (*sensu lato*) is the most speciose of ophichthids, with approximately 65–70 (several undescribed) tropical and subtropical species worldwide. The generic syn-

onyms of *Ophichthus* are listed in McCosker *et al.* (1989: 379). Several subgenera are recognizable within *Ophichthus*, though a worldwide revision has yet to be accomplished. The two new species of *Ophichthus* that we describe here belong to the subgenus *Coecilophis*. The subgenus *Coecilophis* Kaup 1856 [type species *Ophisurus apicalis* Anonymous (Bennett, 1830) = *Ophisurus compar* Richardson, 1848] was recognized as a subgenus of *Ophichthus* by McCosker (1977). Nearly all deepwater Indo-Pacific species of *Ophichthus* belong to *Coecilophis* (McCosker, 2010). Only one eastern Pacific species (*O. arneutes*, from the Galápagos Islands) and only one western Atlantic species (*O. brevirostris*, from North Carolina) is within the subgenus *Coecilophis*.

It is useful to comment upon McCosker's (2010) observations of the behavior of an eastern Pacific species of the subgenus *Coecilophis* such that it allows an inference of the behavior of our new species which were collected by deepwater trawl. He wrote (pp. 2–3) "I first encountered, observed, and collected *O. arneutes* while diving aboard the manned submersible *Johnson Sea-Link* at 485 m off the Galápagos Islands (McCosker and Rosenblatt, 1998). It was observed on three occasions at 434–557 m. Individuals were observed feeding somewhat like heterocongrine garden eels, their heads and trunks extending from the sand slopes within which they were buried, picking at passing plankton in the current. They withdrew when frightened by the submersible, leaving only their snout tips exposed. Species of the subgenus *Coecilophis* are generally pale and weakly pigmented, and some have darkened snouts, chins, and anterior nostrils, whereas others have anterior nostril tubes that are much paler than the surrounding snout. Such coloration may be correlated with camouflage when they are withdrawn into the substrate, and with signaling behavior between those individuals which have contrasting coloration of their snouts and anterior nostril tubes."

Key to the Japanese Species of *Ophichthus*

- 1a. Body coloration markedly spotted or with distinct dark saddles; dorsal-fin origin (DFO) above gill openings, in advance of pectoral-fin tips; pectoral fins rounded, not elongate . . . . . 2
- 1b. Body coloration uniform, darker dorsally, without distinct spotting or distinct dark saddles; DFO above or behind pectoral fins; pectoral fins rounded or elongate. . . . . 4
- 2a. Body overlain with 18–27 prominent dark saddles, a conspicuous wide saddle above the gill opening, and numerous golden to brown (in life) marblings on snout and face; vertebrae 156–164  
*Ophichthus bonaparti* (Kaup, 1856)
- 2b. Body overlain with numerous dark or ocellated spots, those spots not appearing as saddles. . . . . 3
- 3a. Head and body overlain with numerous ocellated spots, those on body in 3 regular alternating rows, the spots separated by pale interspaces; vertebrae 141–148  
. . . . . *Ophichthus polyophthalmus* Bleeker, 1864
- 3b. Head and body overlain with numerous dark spots, those on body in 2 irregular rows, the spots about equal in size to their interspaces; vertebrae 151–155  
. . . . . *Ophichthus erabo* (Jordan and Snyder, 1901)
- 4a. DFO behind gill opening by more than 3 pectoral-fin lengths; vertebrae 160–163 . . . *Ophichthus megalops* Asano, 1987
- 4b. DFO in advance of, above, or slightly behind (less than one pectoral-fin length) gill opening . . . 5
- 5a. Body moderately elongate, its depth 45–48 times in total length; vomerine teeth and jaw teeth biserial; 2 preopercular pores (POP); vertebrae 169–173 . . . *Ophichthus stenopterus* Cope, 1871
- 5b. Body less elongate, its depth less than 40 times in total length; teeth may be uniserial or biserial; 2 or 3 POP (those pores may be minute and difficult to observe) . . . . . 6
- 6a. Dorsal surface of trunk and tail overlain with brown irregular blotches, ventral surface distinctly pale; dorsal surface of head and gill basket brownish-black; DFO above mid-pectoral fin; pectoral fins elongate, not pointed; teeth uniserial; vertebrae 151–153  
. . . . . *Ophichthus lithinus* (Jordan and Richardson, 1908)<sup>1</sup>
- 6b. Dorsal surface of head and trunk tan to brown, without irregular blotches; head lacks a dark nuchal band; DFO location variable, above or slightly behind pectoral fins; pectoral-fin shape variable; teeth uniserial or biserial . . . . . 7
- 7a. DFO slightly behind end of pectoral fins; pectoral fins spatulate; 3 POP; jaw teeth uniserial; vertebrae 134–139 . . . . . *Ophichthus urolophus* (Temminck and Schlegel, 1846)<sup>2</sup>
- 7b. DFO in advance of or slightly behind end of pectoral fins; pectoral fins rounded or elongate; 2 or 3 POP; jaw teeth uniserial or biserial . . . . . 8
- 8a. Body coloration brownish-black, paler ventrally; median fins black; rear margin of orbit above or slightly behind rictus; 2 cauliflower-shaped labial barbels; vertebrae 148–159  
. . . . . *Ophichthus obtusus* sp. nov.
- 8b. Body coloration yellow to brown dorsally, paler ventrally; median fins pale or with a dark margin; rear margin of orbit in advance of rictus; 1 or 2 smooth-surfaced labial barbels . . . . . 9
- 9a. Dorsal fin with a dark margin; pectoral fins brownish-black; teeth uniserial; vertebrae 171–182  
. . . . . *Ophichthus altipennis* (Kaup, 1856)<sup>3</sup>
- 9b. Dorsal fin margin not notably darkened; pectoral fins pale; teeth uniserial or biserial . . . . . 10

<sup>1</sup>McCosker *et al.* (2006: 272) recognized *O. evermanni* Jordan and Richardson, 1909 as a junior synonym of *O. lithinus* (Jordan and Richardson, 1908).

<sup>2</sup>*Ophichthus urolophus* (Temminck and Schlegel, 1846) includes *Ophichthus tsuchidae* Jordan and Snyder, 1901.

- 10a. Pectoral fin spatulate, shorter than jaw; 3 POP; teeth uniserial; vertebrae 126–132  
 ..... *Ophichthus asakusae* Jordan and Snyder, 1901
- 10b. Pectoral fin elongate, equal to or longer than jaw; 2 POP; vomerine teeth biserial centrally, maxillary teeth uniserial; vertebrae 150–161 ..... *Ophichthus machidai* sp. nov.

***Ophichthus machidai* sp. nov.**

[New English name: Machida's snake eel]

[New Japanese name: Machida-umihebi]

(Figs. 4–6, Tables 2, 3)

*Ophichthus* sp. 1: Ide (2004: 38).

**Holotype.** NSMT-P 106572 (formerly BSKU 68428), 580 mm TL, female, west of Tosa Bay, Saga fish market (33°04.48'N, 133°06.80'E), Kuroshio-cho, Kochi Prefecture, Japan, bottom trawl, coll. by Y. Matsuoka and K. Inoue, 4 Dec. 2003.

**Paratypes.** 22 specimens. 15 from west of Tosa Bay, off Kuroshio-cho, Kochi Prefecture, Japan. From Kamikawaguchi fish market (33°02.27'N, 133°03.55'E): AMS I. 45672-001 (formerly BSKU 65174), 500 mm, 18 Mar. 2002; BSKU 58930, 406 mm, coll. by T. Yamakawa and M. Nakae, 10 Aug. 2001; BSKU 60738, 569 mm, coll. by Y. Machida *et al.*, 30 Oct. 2002; BSKU 83553, 474 mm, 31 July 1997; CAS 231946 (formerly BSKU 58158), 549 mm, a gravid female with densely packed ova (~0.5 mm in diameter), collected with BSKU 58930. From Irino fish market (33°00.73'N, 133°00.60'E): BSKU 83171, 587 mm, 27 May 1997. From Saga fish market: BSKU 58465, 585 mm, coll. by Y. Nogawa *et al.*, 20 Nov. 2002; BSKU 62674, 474 mm, coll. by H. Endo *et al.*, 3 Oct. 2002; BSKU 65076, 449 mm, 22 June 2002; BSKU 66275, 521 mm, USNM 404481 (previously BSKU 66276), 529 mm, coll. by M. Nakae *et al.*, 31 Aug. 2003; BSKU 72119, 497 mm, coll. by Y. Machida *et al.*, 14 May 2004; NSMT-P 106573

(formerly BSKU 64237), 576 mm, coll. by Y. Machida *et al.*, 21 Apr. 2003; USNM 404481 (previously BSKU 66276), 529 mm, collected with BSKU 65076. From Tosa Bay: BSKU 87093, 570 mm, data unknown. 5 specimens from the Kii-suido channel (34°00'N, 134°50'E): FAK 19243, 655 mm, 3 Aug. 1983, 70–80 m; FAK 19630, 582 mm, 6 Aug. 1986; FAK 19631, 515 mm, 6 Aug. 1986; FAK 19633, 468 mm, 6 Aug. 1986; FAK 19638, 672 mm, 28 May 1983. 2 specimens from off Tsushiro (31°17'N, 31°05'E), Uchinour Bay, Kouyama, Kimotsuki, Kagoshima Prefecture, Japan, set net at 40 m, coll. by M. Yamada, 20 Feb. 2007, KAUM 03944 (519 mm) and KAUM 06869 (513 mm).

**Diagnosis.** A moderately elongate species of *Ophichthus* with the following characters: tail 53–61% TL and head 8.5–10% TL; dorsal-fin origin above or slightly behind pectoral fin; pectoral fins elongate, longer than jaw; posterior nostril opening within mouth; single labial barbel; head pores minute, difficult to observe, SO 1 + 4, IO 4 + 2, POM 2 + 5; teeth small and numerous, biserial centrally and uniserial anteriorly and posteriorly on vomer, uniserial on maxillary and mandible; coloration pale ventrally, brown dorsally, fins pale; mean vertebral formula 13/56/154, total vertebrae 150–161 (n = 10).

**Counts and measurements (in mm) of the holotype.** Total length 580; head 51.6; trunk ; tail 341; predorsal distance 77.1; pectoral-fin length 19.3; pectoral-fin base 5.7; body depth at gill openings 18.5; body width at gill openings 16.7; body depth at anus 18.5; body width at anus 17.6; snout 9.4; tip of snout to tip of lower jaw 2.8; tip of snout to rictus 14.2; eye diameter 5.9; interor-

<sup>3</sup> We follow McCosker and Randall (2002) in recognizing *O. melanochir* as a junior synonym of *O. altipennis*. We follow Hatoooka (2002: 1457) and recognize *Pisodonophis zophistius* Jordan and Snyder, 1901 and *Ophichthys intermedius* Regan, 1905 as synonyms of *O. altipennis*.



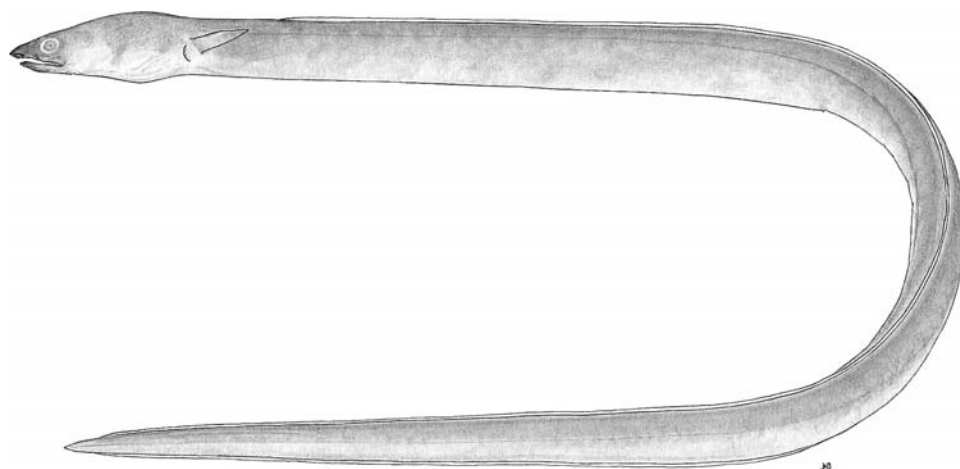


Fig. 4. Holotype of *Ophichthus machidai* sp. nov., NSMT-P 106572, 580 mm SL. Illustration by Juliana Olsson.

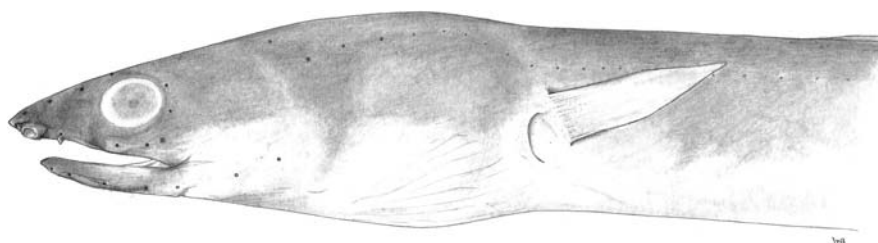


Fig. 5. Head of holotype of *Ophichthus machidai* sp. nov., NSMT-P 106572, 580 mm SL. Illustration by Juliana Olsson.

bital distance 7.7; gill-opening height 7.6; isthmus width  $\sim 11$ . Vertebral formula 16/58/158. Left lateral line pores minute, the majority uncountable, 9 in branchial region, 57 preanal.

*Description.* Body (Fig. 4) moderately elongate, laterally compressed in posterior tail region, depth at gill openings 27–40 in TL. Branchial basket slightly wider and deeper than body. Head and trunk short, 2.1–2.6 in TL; head 10–12 in TL, 2.8–3.9 in trunk. Snout conical, acute when viewed from above. Snout bisected on underside by a groove from posterior margin of anterior nostril to anterior margin of posterior nostril. Lower jaw included, upper and lower lips almost meeting when mouth is closed. Underside of snout with numerous minute fleshy bristles in ethmoidal region. Mouth moderately elongate, rictus beneath rear margin of eye. Eye 2.3–2.4 in upper jaw and 7.3–11.3 in head, its center well

behind middle of upper jaw. Tube of anterior nostril short, anterolaterally inclined, hardly capable of being deflected forward. A small barbel beneath 2nd infraorbital pore, about 1/3 the distance between anterior and posterior nostrils. A second small pore usually present beneath the center of the orbit. Posterior nostril opens into mouth, not visible along margin of lip. Dorsal-fin origin above or slightly behind pectoral fin; dorsal fin low in anterior trunk region, elevated in posterior trunk region. Anal fin elevated. Pectoral fins elongate, rounded posteroventrally, longer than jaw in length. Pectoral fin (Fig. 5) arises above gill opening and extends to mid-opening.

Head pores (Fig. 5) minute, inconspicuous. Single median interorbital and temporal pores. Supraorbital pores 1 + 4, infraorbital pores 4 + 2, mandibular pores 5, preopercular pores 2, rarely 3. Lateral-line pores present but too small to enu-

merate, 9 before gill opening.

Teeth (Fig. 6) conical, small, very close set and erect. Intermaxillary with an irregularly biserial patch of 3–5 teeth, followed by a gap, followed by a uniserial row of 6–7 (6 in holotype) teeth, then 5–6 (5) pairs of vomerine teeth which become a uniserial row of ~5–6 teeth. Maxillary teeth linear and uniserial, 29–30 (29) teeth on each side, becoming smaller posteriorly. Mandibular teeth strictly uniserial, 37–40 (37) teeth on each side, becoming smaller posteriorly.

Color in ethanol pale ventrally, brown above lateral midline; cheeks, throat and fins pale; median fin bases darkened; a fine brown speckling overlays pale region of body and tail; lower lip, anterior chin region and anterior nostrils darkened; palate overlain with fine brown speckling; peritoneum pale.

*Size.* The largest known specimen is 672 mm SL (FAK 19631), a gravid female captured in the Kii-suido channel.

*Etymology.* Named in honor of Yoshihiko Machida, who guided Sachiko Ide through her thesis at BSKU.

*Distribution.* Known only from the type series, from Kuroshio-cho, Kochi Prefecture, the Kii-suido channel separating Honshu and Shikoku islands, and from Uchinour Bay, Kagoshima Prefecture, Japan. Specimens were captured at approximately 30–150 m depth.

*Remarks.* The holotype of *O. machidai* is a female with eggs ~0.3–0.5 mm in diameter. All of the FAK specimens captured in the Kii-suido channel during late May and early August were gravid females with well developed ova.

The range of total vertebrae of ten specimens of this species is expressed in Table 3. We have excluded two paratypes (BSKU 65174 and FAK 19631) which have 13/52/146 and 12/48/145 vertebrae, significantly less than the range of the other paratypes (150–161). It is not uncommon for individuals of a large sample of an eel species to have abnormally reduced vertebral numbers resulting from developmental flaws or damaged and healed tails.

The new species is unique within *Ophichthus*

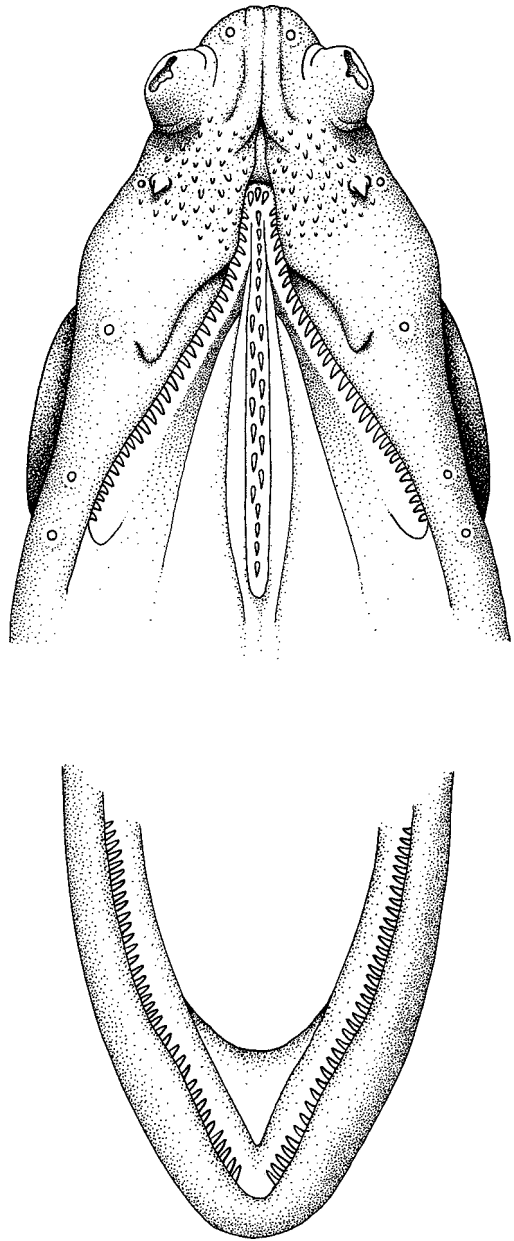


Fig. 6. Semi-diagrammatic illustration of dentition of holotype of *Ophichthus machidai* sp. nov., NSMT-P 106572, 580 mm SL. Illustration by Claire Schneider.

and would not be mistaken for any of its Japanese congeners. Minute fleshy bristles are well-developed on the ethmoidal region of the underside of the snout (Fig. 6). Such structures are present on the lips and ethmoidal region of other

Table 2. Vertebral counts of valid Japanese species of *Ophichthus*. Sources: 1) this study; 2) McCosker and Randall, 2002; 3) Sumida and Machida, 2000; 4) McCosker, 2002; 5) Asano, 1987; 6) Asano, 1984; 7) Randall, 2007; 8) Böhlke, 1982; 9) McCosker, 2010.

As described	Holotype	MVF	Range	Source
<i>altipennis</i>	9/52/178	9/56/176	171–182	1,2
<i>asakusae</i>	11/54/128	11/54/130	126–132	1,3
<i>bonaparti</i>	9/89/164	9/89/164	163–164	1,4
<i>erabo</i>	6/78/155	8/27/153	151–155	1
<i>lithinus</i>	13/72/153	12/70/152	151–153	1
<i>machidai</i>	16/58/158	13/56/154	150–161	1
<i>megalops</i>	29/60/160	30/61/162	160–163	1,5
<i>obtusus</i>	12/57/151	11/55/151	148–153	1
<i>polyophthalmus</i>	8/74/145	8/74/145	141–149	1,6,7
<i>stenopterus</i>	17/63/169*	18/59/170	169–173	1,8
	19/66/173*			
<i>urolophus</i>	16/54–136	16/54/136	134–139	1,9

\* syntypes

species of *Ophichthus*, however they are well developed in *O. machidai*. They probably serve a sensory function but have not been comprehensively analyzed within the genus. It shares several characters with some deepwater (living at or below 200 m) Indo-Pacific species of *Ophichthus* (McCosker, 2010), such as its pale coloration, numerous conical and uniserial teeth, its moderately elongate body depth, the location of its dorsal-fin origin, its pectoral-fin condition (elongate, but not attenuate), and having two preopercular pores. The preopercular pore numbers (either 2, 3, or 4) of species of *Ophichthus* is a useful indicator of phylogeny (McCosker, 1977). The presence of a small labial barbel between the anterior and posterior nostrils is probably a significant character among species of *Ophichthus*; it has not yet been comprehensively assessed.

*Ophichthus machidai* is similar to *Ophichthus microstictus* McCosker, 2010, known from 362–450 m depth off Fiji and Tonga, and possibly a specimen from 200 m off New Caledonia. It is similar to *O. machidai* in its vertebral condition (*O. microstictus* has MVF 13/56/152, total vertebrae 151–156 vs. *O. machidai* MVF 13/56/154, total vertebrae 150–161) its preopercular pores (2–3 vs. 2), and its head (10.8–11.3% vs. 8.5–10%) and tail proportions (57–59% vs. 53–61%).

Table 3. Counts and proportions (in thousandths) of the holotype (NSMT-P 106572) and 9 paratypes of *Ophichthus machidai* sp. nov. (BSKU 58158, BSKU 58465, BSKU 58930, BSKU 60738, BSKU 65076, BSKU 72119, BSKU 87093, CAS 231946, KAUM O6869 and USNM 404481). TL = total length. HL = head length.

	Mean	Range
TL (mm)	—	406–579
HL/TL	89	85–100
Head and trunk/TL	414	388–468
Tail/TL	586	532–612
Depth at gill opening/TL	30	25–37
Dorsal-fin origin/TL	124	110–131
Pectoral-fin length/HL	363	320–404
Upper jaw/HL	290	205–332
Snout/HL	223	186–258
Eye/HL	114	93–136
Interorbital/HL	136	116–150
Gill opening/HL	115	81–138
Isthmus/HL	239	212–287
Predorsal vertebrae	13.1	11–16
Preanal vertebrae	56.1	52–59
Total vertebrae	154.3	150–161

It differs from *O. machidai* in lacking a small labial barbel between the anterior and posterior nostrils, in its pectoral-fin length (less than the jaw length vs. greater than the jaw length) and in its dentition (less numerous, slightly larger, and irregularly biserial on the maxillary). The new species is also similar to the eastern Pacific species *Ophichthus apachus* McCosker and Rosenblatt, 1989 and *Ophichthus longipenis* McCosker and Rosenblatt, 1989, both of which have the single barbel, two preopercular pores, and dorsal-fin origins and pectoral-fin shapes similar to that of *O. machidai*. They differ in having more vertebrae (176–186) and biserial upper jaw dentition, and are much more elongate (body depth 1.4–2.5% of TL). Other New World species with similar dorsal-fin origins, pectoral-fin conditions, and the presence of a minute labial barbel between the nostrils are: *Ophichthus cylindroides* (Ranzani, 1839), *Ophichthus mecopterus* McCosker and Rosenblatt, 1989 (which has two additional labial barbels), *Ophichthus ophis* (Linnaeus, 1758), *Ophichthus rugifer* Jordan and Bollman, 1890, and *Ophichthus triserialis*

(Kaup, 1856). All however typically have three, rather than two, preopercular pores and possess quite different body colorations.

***Ophichthus obtusus* sp. nov.**

[New English name: Pug-nosed snake eel]

[New Japanese name: Shishi-gashira-umihebi]

(Figs. 7–9; Tables 2, 4)

*Ophichthus* sp. 2.: Ide (2004: 40).

**Holotype.** NSMT-P 106574 (previously BSKU 71725), 684 mm TL, a gravid female, west of Tosa Bay, Irino fish market, Kuroshio-cho, Kochi Prefecture, Japan, 4 Mar. 2004.

**Paratypes.** 20 specimens. 18 from west of

Tosa Bay, off Kuroshio-cho, Saga fish market: AMS I.45673-001 (formerly BSKU 83168), 630 mm, female, 1 May 1997; BSKU 56056, 560 mm, 10 Aug. 2000; BSKU 56850, 614 mm, coll. by T. Yamakawa and M. Nakae, 26 Aug. 2001; BSKU 60521, 697 mm, female, coll. by K. Nishida, 16 Oct. 2002; BSKU 60737, 575 mm, coll. by Y. Machida *et al.*, 30 Oct. 2002; BSKU 64546, 731 mm, female, BSKU 64547, 513 mm, coll. by Y. Machida *et al.*, 29 Nov. 2002; BSKU 65078, 566 mm, female, coll. by Y. Takata *et al.*, 22 June 2003; BSKU 68429, 573 mm, female, BSKU 68430, 633 mm, coll. by Y. Matsuoka and K. Inoue, 4 Dec. 2003; BSKU 72117, 531 mm, female, coll. by Y. Machida *et al.*, 14 May 2004; BSKU 77288, 630 mm, coll. by Y. Machida *et*

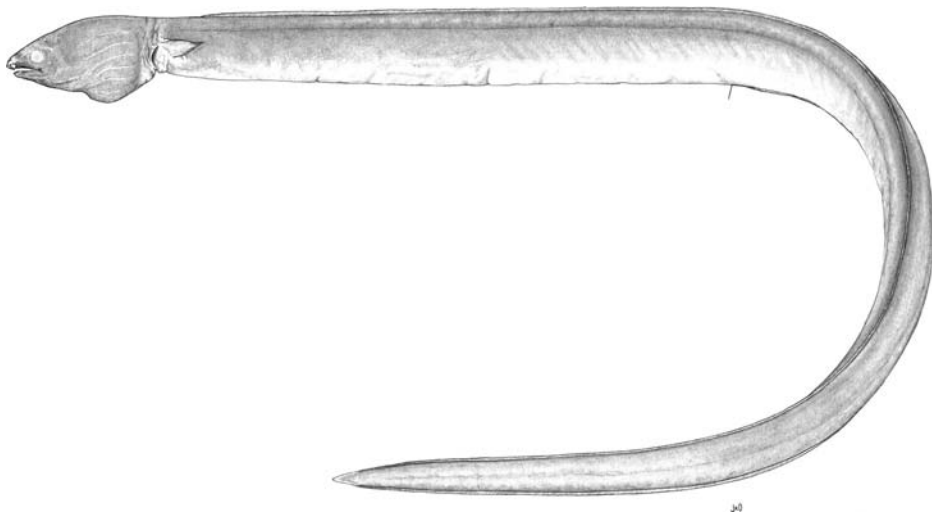


Fig. 7. Holotype of *Ophichthus obtusus* sp. nov., NSMT-P 106574, 684 mm SL. Illustration by Juliana Olsson.

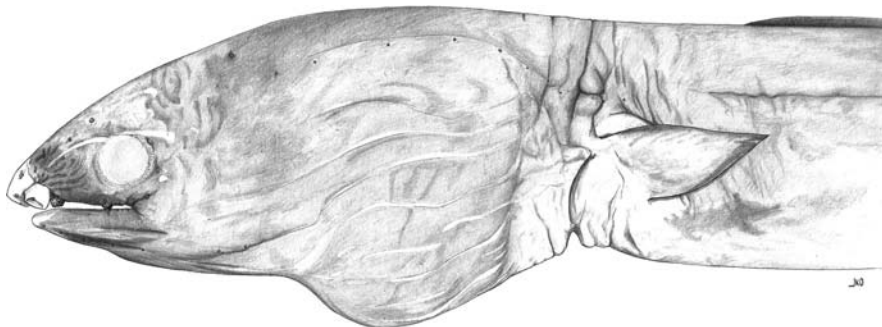


Fig. 8. Head of holotype of *Ophichthus obtusus* sp. nov., NSMT-P 106574, 684 mm TL. Illustration by Juliana Olsson.

*al.*, 11 Dec. 2004; BSKU 90890, 632 mm, coll. by Y. Machida *et al.*, 15 Apr. 2007; BSKU 101341, 540 mm, male, BSKU 101342, 543 mm, female, coll. by Y. Machida *et al.*, 15 Nov. 2009; CAS 231947 (formerly BSKU 68432), 664 mm, NSMT-P 106575 (previously BSKU 68431), 690 mm, female, coll. by Y. Matsuoka and K. Inoue, 4 Dec. 2003. USNM 404482 (previously BSKU 64544), 570 mm, collected with BSKU 64545. 2 specimens from the Kii-suido channel (34°00'N, 134°50'E): FAK 15097, 553 mm, female, 5 Nov. 1978; FAK 19242, 695 mm, female, 3 Aug. 1983, 70–80 mm.

*Diagnosis.* A moderately elongate species of *Ophichthus* with the following characters: tail 1.7–1.8 and head 10.9–11.9 in TL; body depth at gill openings 29–37 times in TL; dorsal-fin origin above pectoral-fin tips; pectoral fins short, slightly longer than jaw; posterior nostril within mouth; upper jaw short, rear margin of orbit above or slightly behind rictus; snout short, blunt; 2 labial cauliflower-shaped barbels; head pores minute, SO 1 + 4, IO 4 + 2, POM 3 + 5; teeth small and numerous, uniserial on vomer and jaws; coloration yellow ventrally, brownish-black dorsally, median fins black; mean vertebral formula 11/55/151, total vertebrae 148–153 ( $n = 10$ ).

*Counts and measurements (in mm) of the holotype.* Total length 684; head 61.5; trunk 232.5; tail 390; predorsal distance 79.1; pectoral-fin length 17.3; pectoral-fin base 6.6; body depth at gill openings  $\sim 26$ ; body width at gill openings  $\sim 21$ ; body depth at anus  $\sim 30$ ; body width at anus  $\sim 24$ ; snout 10.6; tip of snout to tip of lower jaw 4.0; tip of snout to rictus 14.2; eye diameter 5.8; interorbital distance 12.6; gill-opening height  $\sim 7$ ; isthmus width  $\sim 8.5$ . Vertebral formula 12/57/151. Left lateral line pores minute, the majority uncountable, 8 in branchial region, 56 preanal.

*Description.* Body (Fig. 7) moderately elongate, tail laterally compressed, depth at gill openings 29–37 in TL. Branchial basket wider and deeper than body. Head and trunk short, 2.2–2.4 in TL; head 10.9–11.9 in TL, 3.7–4.2 in trunk.

Snout short and conical, acute when viewed from above. Snout bisected on underside from mid-anterior nostril to slightly in advance of anterior nostril base by a groove. Lower jaw included, upper and lower lips meet when mouth is closed. Underside of snout with numerous minute fleshy bristles in ethmoidal region. Mouth short, rictus ahead of rear margin of eye. Eye 2.1–3.2 in upper jaw and 10–16 in head, its center far behind middle of upper jaw. Tube of anterior nostril extends slightly below margin of lower lip. Small cauliflower-shaped barbels immediately behind base of anterior nostril and beneath 2nd infraorbital pore, followed by a second small cauliflower-shaped barbel beneath eye and 3rd infraorbital pore (Fig. 8). Posterior nostril opens into mouth, not visible along margin of lip, and covered by a flap. Dorsal-fin origin slightly in advance of pectoral-fin tips. Dorsal fin low, in a groove. Anal fin slightly more elevated, in a groove similar to that of dorsal. Pectoral fins short, not elongate, central rays longest, slightly longer than jaw. Pectoral-fin base arises just above and extends below middle of gill opening.

Head pores (Fig. 8) small, inconspicuous except for supraorbital series. Single median interorbital and temporal pores. Supraorbital pores 1 + 4, infraorbital pores 4 + 2, mandibular pores 5, preopercular pores 3.

Teeth (Fig. 9) conical, not enlarged. Intermaxillary with 5 teeth in an irregularly biserial row, followed by a gap, then a patch of 5 teeth, followed by a row of 35–40 uniserial teeth on vomer, becoming smaller posteriorly. Maxillary teeth uniserial, 18–21 teeth in a row. Mandibular teeth small, about 5 pairs at symphysis followed by 22–25 teeth in a uniserial row.

Color in ethanol pale yellow ventrally, brownish-black on mid-flank and dorsal surface. Snout tip, tip of mandible, anterior nostrils, and tail pale. A dark halo encircles anal opening. Pectoral fins brown. Median fins black. Inside of mouth dusky with fine brown punctations. Peritoneum pale.

*Size.* The largest known specimen is 697 mm SL, a female (BSKU 60521).



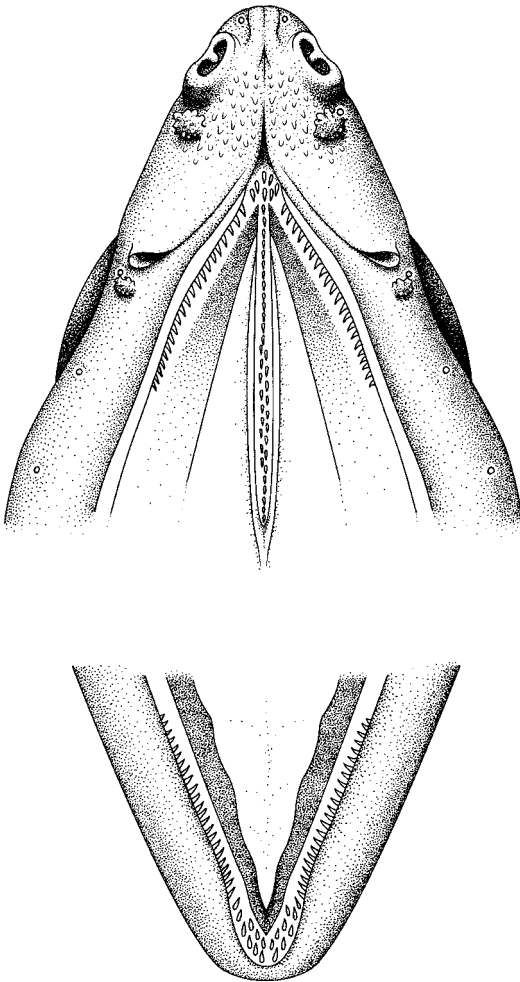


Fig. 9. Semi-diagrammatic illustration of dentition of holotype of *Ophichthus obtusus* sp. nov., NSMT-P 106574, 684 mm TL. Illustration by Claire Schneider.

*Etymology.* From the Latin *obtusus* (blunt) in reference to its snout condition.

*Distribution.* Known only from the type series, from Kuroshio-cho, Kochi Prefecture, and the Kii-suido channel separating Honshu and Shikoku islands, Japan. Specimens were captured at approximately 30–150 m depth.

*Remarks.* The holotype is a gravid female with eggs ~0.4–0.7 mm in diameter. The FAK specimens captured in the Kii-suido channel, like those of *O. machidai*, were gravid females. The large paratype (FAK 19242), collected in August,

has very well-developed ova.

The new species could not be mistaken for other Japanese congeners using the characters in our diagnostic key. The condition of its small labial barbels, cauliflower-shaped rather than smooth, appears to differ from that of other barbel-bearing ophichthids.

This new species is similar in appearance and proportions to *Ophichthus habereri* (Franz, 1910), described from a 90 cm specimen from Yokohama. The specimen was destroyed during WWII and has received little notice since its description (Eschmeyer, 2012). Franz's illustration and description indicate a robust eel with an anterior dorsal-fin origin and uniserial teeth. Its eye position is slightly more anterior and the length of its jaw is considerably longer than that of *O. obtusus*, and we thereby consider it to be a different species.

*Ophichthus obtusus* is similar to the shallow water (shoreline to 22 m depth), widely distributed Indo-Pacific (Kenya to Madagascar, Thailand, Philippines and Korea) species *O. apicalis* (Bennett, 1830). They have the same labial barbel number (both have a second barbel beneath the orbit), similar head proportions and dentition, have a dark dorsal fin, and similar vertebral numbers (*O. obtusus* has a MVF 12/55/151, total vertebrae 148–153 vs. *O. apicalis* with a MVF 12/52/144, total vertebrae 143–145). *Ophichthus obtusus* differs in its preopercular pore condition (*O. obtusus* has three pores and *O. apicalis* has two) and in having a blunter snout. *Ophichthus obtusus* is also similar to *O. altipennis* (Kaup, 1856), a widely distributed Indo-Pacific species known from western India, Malaysia, Indonesia, Australia and Philippines to Japan, from 1–40 m depth (McCosker and Randall, 2002). It is similar in its dentition and head, tail, and body depth proportions, and both have a dark dorsal fin. However *O. obtusus* has fewer vertebrae (*O. altipennis* has a MVF 9/56/178, total vertebrae 172–182), a blunter snout, and a low rather than an elevated dorsal fin.

*Ophichthus obtusus* is also similar to the widely distributed eastern-Pacific species *O. zophochir*

Table 4. Counts and proportions (in thousandths) of the holotype (NSMT-P 106574) and 9 paratypes of *Ophichthus obtusus* sp. nov. (AMS I. 45673-001, BSKU 60521, BSKU 64546, BSKU 65078, BSKU 68429, BSKU 68432, BSKU 101341, CAS 231947, and NSMT-P 106575). TL = total length. HL = head length.

	Mean	Range
TL (mm)	—	540–697
HL/TL	88	84–92
Head and trunk/TL	429	417–449
Tail/TL	571	551–583
Depth at gill opening/TL	31	27–35
Dorsal-fin origin/TL	112	106–120
Pectoral-fin length/HL	310	272–330
Upper jaw/HL	230	187–270
Snout/HL	180	138–211
Eye/HL	88	62–104
Interorbital/HL	162	133–186
Gill opening/HL	109	85–130
Isthmus/HL	250	214–287
Predorsal vertebrae	11.4	11–19
Preeanal vertebrae	55.3	52–57
Total vertebrae	150.8	148–153

Jordan and Gilbert 1882, found between 1–110 m between northern California and Peru (McCosker and Rosenblatt, 1998). They have a similar labial barbel condition (both have a second barbel beneath the orbit), similar head proportions and dentition, have a dark dorsal fin, and similar vertebral numbers (*O. obtusus* has a MVF 12/55/151, total vertebrae 148–153 vs. *O. zophochir* with a MVF 14/46/153, total vertebrae 149–162). They differ in coloration (*O. zophochir* is gray dorsally, paler ventrally, and typically has black median and pectoral fins), somewhat in pectoral-fin length (*O. zophochir* has a longer pectoral fin), and considerably in dentition (the jaw teeth of *O. zophochir* are biserial).

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*thus bonaparti*; the late Eugenia Böhlke (ANSP) for loaning us the syntypes of *Ophichthus stenopterus*; Juliana Olsson and Claire Schneider for the preparation of the illustrations; Hitoshi Honda, Hideo Sakaji, and Kazuya Nashida (Fisheries Research Agency, Japan), the crew of R/V *Kotaka-maru* (National Research Institute of Fisheries Science, Japan), Yoshihiko Machida (Professor Emeritus of Kochi University), Eri Katayama, Naohide Nakayama, Shunsuke Yamamoto, and other BSKU members for collecting specimens and various assistances; and Toshiyuki Ookawa (Kochi Prefecture Fisheries Station) for assistance in taking radiographs. For assistance with the transfer of specimens we thank: Mark McGrouther and Amanda Hay (AMS); Mysi Hoang and David Catania (CAS); Hiroyuki Motomura (Kagoshima University); and Jeff Williams and Shirleen Smith (USNM). We thank Kiyotaka Hatooka for his advice on Japanese eels; and Keiichi Matsuura for assistance with this manuscript. Much of McCosker's participation in this project was accomplished during and following the 2010 Deep Sea Fish Workshop held at the National Museum of Nature and Science, Tokyo; he thanks Keiichi Matsuura and Gento Shinohara for their kind invitation. The second author thanks Yoshihiko Machida for his generous advice during her thesis on snake eels from Tosa Bay at BSKU. The study was supported in part by the grant-in-aid of the Marine Science Project of the Natural Science Cluster, Sciences Unit, Kochi University.

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