Vietnam Journal of Marine Science and Technology 2024, 24(1) 55–68

Vietnam Academy of Science and Technology

Vietnam Journal of Marine Science and Technology

journal homepage: vjs.ac.vn/index.php/jmst

Records of species of the snake eels genus *Ophichthus* (family Ophichthidae) from Vietnam

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Received: 12 June 2023; Accepted: 6 August 2023

ABSTRACT

In Vietnam, the snake eel genus *Ophichthus* was previously comprised 14 distinct species. This research aims to document and visually represent three previously undocumented findings and a newly discovered species. The species *Ophichthus bicolor* and *Ophichthus machidai* are meticulously described here, their characteristics based on five specimens each, gathered at depths of approximately 100–180 m and 50–100 m, respectively, in the vicinity of Quy Nhon. Additionally, *Ophichthus obtusus* is comprehensively described using 12 specimens collected from depths ranging from roughly 50 m to 120 m in the Quy Nhon, Nha Trang, and Vung Tau areas. The identification of most species relied on careful examination of their morphological characters. These findings collectively raised the *Ophichthus* genus's representation in Vietnamese waters by introducing three previously undocumented species, raising the total count to 17 compared to prior research. Furthermore, this study provides a comprehensive key to aid in identifying the various *Ophichthus* species found in Vietnam.

Keywords: Ichthyology, systematic, taxonomy, biodiversity, Ophichthidae.

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https://doi.org/10.15625/1859-3097/18415
ISSN 1859-3097; e-ISSN 2815-5904

INTRODUCTION

The family Ophichthidae is the most abundant species in anguilliform families, possessing more than 300 species distributed among 61 genera [1, 2]. Many species have been described during the last two decades [3–11]. The family is a diverse and highly successful group of eels that occurs in various habitats from the marine and continental shelf, some species in or occasionally entering freshwater, coastal areas of tropical to warm temperate oceans, and rarely in mid-water. They are found from the shore to depths of 700–800 m or more, but most occur in less than 200 m [12].

Studies on the eels of Vietnam started from the surveys of fish fauna at the end of the 19th century [13, 14]. From the published list, only 4 species belonging to the genus *Ophichthus* [15–20] reviewed the literature records of eel species in Vietnam between 1974–2012 and listed 11 species belonging to the genus *Ophichthus*. Hibino (2018) [21] recorded 13 species belonging to Ophichthidae from Ha Long Bay, including five unidentified species in the genus *Ophichthus*, which may need further descriptions. The described *Ophichthus* eels are poorly in Vietnam, with the species described as new species for science and new records in the decades. Vo et al. (2019) [22] described one new species and added the data of 5 species from Vietnam. Vo & Ho (2021) [23] also described one new species collected at Luong Son Port of Nha Trang City. Fourteen species of *Ophichthus* have been found in Vietnam [18, 20–24].

Significant amounts of eels were collected during investigations of the fish fauna along the coastal line and fishing ports in Quy Nhon and Nha Trang cities. This study reports three new record species from Quy Nhon, Nha Trang, and Vung Tau collected during 2018–2020 in Vietnam. Detailed descriptions of all species are provided.

MATERIALS AND METHODS

All the specimens examined in this study were collected from Ham Tu fishing harbor, caught off Quy Nhon City, Binh Dinh Province, and Luong Son fishing harbor, caught off Nha Trang City, Khanh Hoa Province (see for each species in the results). All specimens are deposited in the Institute of Oceanography, Vietnam (OIM).

Measurements are straight-line, made either with a 100 mm ruler (for total length, standard length, trunk length, and tail length) or with dial calipers (all other measurements) and recorded to the nearest 0.1 mm and terminology generally followed McCosker (1977), McCosker et al., (1989) and McCosker & Ho (2015) [7, 25, 26]. Vertebral counts were taken from radiographs. The mean vertebral formula (MVF) is the average of predorsal, preanal, and total vertebrae [27]. The comparison and identification was based on documents of Temminck & Schlegel (1846), Jordan & Snyder (1901), Jordan & Richardson (1908), Asano (1984), McCosker & Rosenblatt (1998), Sumida & Machida (2000), McCosker & Randall (2002), Hatooka (2002), Hibino (2019) [28–38].

RESULTS

Genus *Ophichthus* Ahl, 1789

Type species. *Ophichthus ophis* (Linnaeus, 1758), original name: *Muraena ophis* Linnaeus, 1758.

Diagnosis. Body moderately to very elongate, cylindrical, and laterally compressed posteriorly. Snout moderate or short, jaws stout and short, capable of closing completely; Anterior nostrils without conspicuous, leaf-like appendages; Upper lip not fringed with cirri, having 1 or 2 barbels may be present; Eyes and pectoral fins variable; Pectoral fins present, moderately to well developed, greater than gill opening, the base of pectoral fins restricted, not spanning the entire rear border of gill opening; Dorsal fin begins over or behind gill opening; Dorsal and anal fins stop well short of a pointed tail tip, the tail tip often hard; Teeth conical, not molariform or granular on jaws and vomerine, uniserial to multiserial on jaws and

vomer; Coloration variable, often marked, but generally uniform and darker dorsally.

Key to selected species of *Ophichthus* in the Western Indo-Pacific Ocean.

Key to selected Viet Nam waters species of *Ophichthus*

(*Note:* The species of *Ophichthus* include those for which we have examined specimens and referred to the keys of McCosker & Ho (2015); Vo et al., (2019); Hibino et al., (2019); Vo & Ho (2021))

1a. Dorsal surface of the gill basket with a large brownish-black saddle.....2
1b. Dorsal surface of the gill basket without a large saddle.....3
2a. A dark brown or black saddle on posterior half of the head; body brown, without spots or saddles; total vertebrae 155–157.....*Ophichthus cephalozona* Bleeker, 1864
2b. Dorsal surface of trunk and tail overlain with brown irregular blotches, ventral surface distinctly pale; total vertebrae 149–153.....*Ophichthus lithinus* (Jordan & Richardson, 1908)
3a. Body coloration was markedly spotted. Head and body with numerous brown to dark brown (in life), those on the body usually in two or three irregular rows; prominent spots present on the anterior-nostril tube; dorsal fin origin justly above gill opening; total vertebrae 151–155.....*Ophichthus erabo* (Jordan & Snyder, 1901)
3b. Body coloration uniform or with irregular brown blotches, darker dorsally, without distinct spotting or distinct dark saddles; dorsal-fin origin above or behind pectoral fins; pectoral fins rounded or elongate.....4
4a. Body elongate to extremely elongate, its depth behind gill openings > 40 in TL.....5
4b. Body stout to moderately elongate, its depth behind gill openings < 40 in TL.....7
5b. Dorsal-fin origin above or slightly behind pectoral-fin tip; tail length 1.4–1.6 in TL; teeth uniserial; total vertebrae > 220.....*Ophichthus macrochir* (Bleeker, 1852)
5b. Dorsal-fin origin distinctly behind pectoral-fin tip; tail length 1.6–1.8 in TL; teeth biserial or triserial; vertebrae < 220.....6
6a. Head length 6.5 in trunk length; teeth biserial on jaws, and irregularly triserial on vomer vertebrae 214.....*O. microcephalus* Day 1878
6b. Head length 4.2–5.0 in trunk length; teeth uniserial on vomer, uniserial on maxillary or uniserial on anterior and biserial on the posterior maxillary, biserial on anteriorly and uniserial on the posterior mandible; total vertebrae 195–199.....*Ophichthus rutidoderma* (Bleeker, 1852)
7a. Dorsal-fin origin at least 2 pectoral-fin lengths behind gill opening; teeth biserial anteriorly on vomer.....8
7b. Dorsal-fin origin less than 2 pectoral-fin lengths behind gill opening; total vertebrae more than 180.....9
8a. Dorsal-fin origin at 2.0–2.5 pectoral-fin lengths behind gill opening; teeth biserial anteriorly on vomer and maxillary, uniserial on the mandible; all fins pale; mean vertebral formula 18–64–158.....*Ophichthus bicolor* McCosker & Ho, 2015
8b. Dorsal-fin origin situated at 4.4–6.7 pectoral-fin length behind gill opening; teeth biserial anteriorly and uniserial posteriorly on both jaws and vomer; dorsal fin light grayish with an indistinct white margin; anal fin white with a slightly blackish base; mean vertebral formula 27-68-159.....*Ophichthus longicorpus* Vo & Ho, 2021
9a. Posterior nostril hole opening outside mouth, covered by skin; mandibular pore 6–10; color of median fins without prominent dark to black margin; total vertebrae 121–140.....10
9b. Posterior nostril hole opening along upper lip, covered by skin; mandibular pore 5–7; color of median fins various, usually with prominent dark to black margin, or totally black; total vertebrae 136–168.....12
10a. Dorsal-fin origin slightly behind or not behind pectoral-fin tip; three preopercular pores; total vertebrae 138–140.....*Ophichthus urolophus* (Temminck and Schlegel, 1846)

10b. Dorsal-fin origin above pectoral fins; two or three preopercular pores, total vertebrae 121–132.....11
11a. Teeth uniserial vomerine; maxillary teeth an irregularly uniserial; mandibular teeth mostly uniserial, body depth at vertical mid-anus 3,9–4,8% TL; dorsal fin with white margin; total vertebrae 123–132.....*Ophichthus. asakusae* Jordan & Snyder, 1901
11b. Teeth uniserial vomerine; maxillary teeth an irregularly biserial; mandibular teeth mostly uniserial, with an inner row of 6 teeth anteriorly, body depth at vertical mid-anus 3.0–4.2% TL; dorsal fin with grayish margin; total vertebrae 121–125.....*Ophichthus vietnamensis* Vo, Hibino & Ho, 2019
12a. Teeth biserial on vomer and on jaws; median anal fin gray with black margin, total vertebrae 155–158.....*Ophichthus celebicus* Bleeker, 1856
12b. Teeth biserial on vomer, uniserial or biserial anteriorly and uniserial posteriorly on jaws; anal fins pinkish white, light brown with dark-brown margin posteriorly or pale; total vertebrae 138–164.....13
13a. All fins pinkish white without dark margin; snout more than 29% of head length; total vertebrae 158–161.....*Ophichthus singapurensis* Bleeker, 1856
13b. Dorsal fin dark brown, yellowish with dark brown or pale margin; snout more than 29% of head length; total vertebrae 138–164.....14
14a. Tail length slightly shorter than head and trunk, its length 2.0 in TL; vomerine teeth uniserial; median fins pale; total vertebrae 155–168.....*Ophichthus shaoi* McCosker & Ho, 2015
14b. Tail length longer than head and trunk, its length 1.6–1.9 in TL; vomerine teeth generally biserial.....15
15a. Snout 19–26% HL; total vertebrae 150–164.....*Ophichthus machidai* McCosker, Ide & Endo, 2012
15b. Snout less than 21 % HL; total vertebrae 143–155.....16
16a. Head 8.2–9.5 % TL; total vertebrae 151–155.....*Ophichthus obtusus* McCosker, Ide & Endo, 2012
16b. Head 10.5–11% TL; total vertebrae 143–145.....*Ophichthus apicalis* (Anonymous [Bennett] 1830)

Ophichthus bicolor McCosker & Ho, 2015 (New record)

Figs. 1–2; Table 1

Ophichthus bicolor McCosker & Ho, 2015: 76-80, figs.4–6; table 2 (type locality: SW Taiwan, Dong-gang, Pingtung).

Material examined. 5 specimens: OIM_E.55791 (3 spec.), 714–730 mm TL, Ham Tu fishing harbor, caught off Quy Nhon City, Binh Dinh Province, using a bottom trawl at 150–180 m in depth, 22 August 2018. OIM_E.55792 (2 species), 602–644 mm TL, Ham Tu fishing harbor, caught off Quy Nhon City, Binh Dinh Province, using a bottom trawl at 120–170 m in depth, 23 August 2018.

Description. The body is moderately elongated (Fig. 1) subcircular to the posterior portion of the tail and more compressed in posterior anus. Anus is a slight center of the body. The snout is rounded and moderately acute when viewed from above, and a groove does not bisect the underside of the snout. The lower jaw is included, its tip reaching to the middle of the anterior nostril tube. The upper jaw is moderately elongated, rictus well behind a vertical from posterior margin of the eye. Eye moderate, its center slightly behind the center of the upper jaw. Upper lip without fleshy protrusion.

Head pores are tiny but apparent (Fig. 2A). Single median interorbital and temporal pores. Supraorbital pores 1+4 (with two specimens 1+3), infraorbital pores 4+2, lower jaw pores 5–6 (mainly 6, only one specimen 5 pores on right side), preopercular pores 2, supratemporal pores 3. Faint rows of minute sensory pits are present along the nape, along the anterior margin of the orbit, and in a horseshoe-shaped pattern around the base of the anterior nostril.

Lateral-line pores apparent; 7–8 before gill opening in an arching sequence, 17–18 before the dorsal-fin origin; 64–66 before the anus, 153–157 in total, the last ca. 2 eye diameters before tail tip. The mean vertebral formula (MVF): 17—65-158 (*n* = 3).

Figure 1. Ophichthus bicolor, OIM_E.55791, 730 mm TL, in fresh

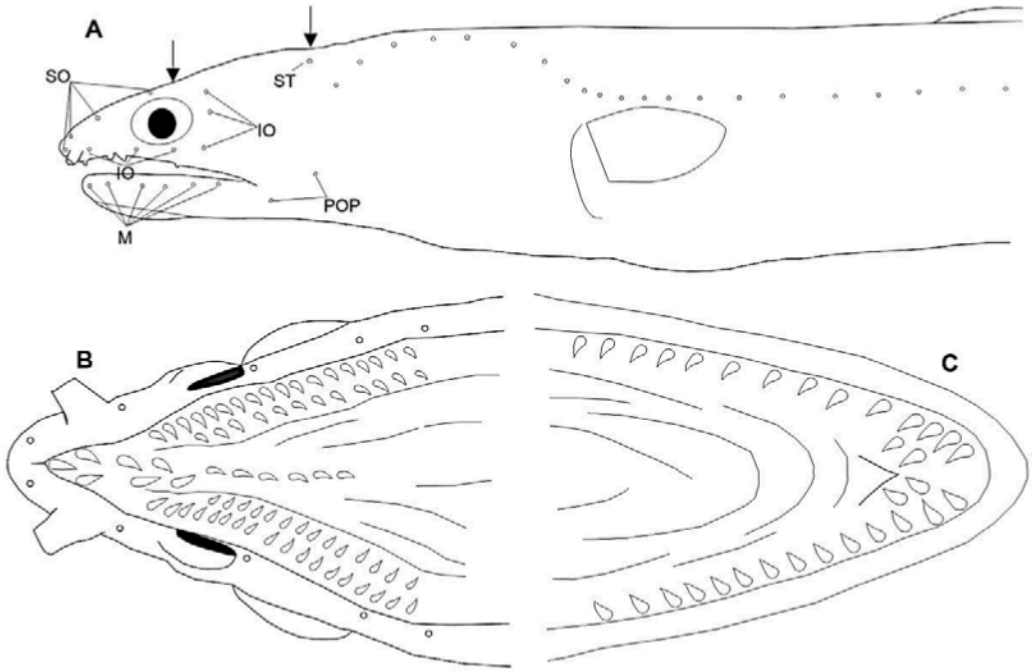

Figure 2. Lateral view of head (A), teeth on maxilla and palatal area (B) and mandible (C) of *Ophichthus bicolor*; OIM_E.55791. IO- Infraorbital pores; M- Mandibular pores; POP- Preopercular pores, SO- Supraorbital pores; ST- Supratemporal pore. Arrows indicate interorbital (left) and mid-supratemporal (right) pores

Teeth fang-like, none enlarged, conical, slightly retrorse, and rather widely spaced (Fig. 2B, C). An intermaxillary rosette of 4–5 teeth followed by an intermaxillary patch of 3 pairs followed by 6–8 uniserial vomerine teeth, which decrease slightly in size posteriorly. Maxillary teeth biserial, 7–10 in the inner tooth row and 12–14 in the outer row. Mandibular teeth uniserial posteriorly; an anterior patch of 2-3 pairs of teeth at the symphysis; the outer row of 14–17 widely spaced teeth on each side, decreasing in size posteriorly.

Coloration. Coloration when fresh (Fig. 1) is yellowish-brown dorsally, strongly contrasting with the white throat and belly, extending to the anus. Dorsal and anal fins are yellowish with narrow brown margins. The pectoral fin is brownish, with a brown patch at its base. Nostrils are white, contrasting with brown snout and upper lips. Lower jaw with brown bands overlying mandibular pore series. Tail tip white. Color in ethanol white ventrally, brown above lateral midline; median fin bases dark brown; brownish snout and upper lips; lower jaw with brownish bands overlying mandibular pore series.

Distribution. This species is described in Taiwan, with specimens collected from off Dong-gang, Southwest Taiwan, and off Taitung, Southeast Taiwan. It was first recorded in Vietnam. Now, its distribution has expanded from Taiwan to Central Vietnam.

Table 1. Measurements and counts of *Ophichthus bicolor*, *O. machidai* and *O. obtusus*

	Ophichthus bicolor (*n* = 5)	*O. machidai* (*n* = 5)	*O. obtusus* (*n* = 12)
Total length (TL)	602–730	425–519	412–722
Measurements			
As %TL			
Head length (HL)	8.9–9.7	8.5–9.2	8.2–9.4
Preanal length	43.5–46.3	39.3–41.2	40.1–44.3
Predorsal length	13.9–15.0	10.4–12.0	10.2–11.9
Tail length	53.7–56.5	58.8–60.7	55.7–59.9
Head depth at gill opening	3.0–3.4	2.3–2.6	2.6–3.2
Head width at gill opening	2.3–3.2	2.1–2.6	2.3–3.0
Body depth at mid-anus	3.2–4.1	2.0–2.5	2.6–3.7
Body width at mid-anus	2.5–3.6	2.2–2.6	2.6–3.3
As % HL			
Snout length	17.4–20.9	20.9–21.8	17.2–20.4
Eye diameter	9.1–12.1	10.0–13.6	9.5–10.0
Upper jaw length	37.9–40.2	30.8–34.5	24.6–28.9
Low jaw length	33.3–37.2	22.3–28.1	19.0–23.8
Interorbital	11.3–13.8	11.6–13.9	13.3–19.7
Gill opening	11.9– 15.5	7.5–11.4	10.1–13.2
Isthmus width	21.7 –26.2	17.3–20.4	21.9–27.3
Pectoral fin length	16.4–21.7	29.7–37.1	29.6–34.3
Counts	*n* = 5	*n* = 5	*n* = 7
Lateral-line pores before dorsal-origin	18	13–16	11–15
Lateral-line pores before anus	64–66	57–59	54–61
Total lateral-line pores	153–155	142–148	143–151
Predorsal vertebrate	16–18	11–15	11–12
Preanal vertebrate	63–64	56–59	55–58
Total vertebrate	156–159	155–164	151–155

Ophichthus machidai **McCosker, Ide & Endo, 2012**

(New record)

Figs. 3–4; Table 1

Ophichthus machidai McCosker, Ide & Endo, 2012: 8–12, figs. 4–6; table 3 (type locality: west of Tosa Bay, Kuroshio-cho, Kochi Prefecture, Japan).

Material examined. 5 specimens: OIM_E.55793 (3 spec.), 425–519 mm TL, Ham Tu fishing harbour, caught off Quy Nhon City, Binh Dinh Province, bottom trawl 80–100 m, 22 August 2018. OIM_E.55794 (2 spec.), 439–460 mm TL, Ham Tu fishing harbor, caught off Quy Nhon City, Binh Dinh Province, bottom trawl 50–70 m, 23 August 2018.

Description. The body is moderately elongated (Fig. 3) and laterally compressed in the posterior tail region. The branchial basket is slightly broader and deeper than the body. Head and trunk short. The snout is conical, acute when viewed from above. The snout is bisected on the underside by a groove from the posterior margin of the anterior nostril to the anterior margin of the posterior nostril. The lower jaw includes upper and lower lips almost meet when the mouth is closed. The underside of the snout with numerous minutes of fleshy papillae in the ethmoidal region. Mouth moderately elongated, rictus beneath the rear margin of the eye. The eye is moderate; its center is well behind the middle of the upper jaw, and the upper lip has 2 thorn-shaped protrusions.

Head pores minute (Fig. 4A), inconspicuous. Single median interorbital and temporal pores. Supraorbital pores 1+4, infraorbital pores 4+2, mandibular pores 5, preopercular pores 2. Lateral-line pores present but too small to enumerate, 9 before gill opening, 57–59 before the anus, and 142–148 in total. The mean vertebral formula (MVF): 12-57-159 (n = 5).

The teeth are conical, small, very close set, and erect (Fig. 4B, C). Intermaxillary with an irregularly biserial patch of 3–5 teeth, a gap, a uniserial row of 6–7 teeth, then 5–6 pairs of vomerine teeth become a uniserial row of 5–6 teeth. Maxillary teeth are linear and uniserial, with 29–32 (29) teeth on each side, becoming smaller posteriorly. Mandibular teeth are strictly uniserial, 36–41 (37) teeth on each side, becoming smaller posteriorly.

Figure 3. Ophichthus machidai McCosker, Ide & Endo, 2012; OIM_E.55793, 448 mm TL, in fresh

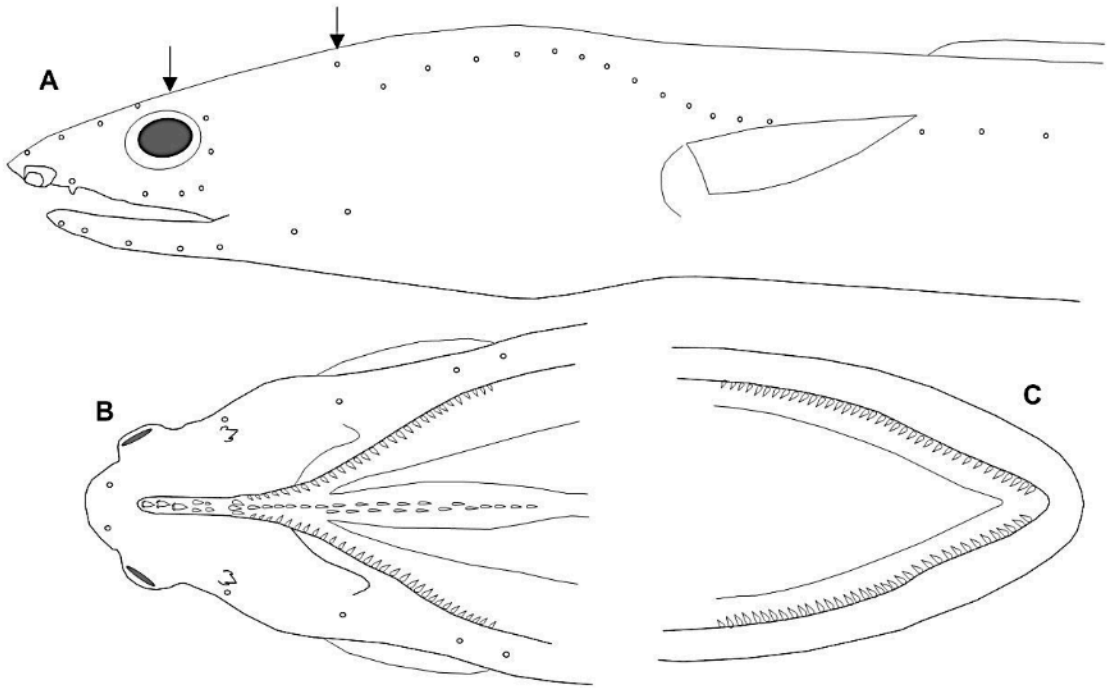

Figure 4. Lateral view of head (A), teeth on maxilla and palatal area (B) and mandible (C) of *Ophichthus machidai*; OIM_E.55793

Coloration. Color in fresh yellowish-brown above lateral midline, white ventrally, fins pale, cheeks brown, anterior chin region and anterior nostrils dark brown, median fin bases pale. 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; supraorbital pores anterior eye, infraorbital pores behind eye and mandibular pores with dark margin.

Distribution. This species is described in Japan and was first recorded in Taiwan, India, and Vietnam. Its distribution has expanded from these countries.

Ophichthus obtusus McCosker, Ide & Endo, 2012 (New record)

Figs. 5–6; Table 1

Ophichthus obtusus McCosker, Ide & Endo, 2012: 12–15, figs. 7–9; Table 9 (type locality: west of Tosa Bay, Kuroshio-cho, Kochi Prefecture, Japan).

Material examined. 12 specimens: OIM_E.55795 (5 spec.), 458–722 mm TL, from Ham Tu fishing harbor, catching off Quy Nhon City, Binh Dinh Province, bottom trawl, 50–80 m, 22 August 2018. OIM_E.55796 (2 spec.), 416-685 mm TL, from Ham Tu fishing harbor, caught off Quy Nhon City, Binh Dinh Province, bottom trawl, 70–120 m, 23 August 2018. OIM_E.55797 (4 spec.), 412–684 mm TL, from Luong Son fishing harbor, caught off Nha Trang City, Khanh Hoa Province, bottom trawl, 80–130 m, 08 August 2018. OIM_E.55798 (1 spec.), 504 mm TL, from Vung Tau fishing harbor, catching off Vung Tau City, bottom trawl, 50–60 m, 10 September 2020.

Description. The body is moderately elongated, and the tail is laterally compressed (Fig. 5). Head and trunk are short. The branchial basket is broader and deeper than the body. The snout is short and conical, acute when viewed from above; it is more acute from a small size. The snout is bisected on the underside from the mid-anterior nostril slightly before the anterior nostril base by a groove. The lower jaw includes upper and lower lips meet when the mouth is closed. The underside

of the snout with numerous minutes of fleshy papillae in the ethmoidal region. Mouth short, rictus ahead of rear margin of the eye. Eye moderate, its center far behind the middle of the upper jaw. Upper lip with two labial cauliflower-shaped barbels.

Figure 5. Ophichthus obtusus McCosker, Ide & Endo, 2012; OIM_E.55797, 684 mm TL, in fresh

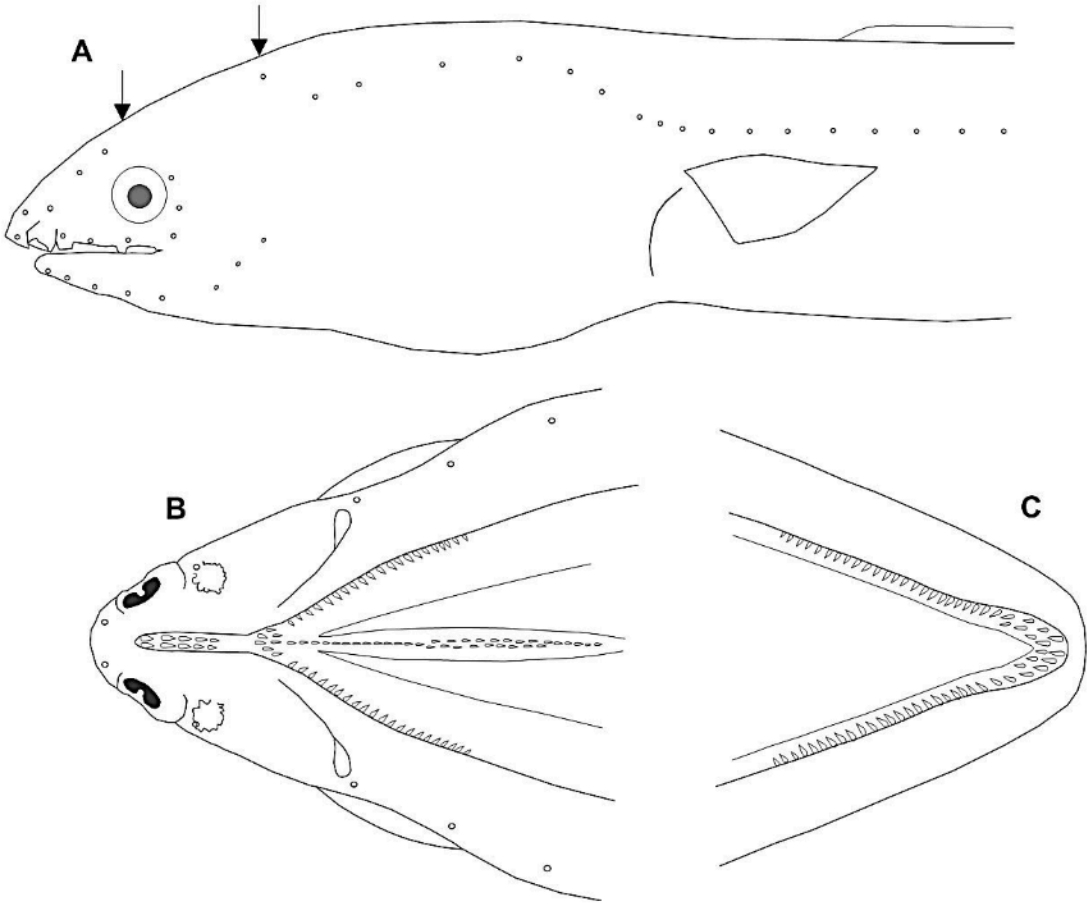

Figure 6. Lateral view of head (A), teeth on maxilla and palatal area (B) and mandible (C) of *Ophichthus obtusus*; OIM_E.55797

Head pores are small (Fig. 6A) and inconspicuous except for the supraorbital series. Single median interorbital and temporal pores. Supraorbital pores 1+4, infraorbital pores 4+2, mandibular pores 5, preopercular pores 3, 8–9 before the dorsal-fin origin, 54–61 before the anus, 143–151 totals, last about a head length before tail tip. The mean vertebral formula (MVF): 11-56-151 (*n* = 7).

Teeth conical, not enlarged (Fig.6B, C). Intermaxillary with 5 teeth in an irregularly biserial row, followed by a gap, then a patch of 5 teeth, followed by biserial teeth, about 8–10 pairs, and sequent by a row of 22–30 uniserial teeth on vomer, becoming smaller posteriorly. Maxillary teeth uniserial of 18–21 teeth in a row. Mandibular teeth are small, about 3–5 pairs at the symphysis, followed by 21–25 teeth in a uniserial row.

Coloration. Color in fresh brownish-black on mid-flank and dorsal surface, and the head is brownish in small size and darkened in large size. The Median fins are black, and the Pectoral fins are dark brown. Color in ethanol pale yellow ventrally, brownish-black on mid-flank and dorsal surface. The snout tip, mandible tip, anterior nostrils, and tail pale. A dark halo encircles the anal opening. Pectoral fins brown. Median fins black. Inside of mouth dusky with fine brown punctuation.

Distribution. This species is described in Japan and first recorded in Taiwan and Vietnam. Its distribution has expanded from Japan to Taiwan and Vietnam.

DISCUSSION

McCosker & Ho (2015) [7] regarded that *O. bicolor* would not be mistaken for most other *Ophichthus* because of the similarity of the posterior dorsal-fin origin, dentition, jaw length, eye position, and its distinctive body coloration with congeners. It is similar to *O. megalops* Asano, 1987, known from Japan and Taiwan. It differs from *O. megalops* in the more anterior location of its dorsal-fin origin (14–19% of TL behind the snout tip vs. 24–26%), its mean predorsal vertebral number (18 vs. 29), in its preopercular pores (2 vs. 3), in its posterior anal-fin coloration (pale vs. black), and in having fewer maxillary teeth (8–11 inner row and 11–14 outer row vs. 25–30 inner row and 25–30 outer row teeth). They are quite similar in the tail and head proportions, total vertebral numbers (155–163 vs. 161–163), and body depth (2.5–4.1 vs. 2.5–2.9 times in TL) ([7]; this study). It refers to *Ophichthus retrodorsalis* Liu, Tang & Zhang 2010. It differs from *O. bicolor* in total vertebral numbers (175 vs. 155–163), body depth (50 times in TL at gill opening), head length (14.7 times in TL), eye position (posterior margin of orbit above rictus) and in its dentition (triserial throughout) [7, 37].

McCosker et al. (2012) [6] showed that *Ophichthus machidai* McCosker, Ide & Endo, 2012 is similar to *O. 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 13–56–154, total vertebrae 151–156 vs. *O. machidai* MVF 13–56–154, total vertebrae 150–164); its preopercular pores (2–3 vs. 2-3), and its head (10.8–11.3% vs. 8.5–10.0?%) and tail proportions (57–61% vs. 53–61%), but *O. microstictus* has a dark tip ([6, 10], this study). Mohapatra et al. (2019) [10] recorded *O. machidai* in India.

Chiu et al. (2013) [38] asserted that *O. obtusus* is nearly all dark in body coloration with two flower-like mastoids within its mouth, the rear margin of eyes just above the rictus, many deep corrugation covers the head; 1-row maxillary with several teeth by the side, 8 teeth on premaxillary, 3 teeth on middle-premaxillary, orderly biserial teeth in the vomer, and 1 row on mandibular, in some case biserial in the anterior part. *O. obtusus* could be mistaken for other Vietnamese congeners using the characters in diagnostic of its small specimens, including *Ophichthus apicalis* (Anonymous [Bennett], 1830), *O. asakusae* Jordan & Snyder, 1901, *O.celebicus* (Bleeker, 1856), *O. cephalozona* Bleeker, 1864, and *O. urolophus* (Temminck & Schlegel, 1846) ([22], this study). The condition of its small labial barbels, cauliflower-shaped rather than smooth, appears to differ from that of other barbel-bearing ophichthids. This species is similar in appearance and proportions to *O. asakusae*, a

robust eel with an anterior dorsal-fin origin and uniserial teeth. The eye position is slightly more anterior, and the jaw length is considerably longer than that of *O. obtusus*, a different species. *O. obtusus* is similar to *O. apicalis* (Anonymous [Bennett], 1830). They have the same labial barbel number (both have a second barbel beneath the orbit), similar head proportions and dentition, a dark dorsal fin, and similar vertebral numbers of anterior dorsal-fin origin and anus (*O. obtusus* has an MVF 12-55-151, total vertebrae 148–155 vs. *O. apicalis* with an MVF 12-52-144, total vertebrae 143–145); *O. obtusus* differs in its pectoral length, which is less than jaw length, and labial protrusions stout ([6], this study).

Table 2. Comparison of proportions and counts of *Ophichthus bicolor*, *O. machidai* and *O. obtusus*. [1]McCosker & Ho (2015); [2]McCosker et al., (2012)

	Ophichthus bicolor		*O. machidai*		*O. obtusus*	
	Vietnam (*n* = 5)	Taiwan[1] (*n* = 21)	Vietnam (*n* = 5)	Japan[2] (*n* = 21)	Vietnam (*n* = 12)	Japan[2] (*n* = 21)
Total length (TL)	602–730	489–919	425–519	406–579	412–722	540–697
As %TL						
Head length (HL)	8.9–9.7	8.6–10.8	8.5–9.2	8.5–10.0	8.2–9.4	8.4–9.2
Trunk	33.8–37.3	33.6–37.1	30.7–32.7	30.3–36.8	31.0–36.1	33.3–35.7
As % HL						
Snout length	17.4–20.9	17.2–21.5	20.9–21.8	18.6–25.8	17.2–20.4	13.8–21.1
Upper jaw length	37.9–40.2	37.7–48.4	30.8–34.5	20.5–33.2	24.6–28.9	18.7–27.0
Counts						
Preopercular pores	2	2	2	2 (rarely 3)	3	3
Predorsal vertebrate	16–18	15–23	11–15	11–16	11–12	11–19
Preanal vertebrate	63–64	61–66	56–59	52–59	55–58	52–57
Total vertebrate	156–159	155–163	155–164	150–161	146–155	148–153

Fourteen species of the genus *Ophichthus* have been found in Vietnam, including *O. apicalis* (Anonymous [Bennett], 1830); *O. asakusae* (Jordan and Snyder, 1901); *O. celebicus* (Bleeker, 1856); *O. cephalozona* (Bleeker, 1864); *O. erabo* (Jordan and Snyder, 1901); *O. lithinus* (Jordan and Richardson, 1908); *O. longicorpus* Vo & Ho, 2021; *O. macrochir* (Bleeker, 1853); *O. microcephalus* (Day, 1878); *O. rutidoderma* (Bleeker, 1852); *O. shaoi* McCosker and Ho, 2015; *O. singapurensis* (Bleeker, 1864) *O. urolophus* (Temminck and Schlegel, 1846); and *O. vietnamensis* Vo, Hibino & Ho, 2019 [18, 20–24]. Nguyen (2001) [24] provided descriptions of 4 species *O. apicalis*, *O. celebicus*, *O. lithinus* and *O. rutidoderma*, based on specimens deposited in the Institute of Marine Environment and Resources, Hai Phong, Vietnam (IMER) and Museum of Oceanography, Institute of Oceanography. In contrast, Nguyen & Nguyen (1994) and Le et al. (2013) provided lists of species only, and no vouchers were mentioned. Hibino (2018) recorded four *Ophichthus* based on the specimens deposited in the Fisheries Research Laboratory, Mie University (FRLM) collected in Ha Long Bay. They also stated that five unidentified species may be new species to Vietnam waters, but they still only identify a genus as sp., which needs study in the future. Vo et al. (2019) presented five species recorded from the central coast of Vietnam and one new species. Vo & Ho (2021) also described one new species in Vietnam. These results added more than three species and elevated to 17 species of genus *Ophichthus* in Vietnamese waters ([20–23], this study) (Table 2).

CONCLUSIONS

These results added detailed descriptions of three species and elevated the number *Ophichthus* species in Vietnamese waters to 17.

This study provides an additional understanding of snake eel species in Vietnamese waters. These works need to continue to help further understanding of the diversity of this group.

Acknowledgements: This study is supported by the Vietnam Academy of Science and Technology (VAST) for QVV (grant VAST06.05/23-24), and The National Museum of Marine Biology & Aquarium, Taiwan, which has supported making the x-rays of the specimen's vertebrae.

REFERENCES

[1] Hibino, Y., and Kimura, S., 2016. Revision of the *Scolecenchelys gymnota* species group with descriptions of two new species (Anguilliformes: Ophichthidae: Myrophinae). *Ichthyological research*, *63*, 1–22. https://doi.org/10.1007/s10228-015-0485-4

[2] Tawa, A., Tahara, Y., and Hibino, Y., 2018. New record of a snake eel *Myrichthys paleracio* collected from Iriomote Island, Okinawa Prefecture, Japan. *Japanese Journal of Ichthyology*, *65*(1), 41–47.

[3] McCosker, J. E., and Chen, Y. Y., 2000. A new species of deepwater snake-eel, *Ophichthus aphotistos*, with comments on *Neenchelys retropinna* (Anguilliformes: Ophichthidae) from Taiwan. *Ichthyological Research*, *47*, 353–357. https://doi.org/10.1007/BF02674262

[4] McCosker, J. E., 2005. A New Species of Deepwater Snake Eel, *Ophichthus pullus* (Anguilliformes: Ophichthidae), from Angola and Guinea-Bissau. *Proceedings-California Academy of Sciences*, *56*(27/37), 669.

[5] McCosker, J. E., 2010. Deepwater Indo-Pacific species of the snake-eel genus *Ophichthus* (Anguilliformes: Ophichthidae), with the description of nine new species. *Zootaxa*, *2505*(1), 1–39. https://doi.org/10.11646/zootaxa.2505.1.1

[6] McCosker, J. E., Ide, S., and Endo, H., 2012. Three new species of ophichthid eels (Anguilliformes: Ophichthidae) from Japan. *Bulletin of the National Museum of Nature and Science*, 1–16.

[7] McCosker, J. E., and Ho, H. C., 2015. New species of the snake eels Echelus and *Ophichthus* (Anguilliformes: Ophichthidae) from Taiwan. *Zootaxa*, *4060*(1), 71–85. https://doi.org/10.11646/zootaxa.4060.1.11

[8] McCosker, J. E., and Hibino, Y., 2015. A review of the finless snake eels of the genus *Apterichtus* (Anguilliformes: Ophichthidae), with the description of five new species. *Zootaxa*, *3941*(1), 49–78. doi: 10.11646/ZOOTAXA.3941.1.2

[9] McCosker, J. E., and Psomadakis, P. N., 2018. Snake eels of the genus *Ophichthus* (Anguilliformes: Ophichthidae) from Myanmar (Indian Ocean) with the description of two new species. *Zootaxa*, *4526*(1), 71–83. https://doi.org/10.11646/zootaxa.4526.1.5

[10] Mohapatra, A., Ray, D., Mohanty, S. R., and Mishra, S. S., 2019. First report of *Ophichthus machidai* (Actinopterygii: Anguilliformes: Ophichthidae) from the Indian Ocean. *Acta Ichthyologica et Piscatoria*, *49*(1), 49–51. doi: 10.3750/AIEP/02523

[11] Hibino, Y., McCosker, J. E., and Tashiro, F., 2019. Four new deepwater *Ophichthus* (Anguilliformes: Ophichthidae) from Japan with a redescription of *Ophichthus pallens* (Richardson 1848). *Ichthyological Research*, *66*, 289–306. https://doi.org/10.1007/s10228-018-00677-3

[12] Smith, D. G., and McCosker, J. E., 1999. Ophichthidae: snake eels, worm eels. *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, *3*, 1662–1669.

[13] Chevey, P., 1932. Poissons des campagnes du "de Lanessan" (1925–1929), Ire Partie. *Trav Inst Océanogr Indochine Mémoire Mém*, *4*, 1–155.

[14] Pellegrin, L. D. J., 1905. Mission Permanente Française en Indo-Chine Poissons de la Baie D'along (Tonkin). *Bull Soc Zool France*, *30*, 82–88.

[15] Kuronuma, K., 1961. A check list of fishes of Vietnam. United States Consultants,

Inc. *International Cooperation Administration Contract-IV-153. Division of Agriculture and Natural Resources, United States Operations Mission to Vietnam*, 66.

[16] Fourmanoir, P., and Do, T. N. N., 1965. Liste complémentaire des poissons marins de Nha Trang: CAHIERS ORSTOM Océanographie. *Numéro spécial*.

[17] Orsi, J. J., 1974. A check list of the marine and freshwater fishes of Vietnam. *Publications of the Seto marine biological laboratory*, *21*(3–4), 153–177. doi: 10.5134/175867

[18] Nguyen, H. P., and Nguyen, N. T., 1994. Checklist of marine fishes in Vietnam. Vol. 2. Osteichthyes, from Elopiformes to Mugiliformes. *Science and Technics Publishing House, Vietnam*. 269 p. (in Vietnamese).

[19] Nguyen, K. H., 1995. Fish fauna of Vietnam. *Collection Marine Research Works*, *VI*, 121–126.

[20] Le, T. T. T., Vo, V. Q., Nguyen, P. U. V., Tran, T. H. H., and Tran, C. T., 2013. A checklist of the eels and morays (order: Anguilliformes) in the Vietnamese marine waters. *Proceedings of the Ecology and Biological Resources 5th. Hanoi*, *21*, 282–294. (in Vietnamese).

[21] Hibino, Y., 2018. Ophichthidae. In: *Kimura, S., Imamura, H., Nguyen, V. Q., & Pham, T. D., (eds.), Fishes of Ha Long Bay, the World Natural Heritage Site in Northern Vietnam. Fisheries Research Laboratory, Mie University, Shima, Japan*, pp. 21–27.

[22] Van Vo, Q., Hibino, Y., and Ho, H. C., 2019. A New Species of the Snake Eel Genus Ophichthus, with Additional Records from Viet Nam (Anguilliformes: Ophichthidae). *Zoological studies*, *58*, e43. doi: 10.6620/ZS.2019.58-43

[23] Ho, H. C., 2021. A new species of the snake eel genus Ophichthus from Vietnam, with a new record of Echelus polyspondylus McCosker & Ho, 2015. *Raffles Bulletin of Zoology*, *69*. doi: 10.26107/RBZ-2021-0006

[24] Nguyen, H. P., 2001. Fauna of Vietnam: Elopiformes, Anguilliformes, Clupeiformes, Gonorynchiformes. *National Center for Science and Technology of Vietnam. Science and Technics publishing House*, 98–104.

[25] McCosker, J. E., 1977. The osteology, classification, and relationships of the eel family Ophichthidae. *Proc. Calif. Acad. Sci., ser. 4*, *41*, 1–123.

[26] McCosker, J. E., Böhlke, E. B., and Böhlke, J. E., 1989. Family Ophichthidae. *Fishes of the western North Atlantic, Part Nine*, *1*, 254–412. https://doi.org/10.12987/9781933789323-012

[27] Böhlke, E. B., 1982. Vertebral formulae for type specimens of eels (Pisces: Anguilliformes). *Proceedings of the Academy of Natural Sciences of Philadelphia*, 31–49.

[28] Temminck, C. J., and Schlegel, H., 1846. Pisces. In: *Siebold, P. F., de (Ed.) Fauna Japonica, sive descriptio animalium, quae in itinere per Japoniam suscepto annis 1823–1830 collegit, notis, observationibus et adumbrationibus illustravit Ph. Fr. de Siebold. Lugduni Batavorum [Leiden] (A. Arnz et soc.)*. Parts 10–14, 173–269.

[29] DS, J., 1901. A review of the apodal fishes or eels of Japan, with descriptions of nineteen new species. *Proc US Natl Mus*, *23*, 837–890.

[30] DS, J., 1908. Fishes from islands of the Philippine Archipelago. *Bull Bur Fish*, *27*, 233–287.

[31] Asano, H., 1984. Ophichthidae. In: *Masuda, H., Amaoka, K., Araga, C., Uyeno, T., & Yoshino, T., (eds.), The fishes of the Japanese Archipelago. Tokai University Press, Tokyo*, pp. 30–32, pls. 33–34, 338.

[32] McCosker, J. E., and Rosenblatt, R. H., 1998. A revision of the eastern Pacific snake-eel genus *Ophichthus* (Anguilliformes: Ophichthidae) with the description of six new species. *Proceedings of the California Academy Sciences*, *50*, 397–432.

[33] Sumida, S., and Machida, Y., 2000. Revision of the two sympatric snake-eel species of the genus *Ophichthus*

(Ophichthidae, Anguilliformes) from Tosa Bay, Southern Japan, with comments on *O. tsuchidae*. *Bulletin of Marine Science and Fisferies-Kochi University (Japan)*, (20).

[34] McCosker, J. E., and Randall, J. E., 2002. *Ophichthys melanochir*, A Junior Synonym of the Highfin Snake Eel *Ophichthus altipennis*. *Copeia*, *2002*(3), 798–799. https://doi.org/10.1643/0045-8511(2002)002[0798:OMBAJS]2.0.CO;2

[35] Hatooka, K., 2002. Ophichthidae. In: *Nakabo, T., ed. Fishes of Japan with Pictorial Keys to the Species, English edition. Tokai University Press, Tokyo*, pp. 215–225, 1456–1459.

[36] Chiu, Y. C., Lin, J., and Chen, H. M., 2013. One new record genus and three new record species of snake eels (Ophichthidae: Anguilliformes) from Taiwan. *Journal of Marine Science and Technology*, *21*(7), 25. doi: 10.6119/JMST-013-1220-10

[37] Hibino, Y., 2019. Ophichthidae. In: *Koeda, K., and Ho, H.-C., (eds.), Fishes of Southern Taiwan. National Museum of Marine Biology & Aquarium, Pingtung, Taiwan*, pp. 28–38.