



The congrid eel genus *Ariosoma* in Taiwan (Anguilliformes: Congridae), with description of a new species

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Abstract

A review of the congrid eel genus *Ariosoma* in Taiwan is provided. Eight species are recognized, including *A. anago* (Temminck & Schlegel, 1846), *A. dolichopterum* Karmovskaya, 2015, *A. fasciatum* (Günther, 1872), *A. majus* (Asano, 1958), *A. megalops* Fowler, 1938, *A. meeki* (Jordan & Snyder, 1900), *A. shiroanago* (Asano, 1958) and a new species which is described based on types and non-types collected from off southwestern Taiwan. These species can be distinguished from each other by the coloration, numbers of head pores, lateral-line pores and vertebrae. A key to all Taiwanese *Ariosoma* species is provided.

Key words: Pisces, Anguilliformes, *Ariosoma*, new species, Taiwan

Introduction

The congrid eel genus *Ariosoma* Swainson, 1838 is a group of small and stout eels with about 31 valid species known from tropical and temperate waters worldwide (Eschmeyer *et al.*, 2018).

In Taiwan, Shen (1998a) reviewed the genus and recognized four species, including the description of a new species *A. nancyae* (= *A. fasciatum*). However, his *A. anago* is now reidentified as *A. meeki* and his *A. anagoides* is now reidentified as *A. dolichopterum*. The other species, *Ariosoma shiroanago* major (Asano, 1958), is now recognized as an independent species, *Ariosoma majus*. Ho *et al.* (2015a, b) added one species *A. shiroanago* and removed *A. anagoides* from Taiwan.

Recently, we collected a large number of specimens of *Ariosoma* from Taiwan fish markets and made a detailed investigation. It reveals that eight *Ariosoma* species are found in Taiwan, including two more new records, *A. dolichopterum* and *A. megalops*.

While working on the DNA barcoding of those eels collected from Taiwan (Smith, unpublished data), we found that the specimens initially identified as *A. dolichopterum* were separated into two clades. Further investigation shows that they represent two different species: one belongs to *A. dolichopterum*, whereas the other represents an undescribed species. A formal description is provided for the new species.

In this work, we provide a diagnosis and description, as well as detailed morphometric and meristic data, for all eight species.

Methods and materials

Counts and measurements are as in Smith & Kanazawa (1977). Institutional abbreviations are as in Eschmeyer *et al.* (2018, online version). Proportions are given as percentage of total length (TL) and head length (HL) in Tables.

Lateral-line pores are counted as (1) cephalic, pores before pectoral-fin base; (2) predorsal, pores before dorsal-fin origin; (3) preanal, pores before origin of anal fin (posterior margin of anus); and (4) total pores, the last pore usually runs to a few eye diameters before posterior tip of tail. Abbreviations for head pores are: IO, infraorbital; POP, preopercular; M, mandibular; SO, supraorbital; ST, supratemporal. Preanal length is measured from tip of snout to origin of anal fin (posterior margin of anus).

The detailed information of localities were listed in Ebert *et al.* (2013: table 5).

Data are taken for specimens collected from Taiwan, except where otherwise indicated.

Results

Family Congridae

Ariosoma Swainson, 1838

Ariosoma Swainson, 1838: 220 (type species: *Ophisoma acuta* Swainson 1839, by subsequent designation of Bleeker, 1864: 20).

Definition. A genus of the subfamily Bathymyrinae with body stout to moderately elongate, preanal length 41–52% TL; caudal fin reduced and tip of tail stiff; posterior nostril exposed, in front of eye somewhat below mid-eye level; dorsal- and anal-fin rays unsegmented; flange present on upper lip; dorsal fin begins near level of pectoral-fin base; head pores small, pores along upper jaw located on side of head, rather than on labial flange; adnasal pore absent; teeth villiform, never enlarged or fang-like, those on intermaxillary and dentary forming narrow band with multiple rows, and on vomer forming a moderately long patch.

Description. Based on Taiwanese species only. Body moderately elongate, rounded in cross section, becoming more compressed posteriorly. Trunk moderately long, its length 3.0–4.0 times in total length; tip of tail blunt, caudal rays reduced in length; anus at or slightly before middle of total length.

Dorsal fin begins well before to above pectoral-fin base; continuous around tip of tail with caudal and anal fins. Anal fin begins immediately behind anus. Pectoral fin well developed, pointed or bluntly rounded distally with a narrow base. Gill opening moderately large, usually smaller than eye diameter, its upper end nearly opposite upper half of pectoral-fin base; interbranchial width about same as gill opening and eye.

Head relatively large, its length 4.7–6.6 times in TL, deepest at about occipital region, slightly tapering anteriorly from this point; snout short, blunt to slightly pointed anteriorly in dorsal view, its length 0.8–1.5 times eye diameter, slightly projecting beyond lower jaw; lower jaw longer than snout; rictus behind anterior margin of eye.

Anterior nostril tubular, near tip of snout, directed ventrolaterally. Posterior nostril a small oval pore, with a slightly raised rim, about 3 times its diameter in front of mid-eye level. Upper jaw with a slight upturned flange and lower jaw with well-developed, downturned flange. Tongue free, moderately long, and broad.

Lateral line nearly complete, the last pore runs to less than one head length before caudal fin; 3–11 predorsal, 6–11 cephalic, 42–64 preanal, and 106–158 total.

Head pores small to slightly enlarged (Fig. 1). SO pores 4–6; the first (ethmoidal) tiny, at ventral tip of snout, just above lip; the second small, at dorsal margin of anterior nostril; the third enlarged, above base of anterior nostril; the fourth small, above posterior nostril; the fifth at anterior portion of interorbital space; the sixth at posterior portion of interorbital space. IO pores typically 5–8 (except *A. fasciatum*, which has multiple pores, see description under the species); 4 along upper jaw, the first immediately behind anterior nostril, the next 3 along upper jaw above flange, the fifth in line with these behind rictus; 0–3 pores in ascending branch of canal behind eye. POM pores 10; 7 in mandibular section, 6 before rictus and one behind; and 3 in preopercular section except for *A. fasciatum* which has more. ST pores 0–3 in most species, 1 median pore and 2 lateral pores above first lateral-line pores; *A. meeki* has none and *A. fasciatum* may have more small and irregularly arranged pores.

Predorsal vertebrae 5–12; preanal vertebrae 44–66; precaudal vertebrae 54–84; total vertebrae 116–162.

Teeth small, conical or blunt. Intermaxillary teeth slightly enlarged, curved, in 3–4 transverse rows, slightly visible when mouth closed, the patch continuous with maxillary teeth, but with a gap in front of vomerine teeth. Maxillary and mandibular teeth in bands, wider anteriorly, roughly in 4–5 rows, narrower posteriorly, in 1–2 rows;

outermost teeth slightly larger than innermost. Vomerine teeth forming a small triangular patch, those on anterior portion sharp and curved, followed by slightly wider based but blunt teeth posteriorly, the patch runs to about half the length of maxillary teeth rows.

Coloration pale to dark brown, vertical fins with narrow or broad black margin; black and white bands on head present or absent; *A. fasciatum* with large blotches on body, whereas as the others have none.

Diversity. The genus currently comprises 31 recognized species. Twenty-two species are found in the Indo-West Pacific Ocean, whereas seven species are found in the Atlantic Ocean and two in the Eastern Pacific Ocean. In the northwestern Pacific Ocean, the following ten species were found: *Ariosoma anago* (Temminck & Schlegel, 1846), *A. dolichopterum* Karmovskaya, 2015, *A. fasciatum* (Günther, 1872), *A. majus* (Asano, 1958), *A. meeki* (Jordan & Snyder, 1900), *A. megalops* Fowler, 1938, *A. sazónovi* Karmovskaya, 2004, *A. scheelei* (Strömman, 1896), *A. shiroanago* (Asano, 1958), and a new species described here.

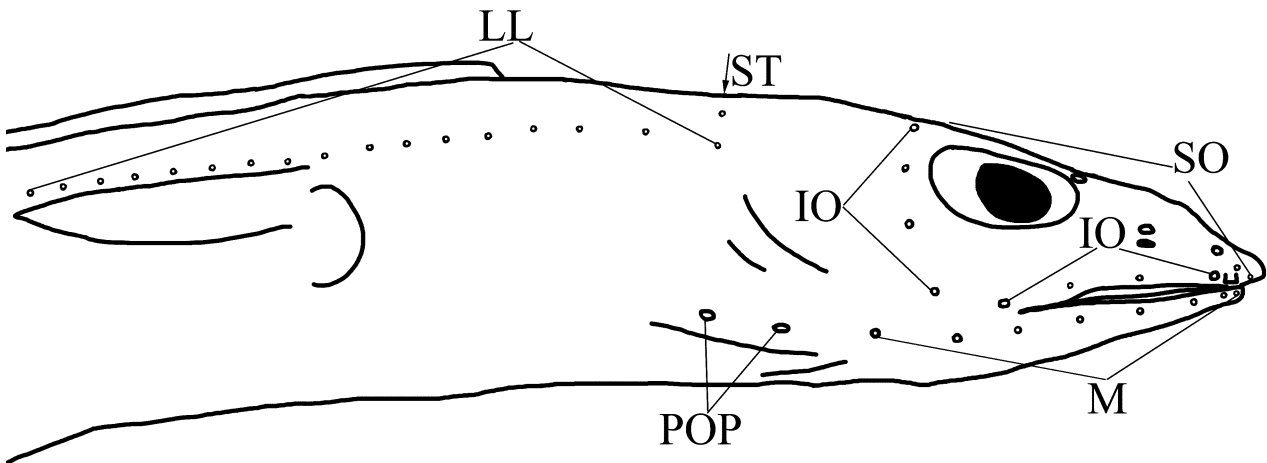


FIGURE 1. Line drawing show the general arrangement of head pores and anterior lateral-line pores. SO, supraorbital (6 pores); IO, infraorbital (4+4); M, mandibular (7); POP, preopercular (3); ST, supratemporal commissure (3); LL, lateral line. Arrow indicates the locality of median pore in supratemporal commissure. From holotype of *A. emmae*, NMMB-P26428.

Key to species of *Ariosoma* in Taiwan

- 1A. Black spots and patches on head; body and fins with 10–14 large black cross marks *Ariosoma fasciatum*
- 1B. Head and body without black spots or patches 2
- 2A. No or one pore behind eye; no pores between eyes; no pores in supratemporal canal; two small black patches on posterior margin of eye *Ariosoma meeki*
- 2B. Three pores behind eye, two pores between eyes, three pores in supratemporal canal; no black patches on posterior margin of eye 3
- 3A. Dorsal-fin origin behind or just above insertion of pectoral fin; total vertebrae 115–121 *Ariosoma megalops*
- 3B. Dorsal-fin origin clearly before insertion of pectoral fin; total vertebrae more than 127 4
- 4A. Clear black and white bands on head; vertical fins with broad black margin, snout relatively pointed 5
- 4B. No (or only weakly defined) black and white bands on head; vertical fins with very thin black margin; snout relatively blunt. 7
- 5A. Preanal vertebrae 54–56; precaudal vertebrae 71–72; total vertebrae 143–144; preanal pores 53–57; total pores 136–140 *Ariosoma anago*
- 5B. Preanal vertebrae 47–55; precaudal vertebrae 59–65; total vertebrae 127–134; preanal pores 47–53; total pores 121–133 6
- 6A. Usually four whitish bars across head; pectoral fin large, its length 40.0–56.7% HL; preanal length 43.1–46.8% TL *Ariosoma dolichopterum*
- 6B. Usually one whitish bar across anterior margin of eye; pectoral fin small, its length 29.1–35.2% HL; preanal length 46.9–49.6% TL *Ariosoma emmae* sp. nov.
- 7A. Preanal vertebrae 58–59; precaudal vertebrae 82–83; total vertebrae 161–162; preanal pores 59; total pores 151–158 *Ariosoma shiroanago*
- 7B. Preanal vertebrae 51–55; precaudal vertebrae 68–73; total vertebrae 140–149; preanal pores 50–55; total pores 132–147 *Ariosoma majus*

***Ariosoma anago* (Temminck & Schlegel, 1846)**

Silvery Short-tail Conger; 白錐體糯鰻

Figs. 2, 3A; Table 1

Conger anago Temminck & Schlegel, 1846:259 (type locality: Nagasaki, Japan). Jordan & Richardson, 1909:171.

Leptocephalus flavirostris Snyder, 1908:93 (type locality Misaki, Japan).

Alloconger anagoides (not of Bleeker, 1853): Chu, 1957:14; Lee & Yang, 1966:54, fig. 2; Chen & Weng, 1967:45; Chen, 1969:132; Chen & Yu, 1986: 252; Shen *et al.*, 1993:115; Shao *et al.*, 1994:274.

Ariosoma anago: Shao *et al.*, 2008:239. Ho *et al.*, 2015a: table 3. Ho *et al.*, 2015b:144.

Material examined. 5 specimens, 355–403 mm TL. TOU-AE 1612 (1, 388), Shanjien, Changbin, Taitung, 14 Jun. 2005. TOU-AE 1614 (1, 368), TOU-AE 5499 (1, 355), Changbin, Taitung, 70–400 m, 21 Apr. 2010. USNM 398749 (1, 403), Chang-bin, Taitung, 27 Jul. 2007. Other locality. USNM 62230 (1, 370), holotype of *Leptocephalus flavirostris*, Misaki, Japan, 30 Oct. 1908.



FIGURE 2. *Ariosoma anago* (Temminck & Schlegel, 1846), USNM 398749, 403 mm TL. A. lateral view, preserved. B. lateral view of head.

Diagnosis. Body brown; four whitish bands across dark background on dorsal and lateral surface of head; vertical fins with very broad conspicuous black margin; snout relatively pointed; preanal vertebrae 54–56, precaudal vertebrae 71–72, total vertebrae 143–144; and preanal lateral-line pores 53–57 and total pores 136–140.

Description. Morphometric and meristic data provided in Table 1. Body stout, anus slightly before midlength, dorsal-fin origin well before gill opening. Jaws moderately long, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus. Snout relatively pointed.

Teeth small, conical, multiserial; maxillary and intermaxillary teeth continuous; maxillary teeth in narrow band, teeth sharp on outer row(s) and blunt on inner row(s). Small teeth on space between intermaxillary and vomerine tooth patches. Vomerine teeth sharp anteriorly followed by about 3 rows of larger, blunt teeth, forming a narrow elongate patch ending behind midpoint of maxillary tooth patch.

Body brown, slightly paler ventrally, dorsal and anal fins with very broad conspicuous black margins, caudal fin white with upper and lower margins black. Dorsal surface of head darker with four whitish bands across levels of posterior nostrils, anterior margin of eyes, slightly posterior to the eyes, and nape; ventral surface of head densely pigmented.

Maximum size exceeding 400 mm TL.

Remarks. Asano (1962) reported this species from Japan under the name *Alloconger anagoides* (Bleeker). The species treated in the same paper as *Anago anago* has been reidentified as *Ariosoma meeki* (Jordan & Snyder, 1900).

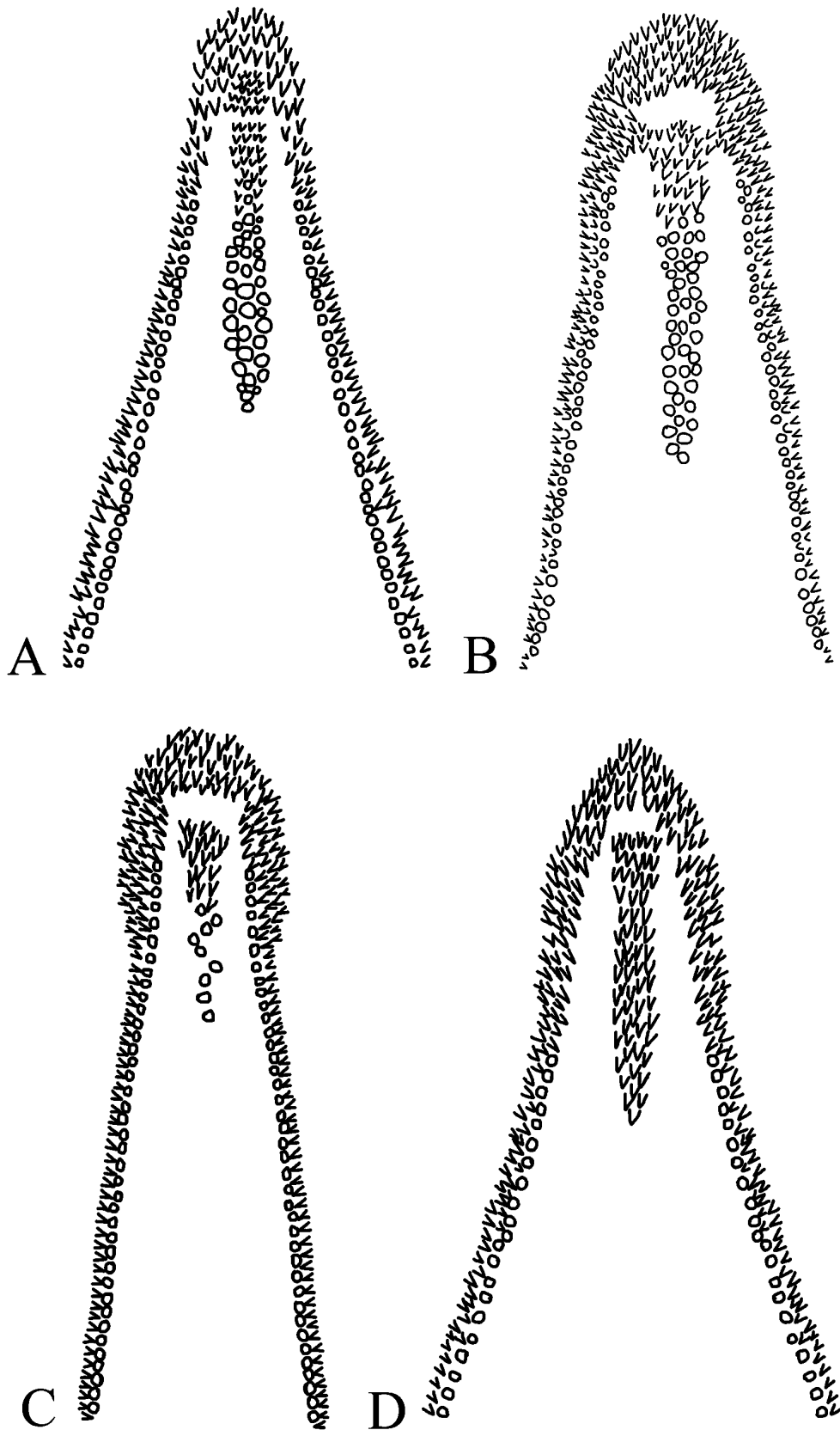


FIGURE 3. Upper-jaw teeth of *Ariosoma* species. A. *A. anago*, TOU-AE5499. B. *A. dolichopectrum*, NMMB-P23477. C. *A. emmae* **sp. nov.**, paratype, NMMB-P26426. D. *A. fasciatum*, NMMB-P23571. Not to scale.

This species most closely resembles *A. dolichopterum* and *A. emmae* **sp. nov.** in the conspicuous black fin margins and the white band(s) across dorsal surface of head. It differs from the former mainly in having more vertebrae (143–144, vs. 129–134) and a shorter pectoral fin; and from the latter in having more vertebrae (143–144, vs. 127–129) and four whitish bands across dorsal surface of head (vs. only one band before the eyes). It differs from *A. majus* by the more distinct bands on the head, the conspicuous black margins on the vertical fins, and slightly more preanal vertebrae (54–56, vs. 51–55).

***Ariosoma dolichopterum* Karmovskaya, 2015**

Long-fin Short-tail Conger; 長鰭錐體糯鰻

Figs. 3B, 4, 6; Table 1

Ariosoma dolichopterum Karmovskaya, 2015:906, fig. 1 (type locality: southern Viet Nam).

?*Alloconger anagoides* (non Bleeker, 1853), in part: Jordan & Richardson, 1909:171. Chu, 1957:14. Lee & Yang, 1966:54, fig.

2. Chen & Weng, 1967:45. Chen, 1969: 132. Chen & Yu, 1986:252. Shao *et al.*, 1994:274.

Ariosoma anagoides (non Bleeker, 1853): Shen, 1998a:9. ?Shao *et al.*, 2008:239.

Material examined. 32 specimens, 105–415 mm TL (*detailed measurements not taken). CAS 15596 (1, 328), CAS 15854 (2, 324–327), Dong-gang. NMMB-P1404 (formerly THUP 3961, 1, 335), Dong-gang, 21 Mar. 1979. NMMB-P3209 (5, 247–330), Tainan, 10 Feb. 1966. NMMB-P3387 (1, 367), Kaohsiung, 7 Feb. 1966. NMMB-P3406 (1, 368), Dong-gang, 1 Aug. 1965. NMMB-P4541 (1, 325), Penghu, 1 Aug. 1957. NMMB-P8816 (5, 223–373), Penghu, 30 Aug. 2005. NMMB-P8970 (1, 379), Penghu, 27 Oct. 2005. NMMB-P9020 (1, 380), Penghu, 27 Oct. 2005. NMMB-P11153 (1, 290), Daxi, Ilan, 12 Oct. 2010. NMMB-P21750 (2, 105–139), Penghu, 1 Aug. 1957 (detailed measurements not taken). NMMB-P22433 (1, 289), Ke-tzu-liao, 21 Jan. 2015. NMMB-P23477 (1, 415), Ke-tzu-liao, 5 Jul. 2016. NMMB-P23478 (1, 140), Ke-tzu-liao, 5 Jul. 2016 (detailed measurements not taken). NMMB-P23713 (2, 248–250), Ke-tzu-liao, 21 Jan. 2015. NSMT-P125309 (2, 232–269), Ke-tzu-liao, 11 Feb. 2015. USNM 398799 (1, 349), Nan-fang-ao, 18 Nov. 2009. USNM 437331 (2, 245–340), Ke-tzu-liao, 16 Oct. 2015.

Diagnosis. Body brown with conspicuous black margins on vertical fins; four whitish bands across dorsal surface of head; snout relatively pointed; pectoral fin very long, 40.0–56.7% HL. Pores present between and behind eyes. Vertebrae 129–134.

Description. Morphometric and meristic data provided in Table 1. Body stout, anus slightly before midlength, dorsal-fin origin well before gill opening. Jaws moderately long, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus. Snout relatively pointed.

Teeth small, conical, multiserial; maxillary and intermaxillary teeth continuous; maxillary teeth in narrow bands, teeth sharp on outer row(s) and blunt on inner row(s). Vomerine teeth sharp anteriorly followed by about 3 rows of larger blunt teeth, forming a narrow elongate patch ending behind midpoint of maxillary tooth patch.

Body brown, often a distinct bicolored appearance, distinctly paler below the lateral line; dorsal and anal fins with very broad conspicuous black margin, caudal fin white with upper and lower margins black. Dorsal surface of head darker with four whitish bands across levels of posterior nostrils, anterior margin of eyes, slightly posterior to eyes, and supertemporal canal; ventral surface of head white with irregular black pigmented patches.

Maximum size at least 415 mm TL. Females appear to mature at around 300 mm TL.

Distribution. Known from the South China Sea off Vietnam and around Taiwan.

Remarks. *Ariosoma dolichopterum* resembles *A. anago* in having a pointed snout, distinct dark and pale bands on the head, and conspicuous black margins on the vertical fins. It differs in having fewer vertebrae (129–134 vs. 143–144) and a longer pectoral fin (40.0–56.7% vs 30.4–34.6 % HL). From the specimens initially identified as this species, we separated another species, *A. emmae* **sp. nov.** See detailed comparison below.

Ariosoma dolichopterum appears to be more common in southern Taiwan than the similar *A. anago*. It is possible that some of the earlier references to *A. anagoides* (now *A. anago*) refer at least in part to this species.



FIGURE 4. *Ariosoma dolichopterum* Karmovskaya, 2015, NMMB-P23477, 415 mm TL. A. lateral view. B. Lateral view of anterior portion of head.

***Ariosoma emmae* Smith & Ho, sp. nov.**

Emma's Short-tail Conger; 黑錐體糯鰻

Figs. 1, 3C, 5, 6; Table 1

Holotype. NMMB-P26428 (236 mm TL), off Ke-tsu-liao, Kaohsiung, southwestern Taiwan, north tip of South China Sea, 18 Jun. 2017, less than 100 m, coll. H.-C. Ho.

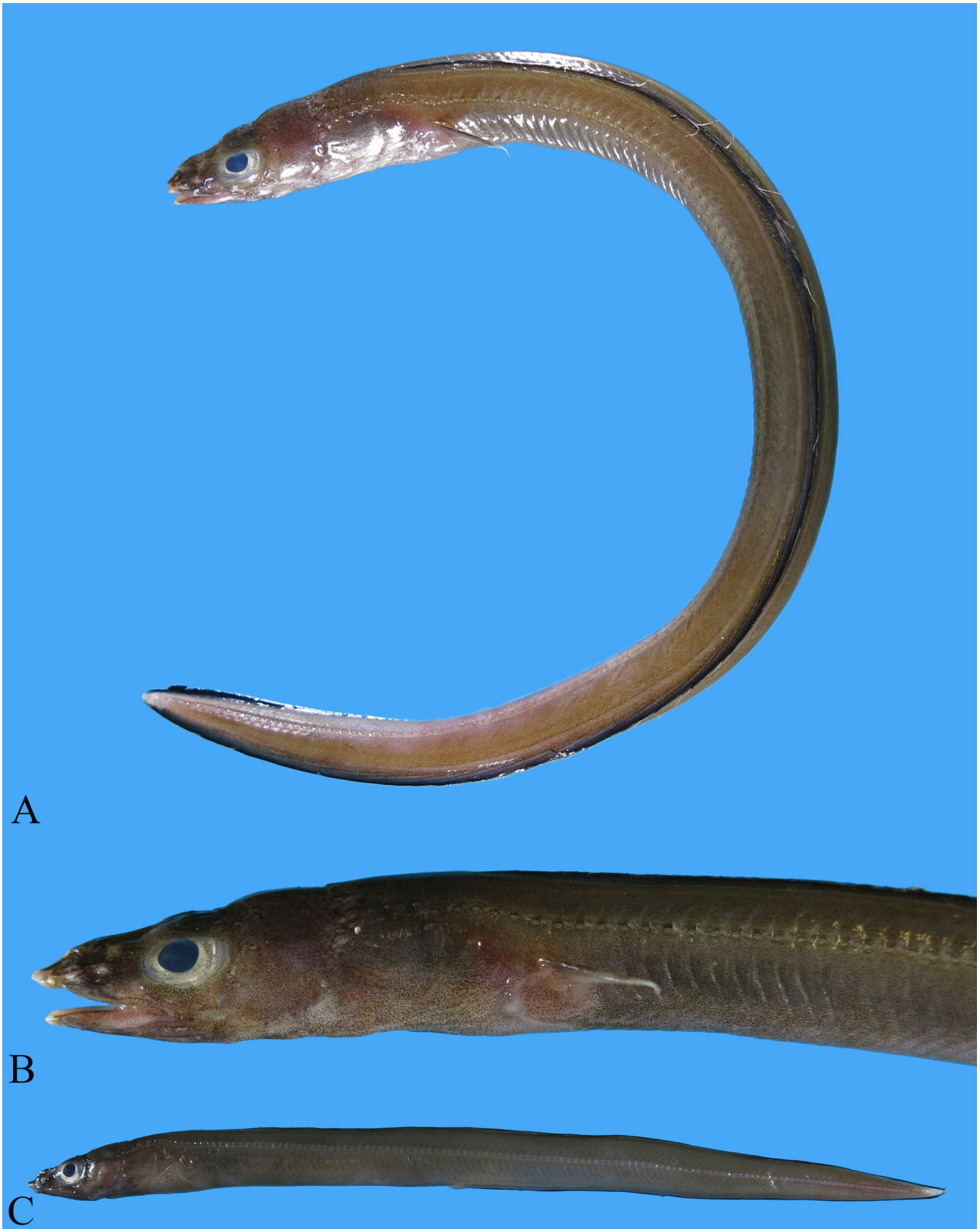


FIGURE 5. *Ariosoma emmae* sp. nov. A–B. Holotype, NMMB-P26428, 236 mm TL. C. Paratype, NMMB-P24376, 177 mm TL.

Paratypes. 9 specimens, 149–242 mm TL. NMMB-P23479 (3, 207–232), Ke-tzu-liao, 13 Jul. 2016. NMMB-P24376 (1, 177), Ke-tzu-liao, 27 Jun. 2016. NMMB-P26426 (1, 193), Ke-tzu-liao, 18 Jun. 2017. NMMB-P26710 (1, 207), Ke-tzu-liao, 17 Aug. 2017. NMMB-P26711 (1, 242), Ke-tzu-liao, 17 Aug. 2017. USNM 439058 (1, 160), USNM 439059 (1, 149), Ke-tzu-liao, 4 Feb. 2016.

Non-types. NMMB-P12217 (1, 306), Daxi, 22 Jan. 2010 (all data included). NMMB-P27032 (3, 125–197), cleared and stained, Ke-tzu-liao, 18 Jun. 2017 (detailed measurements not taken).

Diagnosis. Body blackish, one whitish band crossing snout just anterior to eyes; vertical fins with very broad conspicuous black margin; snout relatively pointed; pectoral fin moderate in size, 29.1–35.2% HL. Preanal vertebrae 51–55, total vertebrae 127–133; preanal lateral-line pores 50–53, total pores 123–126.

Description. Morphometric and meristic data are provided in Table 1. The following values are provided for the holotype, followed by range of paratypes in parentheses. The values of non-types are within range of type series.

Head length 5.9 (5.4–5.9) in TL; preanal length 2.1 (2.0–2.1); predorsal length 7.0 (6.1–7.0); trunk length 3.2 (3.1–3.5); tail length 1.9 (1.9–2.0); depth at gill opening 19.0 (17.0–20.9). Snout length 4.4 (4.2–4.6) in HL; eye diameter 6.4 (5.3–6.4); interorbital width 7.3 (6.9–7.9); upper jaw 3.7 (3.3–3.7); gill opening width 8.3 (7.8–9.7); interbranchial width 6.0 (5.6–7.9); pectoral-fin length 3.1 (2.8–3.4).

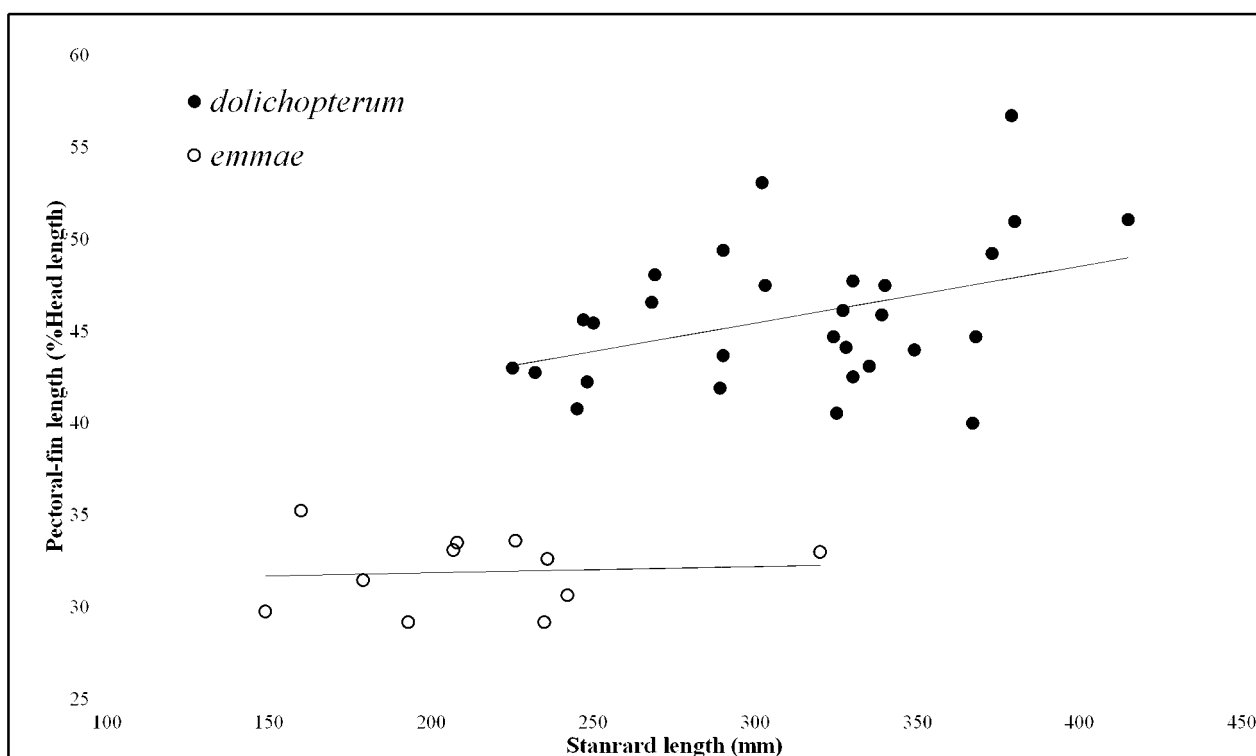


FIGURE 6. Comparison of pectoral-fin length (% HL) versus standard length between *A. dolichopterum* and *A. emmae* sp. nov.

Body relatively stout, cylindrical anteriorly and laterally compressed through the posterior half, becoming more compressed posteriorly; head moderately large; tip of tail blunt; anus at about midpoint of total length.

Dorsal fin begins well before insertion of pectoral fin; continuous around tip of tail with caudal and anal fins. Anal fin begins immediately behind anus. Pectoral fin well developed, pointed distally with a narrow base. Gill opening moderately large, much smaller than eye diameter, its upper end nearly opposite upper half of pectoral-fin base; interbranchial width greater than gill opening and larger than eye.

Head relatively large, 16.9% (16.7–18.4%) TL, deepest about midway between gill opening and tip of snout, tapering anteriorly from this point; snout short, pointed anteriorly in dorsal view, its length 1.5 (1.2–1.5) times eye diameter, projecting slightly beyond lower jaw; lower jaw about same length as snout; fleshy part of snout very narrow, projecting anteriorly slightly beyond anterior end of intermaxillary tooth patch; rictus below about middle of eye, or slightly before.

Anterior nostril small, tubular, near tip of snout, directed ventrolaterally. Posterior nostril a small pore, in front of mid-eye level. Upper jaw with reduced flange; lower jaw with downturned flange. Tongue short and broad, anterior half free from floor of mouth.

Lateral line nearly complete, first pore at level of supratemporal canal, the canal extending to slightly more than one eye diameter before caudal-fin base; 4 (4–6) predorsal, 8 (8–9) cephalic, 51 (50–53) preanal, and 123 (123–126) total.

Head pores small, some may be slightly enlarged. SO canal with 6 pores; the first (ethmoidal pore) very small, on ventral side of tip of snout, just before the lip; the second small and immediately in front of and above anterior nostril; the third enlarged, on dorsal surface of snout closer to anterior nostril than posterior nostril; the fourth slightly enlarged, right above posterior nostril or slightly behind; the fifth small, at anterior portion of interorbital space; and the sixth above posterior portion of interorbital space. IO canal with 8 pores, the first enlarged, right behind anterior nostril; the second below posterior nostril; the third below anterior margin of eye; the fourth slightly behind rictus under middle of eye; the fifth in line with these behind rictus under posterior margin of eye; and 3 in ascending branch of canal behind eye. POM pores 10; 7 in mandibular section, including 1 behind rictus; 3 in preopercular section, in a longitudinal row. ST pores 3.

TABLE 1. Morphometric and meristic data of *Ariosoma anago*, *A. dolichopterum* and *A. emmae* sp. nov. from Taiwan.

	<i>A. anago</i>		<i>A. dolichopterum</i>		<i>A. emmae</i> sp. nov.		
					Holotype	Types+nontype	
TL (mm)	334–403 (n=5)		223–415 (n=29)		236	149–306 (n=11)	
%TL	Mean (Range)	SD	Mean (Range)	SD		Mean (Range)	SD
Head length	16.6 (16.0–17.2)	0.6	16.8 (15.6–18.4)	0.7	16.9	17.6 (16.7–18.4)	0.5
Depth at gill opening	5.9 (5.2–6.6)	0.6	5.2 (4.1–6.4)	0.7	5.3	5.5 (4.8–6.4)	0.5
Depth at anus	5.6 (4.6–6.9)	1.0	5.2 (3.8–6.4)	0.6	5.5	5.3 (4.6–6.5)	0.6
Width at anus	4.2 (3.9–4.6)	0.3	3.9 (3.1–4.7)	0.4	3.8	3.7 (2.9–4.2)	0.5
Predorsal length	14.2 (13.5–14.7)	0.5	15.3 (14.1–16.8)	0.8	14.2	15.5 (14.2–16.3)	0.7
Preanal length	45.7 (44.1–46.7)	1.0	45.4 (43.1–46.8)	0.9	47.9	48.1 (46.9–49.6)	1.0
Trunk length	29.0 (26.9–30.2)	1.4	28.7 (26.6–29.8)	0.8	31.0	30.5 (28.9–32.7)	1.2
Tail length	54.3 (53.3–55.9)	1.0	54.6 (53.2–56.9)	0.9	52.1	51.9 (50.4–53.1)	1.0
%HL							
Snout length	23.2 (21.8–24.8)	1.5	22.3 (19.7–24.7)	1.2	22.6	22.7 (21.5–24.0)	0.9
Eye diameter	21.1 (19.7–22.7)	1.3	16.7 (13.6–19.0)	1.1	15.5	17.3 (15.5–18.8)	1.1
Interorbital width	14.0 (13.4–14.7)	0.6	14.4 (12.1–18.6)	2.1	13.7	13.1 (12.0–14.4)	0.9
Upper jaw	31.2 (29.5–33.4)	1.4	28.9 (24.6–32.6)	2.0	27.1	29.1 (27.1–31.3)	1.3
Gill opening width	14.5 (13.4–14.7)	1.5	14.8 (11.7–18.8)	2.1	12.0	11.4 (10.4–12.8)	2.0
Interbranchial width	16.5 (14.5–17.6)	1.4	17.2 (13.0–21.6)	2.6	16.8	15.5 (12.6–17.8)	2.0
Pectoral-fin length	32.2 (30.4–34.6)	1.6	45.8 (40.0–56.7)	3.9	32.6	31.9 (29.1–35.2)	2.0
Meristics	n=5		n=32			n=14 (types+nontypes)	
Predorsal vert.	5–8		6–9		7	6–8	
Preanal vert.	54–56		47–51		52	51–55	
Precaudal vert.	71–72		59–65		64	63–65	
Total vert.	143–144		129–134		131	127–133	
Cephalic pores	8–9		8–11		8	8–9	
Predorsal pores	3–6		5–9		4	4–6	
Preanal pores	53–57		47–51		51	50–53	
Total pores	136–140		121–129		123	123–126	

Predorsal vertebrae 7 (6–8); preanal vertebrae 52 (51–55); precaudal vertebrae 64 (63–65); total vertebrae 131 (127–133).

Teeth small, conical or blunt. Intermaxillary teeth curved, in 4 transverse rows, separated from vomerine teeth by a gape, partly excluded from closed mouth. Maxillary and mandibular teeth in bands, wider anteriorly, roughly in 3 or 4 rows, narrower posteriorly, in 2 rows; innermost teeth blunt, the rest conical. Vomerine teeth forming a long triangular patch, 3 or 4 transverse rows in anterior portion, followed by 1 or 2 (mostly 1) irregular rows of blunt teeth.

Coloration. Fresh and preserved specimens with similar coloration. When fresh, body uniformly dark brown to blackish, paler ventrally, dorsal and anal fins with very broad conspicuous black margin, caudal fin white with upper and lower margins black. Dorsal surface of head darker with a single white band across level of anterior margin of eyes through the 5th SO pores. The preserved specimens are slightly darker in general.

Measurement of holotype (in mm). Head length 39.9, preanal length 113, predorsal length 33.6, trunk length 73.1, tail length 123, depth at gill opening 12.4, depth at anus 12.9, with at anus 9.0, snout length 9.0, eye diameter 6.2, interorbital width 5.5, upper jaw 10.8, gill opening width 4.8, interbranchial width 6.7, pectoral-fin length 13.0.

Size. The largest known specimen examined is 306 mm TL. It appears to be a small species that matures at around 220 mm TL.

Distribution. The species is currently only known from southwestern Taiwan, southern Taiwan Strait and northeastern Taiwan. The collecting depth is about 100 m or less.

Etymology. We take the opportunity to name this fish after Emma S. Karmovskaya of P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, for her great contribution to our knowledge of congrid eels.

Remarks. As mentioned above, the type series was confused with specimens of *A. dolichopterum* due to the similar vertebral formula and body coloration. However, *A. emmae* **sp. nov.** has a moderately-sized pectoral fin (29.1–35.2% HL; Fig. 6); a relatively long preanal length (46.9–49.6% TL) and trunk (28.9–32.7% TL), and only one whitish band across dorsal surface of anterior margin of eye; whereas *A. dolichopterum* has an unusually large pectoral fin (40.0–56.7% HL; Fig. 6); a relatively short preanal length (43.1–46.8% TL) and trunk (26.6–29.8% TL), and four clear whitish bands across the dorsal surface of head. The body is generally darker in *A. emmae* than in *A. dolichopterum*. Moreover, *A. emmae* appears to mature at around 220 mm TL and the largest specimen examined is 306 mm TL, whereas *A. dolichopterum* matures at around 320 mm TL and attains at least 415 mm TL.

***Ariosoma fasciatum* (Günther, 1872)**

Barred Sand Conger; 條紋錐體糯鰻
Figs. 3D, 7; Table 2

Poecilconger fasciatus Günther, 1872:673 (type locality: Manado, Sulawesi, Indonesia).

Ariosoma nancyae Shen, 1998a:10, figs. 3A–B, 5C, 6C (type locality: Nan-fang-ao fish market, NE Taiwan).

Ariosoma fasciatum (Günther, 1872): Shen, 1998b:107. Ho & Shao, 2011:23, table 1. Ho *et al.*, 2015a: table 3. Ho *et al.*, 2015b:144.

Material examined. 11 specimens, 308–830 mm TL. FRIP 21190 (1, 608), Cheng-gong, Taitung, 22 Jul. 2005. NTUM 7871 (1, 750, holotype of *A. nancyae*), Nan-fang-ao fish market, NE Taiwan, bottom trawl, 15 Sep. 1987. LSUMZ 13544 (1, 543), Taiwan. NMMB-P23571 (1, 810), Daxi, 3 Aug. 2016. TOU-AE 1579 (1, 413), Changbin, Taitung, 25 Aug. 2005. TOU-AE 1664 (1, 472), Taitung, 2004. TOU-AE 3156 (1, 830). TOU-AE 4534 (1, 398), Changbin, Taitung, 6 Aug. 2007. USNM 398476 (1, 509), Chang-bin, 21 Oct. 2008. Other localities. BMNH 1871.7.20.63 (1, 308), holotype of *Poecilconger fasciatus*, Manado, Sulawesi, Indonesia. BMNH 1881.10.18.3 (1, 509), Tahiti.

Diagnosis. Body robust; black spots and patches on head, 10–14 black blotches or saddles across dorsal fin and body; dorsal-fin origin well in front of pectoral-fin base; interorbital space broad and flattened; vomerine teeth in a broad patch extending to about half the length of the maxillary teeth rows; head pore system complex with multiple pores (see below); total vertebrae 155–158; and total lateral-line pores 145–147.

Description. Body robust, anus slightly before midlength, dorsal-fin origin well before gill opening. Jaws moderately long, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus. Interorbital space broad, slightly concave. Snout and interorbital space very broad, tip of snout triangular in dorsal view.

Teeth small, conical, multiserial; maxillary and intermaxillary teeth continuous; teeth on posterior 2/3 of innermost row of maxillary blunt. Vomerine teeth in an elongate patch ending behind midpoint of maxillary tooth patch.

Head pore arrangement clearly different from all other congeners, with clusters of small pores instead of single pores. SO series with 1 irregular row of 4–5 pores on snout tip, followed by 1–3 small pores above posterior nostril, some with a few small pores between anterior nostrils and 3–6 small pores on interorbital space. Mandibular series with 4–5 pores in anterior half, and in posterior part 3 or 4 clusters of 2–5 smaller pores. Preopercular series with 2 rows of 3–5 pores, the last of each row largest. Four large pores in IO series along upper jaw and 4 single or 4 clusters of 3–5 small pores behind eye. Some additional small pores may be present on interorbital space. Three to 7 pores on supratemporal commissure.

Light brown background with prominent black spots and patches on head, 10–14 black blotches or saddles across dorsal fin and body, and black margin on anal fin.

Size. Maximum size at least 830 mm TL.

Distribution. Widespread in the Indo-west Pacific region from Madagascar to the Hawaiian and Society Islands. Found on sandy bottom in shallow water.



FIGURE 7. *Ariosoma fasciatum* (Gunther, 1872), NMMB-P23571, 810 mm TL.

Remarks. *Ariosoma fasciatum* was originally described as the type species of *Poeciloconger* Günther, 1872. Shen (1998b) synonymized *Poeciloconger* with *Ariosoma*, but Smith (1999) recognized the former as a valid genus. Considering the very distinct morphology of head sensory pore system and other morphological differences, this may be warranted to determine the proper definition of the various genera. However, recent DNA barcoding studies (DGS, unpubl. data) show that this species is deeply nested with other Taiwanese *Ariosoma* species, and we therefore retain it in the genus. It is also notable that the boundary between precaudal and caudal vertebrae is usually clear in other congeners, but is less distinguishable in *A. fasciatum*. The species may have a relatively higher precaudal vertebrae count compared to the total number of vertebrae than other congeners (Table 2).

Castle (1990) described a second species of *Poeciloconger*, *P. kapala* from Australia. However, this species

lacks the blotches and bars characteristic of *fasciatus* and has normal head pores. Even if *Poeciloconger* were recognized as a genus, *kapala* would not belong there. We provisionally recognize *Poeciloconger kapala* Castle (1990) as a member of *Ariosoma*.

***Ariosoma majus* (Asano, 1958)**

Major Short-tail Conger; 大錐體糯鰻

Figs. 8, 9A; Table 2

Alloconger shiroanago major Asano, 1958:191 (off Shibushi, Kagoshima Prefecture, Japan). Lee & Yang, 1966:55, fig. 3.

Alloconger major Asano, 1958: Chen & Weng, 1967:47. Chen, 1969: 132. Shen 1984:112. Chen & Yu, 1986:252. Shao *et al.*, 2008:239.

Ariosoma shiroanago major (Asano, 1958): Shen, 1998a:10.

Ariosoma major (Asano, 1958): Ho *et al.*, 2010: table 1. Ho *et al.*, 2015a: table 3. Ho *et al.*, 2015b:144.

TABLE 2. Morphometric and meristic data of *Ariosoma fasciatum*, *A. majus* and *A. meeki* from Taiwan.

TL (mm)	<i>A. fasciatum</i>		<i>A. majus</i>		<i>A. meeki</i>	
	413–830 (n=8)		213–470 (n=23)		232–497 (n=32)	
%TL	Mean (Range)	SD	Mean (Range)	SD	Mean (Range)	SD
Head length	16.4 (15.4–17.2)	0.7	17.3 (15.9–18.9)	0.8	18.3 (16.6–19.9)	1.0
Depth at gill opening	5.3 (4.4–6.2)	0.7	5.5 (4.5–7.2)	0.7	7.7 (5.5–9.2)	0.9
Depth at anus	4.8 (3.6–6.4)	1.1	5.1 (4.3–6.4)	0.6	6.4 (4.6–8.3)	1.0
Width at anus	4.1 (3.8–4.5)	0.5	3.9 (3.3–4.9)	0.4	4.0 (3.1–5.5)	0.6
Predorsal length	13.2 (11.9–14.0)	0.7	15.6 (14.4–17.1)	0.6	18.3 (16.8–19.9)	0.8
Preanal length	43.4 (41.3–45.9)	1.4	45.2 (42.4–47.7)	1.4	49.6 (47.7–51.5)	1.0
Trunk length	27.0 (24.9–30.2)	1.9	27.9 (24.9–29.7)	1.2	31.2 (28.9–32.8)	1.0
Tail length	56.6 (54.1–58.7)	1.4	54.8 (52.3–57.6)	1.4	50.4 (48.5–52.3)	1.0
%HL						
Snout length	23.2 (21.5–25.6)	1.3	23.2 (20.9–25.2)	1.1	19.3 (17.2–21.5)	1.3
Eye diameter	15.8 (14.0–16.8)	1.0	18.6 (17.1–20.3)	1.0	20.4 (18.2–22.9)	1.4
Interorbital width	11.2 (8.6–15.0)	2.3	15.3 (12.7–18.2)	1.6	16.1 (13.7–19.0)	1.4
Upper jaw	32.6 (30.5–34.2)	1.4	29.7 (27.5–31.7)	1.2	26.8 (24.4–30.7)	2.1
Gill opening width	14.0 (11.7–16.1)	1.6	13.7 (11.3–17.7)	1.6	16.6 (15.1–19.2)	1.6
Interbranchial width	12.3 (8.9–15.6)	2.4	15.2 (13.0–19.4)	1.7	17.2 (14.3–21.7)	2.0
Pectoral-fin length	28.7 (23.1–32.5)	3.8	31.7 (27.4–36.3)	2.6	35.0 (33.1–37.2)	1.6
Meristics	n=7		n=32		n=36	
Predorsal vert.	5–6		6–9		7–12	
Preanal vert.	53–59		51–55		54–66	
Precaudal vert.	ca. 82–83		68–73		76–89	
Total vert.	155–158		140–149		144–155	
Cephalic pores	9–11		8–11		7–10	
Predorsal pores	3–4		4–8		7–10	
Preanal pores	53–55		50–55		51–64	
Total pores	145–147		132–147		134–148	

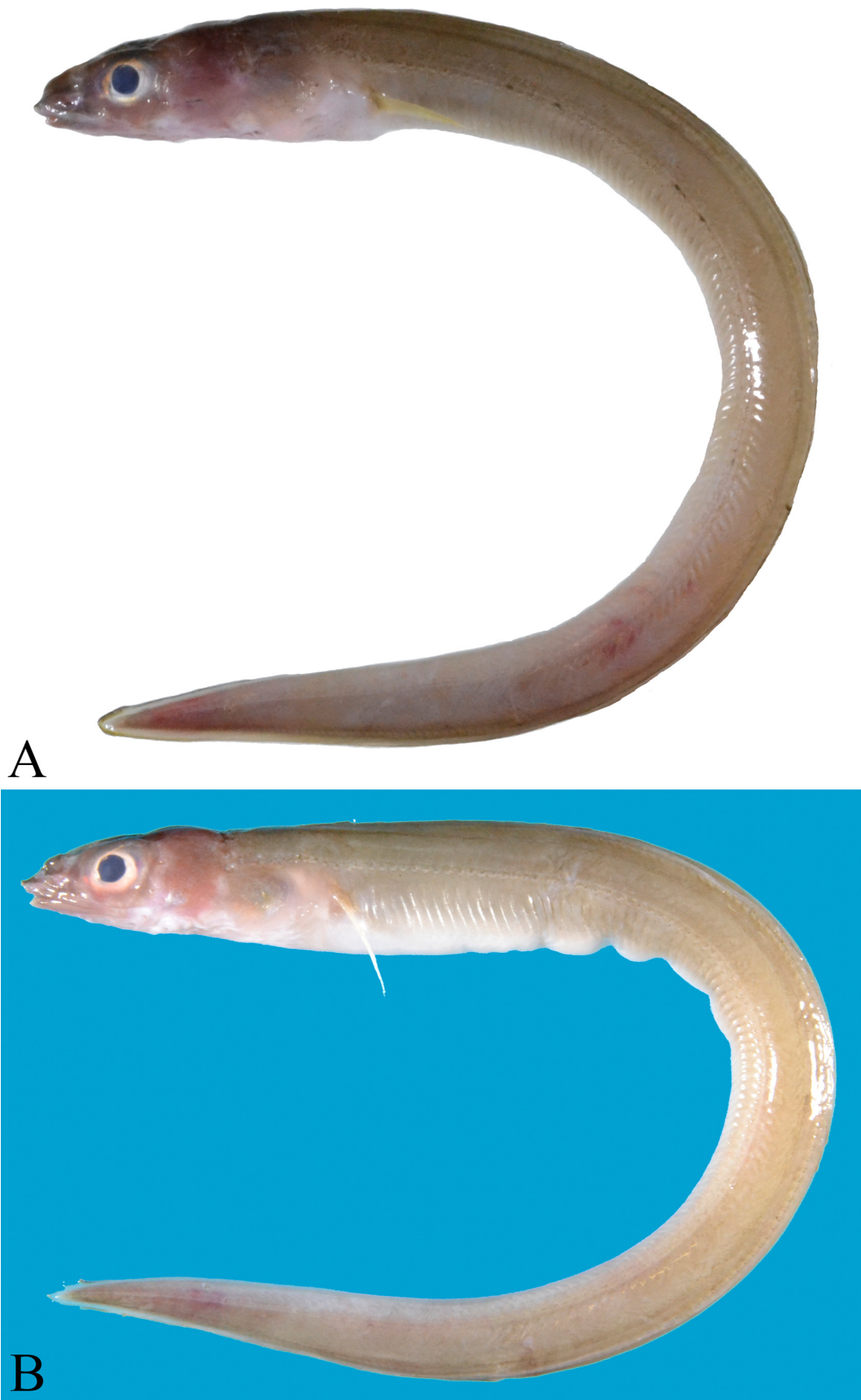


FIGURE 8. *Ariosoma majus* (Asano, 1958). A. NMMB-P23351, 334 mm TL. B. NMMB-P25290, 255 mm TL.

Material examined. 41 specimens, 130–470 mm TL (* means only meristic data used). CAS 15924 (1, 319), Taiwan Strait, ca. 90 m, 16 Jul. 1971. *CAS 51112 (1, 245), southwestern Kaohsiung, 71–91 m, 18 Jul. 1972. NMMB-P1406 (1, 423, formerly THUP 3149), Tainan, 10 Feb. 1966. *NMMB-P1795 (1, 249), Daxi, 9 Sep. 2003. NMMB-P3174 (1, 316), Kaohsiung, no date. NMMB-P11898 (1, 323), Daxi, 20 Jan. 2011. NMMB-P11904 (2, 286–297), Daxi, 21 Jan. 2011. NMMB-P11919 (4, 236–330), Nan-fang-ao, 11 Mar. 2011. *NMMB-P14075 (1, 270), Dong-gang, 10 Aug. 2011. *NMMB-P14095 (1, 321), Nan-fang-ao, 13 Sep. 2011. NMMB-P14181 (1, 320), Nan-fang-ao, 13 Sep. 2011. NMMB-P16140 (1, 265), Nan-fang-ao, 9 Jul. 2010. *NMMB-P16474 (1, 196), Nan-fang-ao, 9 May 2012. *NMMB-P21750 (1, 252), Penghu, 1 Aug. 1957. *NMMB-P23351 (4, 245–334), 31 Mar. 2016. NMMB-P24421 (1, 291), Ke-tzu-liao, 15 Jul. 2016. NMMB-P24786 (3, 225–248), Ke-tzu-liao, 31 Mar. 2016. NMMB-P25257 (1, 213), Dong-gang, 26 Apr. 2015. *NMMB-P25290 (1, 255), Ke-Tzu-liao, 31 Oct. 2016. *NMMB-P26364 (1, 130), Ke-tzu-liao, 23 Jun. 2017. NMMB-P26717 (1, 241), Ke-tzu-liao, 17 Aug. 2017. NMMB-P26983 (1, 235), Ke-tzu-liao, 29 Mar. 2017. NMMB-P27611 (1, 254), Ke-tzu-liao, 6 Mar. 2017. USNM 398442 (1, 470), Daxi, 27 Sep. 2006. USNM 398511 (1, 323), Daxi, 6 Nov. 2009. USNM 398800 (1, 229), Nan-fang-ao, 18 Nov. 2009. USNM 437332 (3, 273–329), Ke-tzu-liao, 12 Mar. 2015. Other localities. USNM 71876 (1, 307), Misaki, Japan, 1906. USNM 76543 (1, 116), Karuizawa, Japan, Aug. 1914. USNM 179752 (1, 253), Tokyo market, Japan, 1906.

Diagnosis. Body color light, with narrow black margin on vertical fins; indistinct white bands across dorsal surface of head; snout blunt; vomerine teeth in a long band, about half to 2/3 of length of maxillary tooth row; preanal vertebrae 51–55, total vertebrae 140–149; preanal lateral-line pores 50–55, total lateral-line pores 132–147.

Description. Body stout, anus slightly before midlength, dorsal-fin origin well before gill opening. Jaws moderate long, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus. Snout long, relatively blunt anteriorly.

Teeth small, conical, multiserial; maxillary and intermaxillary teeth continuous, those on innermost row of maxillary blunt. Vomerine teeth sharp anteriorly, followed by large and stout teeth, forming a narrow elongate patch ending behind midpoint of maxillary tooth patch.

Body uniformly whitish or yellowish gray, slightly paler ventrally, dorsal and anal fins with a very thin black margin. Head and snout either light color or with indistinct bands.

Remarks. *Ariosoma majus* is very similar to *A. shiroanago* but differs from the latter in having fewer total vertebrae and lateral-line pores. It is also similar to *A. anago* in having a very similar vertebral formula and number of lateral-line pores. However, it differs from the latter in having a blunter snout, very narrow dark margins on the vertical fins and lacking indistinct bars across the dorsal surface of the head.

This species was originally described in *Alloconger*, which is masculine. *Ariosoma*, however, is neuter, and the neuter form of *major* is *majus*. The species must therefore be known as *Ariosoma majus*.

***Ariosoma meeki* (Jordan & Snyder, 1900)**

Meek's Short-tail Conger; 米克氏錐體糯鰻

Figs. 9B, 10; Table 2

Congrellus meeki Jordan & Snyder, 1900:347 (type locality: Tokyo Bay, Japan).

Ariosoma meeki (Jordan & Snyder, 1900): Chen, 2004:31. Shao *et al.*, 2008:239. Ho *et al.*, 2015a: table 3. Ho *et al.*, 2015b:144.

Anago anago (non Temminck & Schlegel, 1846): Chu, 1957:15. Lee & Yang, 1966:53, fig. 1. Chen & Weng, 1967:43. Lee, 1967:44. Chen, 1969: 132. Shen 1984:112. Chen & Yu, 1986:252. Shen, 1998a:8.

Ariosoma anago (non Temminck & Schlegel, 1846): Chen, 1956:76. Liang & Yeh, 1964:8.

Material examined. 84 specimens, 121–497 mm TL (^ mean specimens measured). CAS 15923 (1, 203), Taiwan Strait, ca. 90 m, 16 Jun. 1981. CAS 20760 (1, 324), Taiwan Strait, 80–100 m, 22 Jul. 1971. CAS 30572 (1, 157), Taiwan Strait, 19 Jul. 1973. CAS 35144 (3, 132–388), Dong-gang, 7 Jul. 1973. CAS 49354 (2, 295–348), Taiwan, 1956. CAS 224558 (1, 285), Daxi, 8 Dec. 2006. CAS-SU 21244 (6, 246–281), Kaohsiung, 1906. ^NMMB-P1791 (1, 331), Daxi, 9 Sep. 2003. ^NMMB-P2459 (1, 286), Taiwan, no date. ^NMMB-P2517 (1, 298), Wan-li-tong, Pingtung, 15 Sep. 1966. NMMB-P2936 (3, 161–198), no data. ^NMMB-P3290 (10, 137–309), no data. ^NMMB-P3405 (17, 163–497), Penghu, 1 Aug. 1957. ^NMMB-P4134 (1, 343), Penghu, 1 Aug. 1957. ^NMMB-P4140 (2, 429–445), Taichung, 2 Apr. 1962. NMMB-P9022 (1, 129), Penghu, 27 Oct. 2005. ^NMMB-P11185 (3, 171–257),

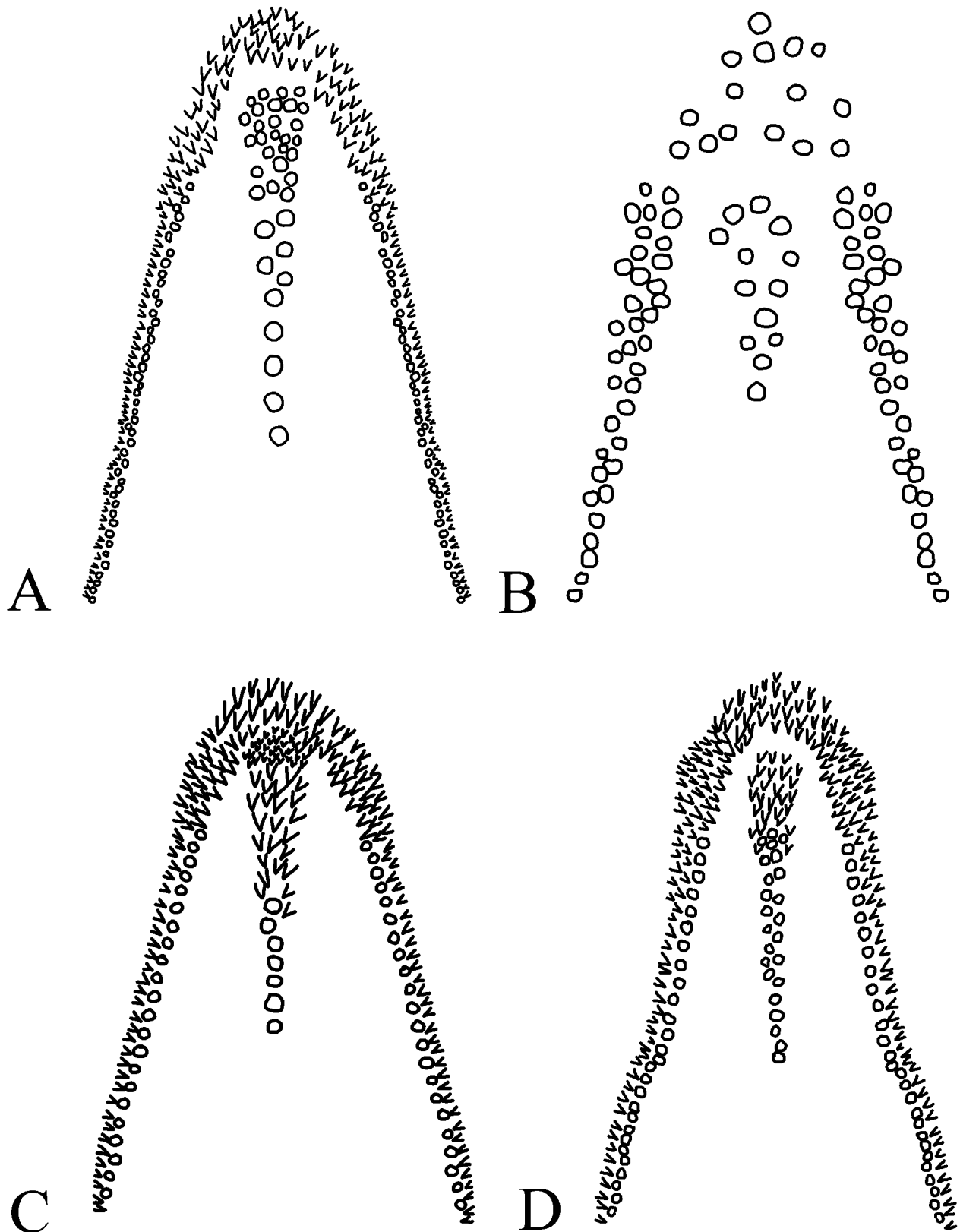


FIGURE 9. Upper-jaw teeth of *Ariosoma* species. A. *A. majus*. B. *A. meeki*. C. *A. megalops*, NMMB-P12306. D. *A. shiroanago*, NMMB-P17984. Not to scale.

Dong-gang, 15 Dec. 2010. ^NMMB-P11187 (2, 320–321), Dong-gang, 4 Sep. 2010. ^NMMB-P11905 (1, 380), Nan-fang-ao, 6 Sep. 2010. ^NMMB-P11908 (1, 333), Dong-gang, 16 Jun. 2009. ^NMMB-P14180 (1, 357), Nan-fang-ao, 13 Sep. 2011. ^NMMB-P14205 (1, 279), Dong-gang, 20 Oct. 2011. ^NMMB-P15564 (8, 159–356), no data. NMMB-P16140 (1, 286), Nan-fang-ao, 9 Jul. 2010. ^NMMB-P17761 (3, 185–267), Dong-gang, 8 Aug. 2012. USNM 76655 (4, 195–258), Kaohsiung, 3–4 Dec. 1914. ^USNM 192569 (2, 250–302), Penghu, 7 Oct. 1961. USNM 273678 (1, 228), Daxi, 23 Nov. 1969. ^USNM 398512 (1, 286), Daxi, 6 Nov. 2009. ^USNM 401978 (1, 332), Taiwan, no other data. ^USNM 437333 (1, 232), Ke-tsu-liao, 16 Oct. 2015. USNM 437334 (1, 121), Dong-gang, 23 Oct. 2015. Tentative identification. ASIZP 71041 (1, 353), Taiwan, no other data. NMMB-P21748 (1, 248), Penghu, Taiwan Strait, 1 Aug. 1957.

Diagnosis. Anus near midlength. Head pores reduced in size and number: interorbital, postorbital, and supratemporal pores absent. Two black patches at posterior margin of eye. Dorsal-fin origin above or slightly in front of pectoral-fin base; broad black margins on vertical fins. Intermaxillary tooth patch slightly upturned at its anterior end; vomerine teeth in a small triangular patch, its length about 1/4 to 1/3 of that of the maxillary tooth row. Preanal vertebrae 54–66, precaudal vertebrae 76–89, and total vertebrae 144–158.

Description. Body stout, anus near midlength, dorsal-fin origin well before gill opening. Jaws small, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus. Snout blunt and short.



FIGURE 10. *Ariosoma meeki* (Jordan & Snyder, 1900), NMMB-P23593, 233 mm TL.

Head pores small. SO canal with 4 pores; the first (ethmoidal pore) very small, on ventral side of tip of snout, just before lip; the second small and immediately in front of and above anterior nostril; the third on dorsal surface of snout above anterior nostril; fourth above and slightly behind posterior nostril at about mid-eye level; fifth and sixth absent. IO canal with 5 or 6 pores; the first right behind anterior nostril; second on upper lip above flange, below or slightly behind posterior nostril; third below anterior margin of eye; fourth above rictus slightly behind middle of eye; fifth behind rictus at level of posterior margin of eye; 0 or 1 in ascending branch of canal behind eye. POM pores 10; 7 in mandibular section, including 1 behind rictus; 3 in preopercular section, in a longitudinal row. No ST pore.

Teeth small, conical, multiserial; maxillary and intermaxillary teeth continuous; intermaxillary tooth patch slightly upturned at anterior end; vomerine teeth stout or blunt, forming a narrow elongate patch ending behind midpoint of maxillary tooth patch.

Body uniformly whitish or yellowish gray, slightly paler ventrally, dorsal and anal fins with a very thin black margin. Head and snout either light color or with indistinct bands; two dark patches behind posterodorsal and posteroventral part of eye.

Remarks. *Ariosoma meeki* can be easily distinguished from other congeners in Taiwan by having two black patches at the posterior margin of the eye and by lacking pores behind and between the eyes and in the supratemporal canal. The color of the pectoral fin shows great variation, from pinkish to entirely black. The pores on the head and lateral line are generally smaller than those of other congeners. The head is generally stouter than that of other congeners.

Two specimens (ASIZP 71041, NMMB-P21748) appeared less similar to *A. meeki*. The overall appearance is similar to *A. meeki*, however, there are slightly more pores on the head, with 3+0 or 3+1 SO pores; IO with 1–4 pores behind the eye; 0–2 preopercular pores; and 0 or 3 small ST pores. There are two indistinct black patches at the posterior margin of the eye, one above and one below, but not as clear as in the other specimens. The dorsal fin has a broad black margin and the anal fin a thin black margin. These should probably be treated separately.

Unpublished genetic data reveal two clades in Taiwan. One of these clades consists only of larvae, however, and we cannot compare and evaluate the two clades until we have morphological data on adults of both. The wide range of vertebral counts also suggests the presence of two species. *Ariosoma meeki* needs to be studied over its entire range, which extends from Japan to Australia, to resolve the taxonomy.

In some characters, *Ariosoma meeki* stands apart from the other species and approaches the condition in *Bathymyrus* and *Parabathymyrus*. The reduction in both the size and number of head pores reflects this, as does the slightly upturned intermaxillary tooth patch. There are other species that partially bridge the gap, however, and it is difficult to find a clear dividing line. A complete analysis of characters may warrant separate generic status for *Ariosoma meeki*, but we leave that for future studies.

***Ariosoma megalops* Fowler, 1938**

Bigeye Short-tail Conger; 大眼錐體糯鰻

Figures 9C, 11; Table 3

Ariosoma megalops Fowler, 1938:12, fig. 1 (type locality: Macao, Hong Kong). Smith, 1999:1686.

Material examined. 76 specimens, 67.5–213 mm TL (^ means data taken). China. ANSP 68287 (1, 136), holotype, Macao, 7 Apr. 1931. ANSP 68288 (1, 155), paratype, Hong Kong. Taiwan. ASIZP 61840 (1, 182), Hsin-chu, western Taiwan. ASIZP 61841 (1, 191), Hsin-chu, western Taiwan. ^NMMB-P1400 (1, 193, formerly THUP 4179), Dong-gang, Pingtung, 21 Jul. 1979. ^NMMB-P3010 (1, 161), no data. ^NMMB-P3209 (3, 131–170), Tainan, 10 Feb. 1966. NMMB-P13163 (1, 163), no data. ^NMMB-P25292 (1, 187), Ke-tzu-liao, Kaohsiung, 31 Oct. 2016. ^NMMB-P25628 (1, 161), Ke-tzu-liao, 7 Dec. 2016. ^NMMB-P26984 (1, 135), Dong-gang, Pingtung, 19 Jul. 2017. ^NMMB-P26985 (1, 121), Dong-gang, 9 Aug. 2017. ^NMMB-P27891 (5, 179–192), Ke-tzu-liao, 28 Mar. 2015. Vietnam. ^NMMB-P12298 (30, 138–208), Phen Thiet, 25 Nov. 2010. ^NMMB-P12300 (7, 122–200), ^NMMB-P12306 (1, 201), Mui Ne, 15 Apr. 2011. ^NMMB-P12310 (2, 65–105), Phen Thiet, 13 Apr. 2011. USNM 399972 (4, 181–203), Mui Ne, 28 Jan. 2010. USNM 399973 (3, 150–213), Mui Ne, 29 Jan. 2010. Philippines. USNM 102584 (5, 84–123), Iloilo, Panay, 6 Apr. 1929. USNM 102634 (1, 144), Iloilo, Panay, 3 Apr. 1929. USNM 102833 (1, 172), Iloilo, Panay, 6 Apr. 1929. USNM 122952 (2, 118–124), Iloilo, Panay, 6 Apr. 1929. USNM 135277 (1, 67.5), Visayas, Panay, 30 Mar. 1908.

Diagnosis. A small species usually less than 200 mm TL; eye large, eye diameter 20.1–25.3% HL; dorsal-fin origin usually behind insertion of pectoral fin, sometimes just above it; total vertebrae 116–121; total lateral-line pores 106–116; body pale grayish, without any marks on head and body. Myorhabdoi present (intermuscular bones above the epineurals and below the epipleurals).

Description. Body moderately slender, anus slightly before midlength, dorsal-fin origin above to well behind insertion of pectoral fin. Jaws small, snout relatively blunt, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus.

TABLE 3. Morphometric and meristic data of *Ariosoma megalops*, from Taiwan and Vietnam, and *A. shiroanago* from Taiwan.

	<i>A. megalops</i>				<i>A. shiroanago</i>
	Taiwan		Vietnam		300–324 (n=2)
TL (mm)	121–192 (n=14)		136–208 (n=14)		
%TL	Mean (Range)	SD	Mean (Range)	SD	Range
Head length	16.2 (15.1–16.9)	0.7	15.9 (14.7–17.6)	0.8	16.7–17.9
Depth at gill opening	4.8 (4.1–5.5)	0.4	5.2 (3.8–6.6)	0.8	5.2–5.5
Depth at anus	4.2 (2.9–5.6)	0.8	4.9 (3.4–6.7)	1.1	4.9–5.3
Width at anus	3.0 (2.6–4.0)	0.4	3.9 (2.6–5.1)	0.9	3.3
Predorsal length	16.9 (16.5–18.0)	0.5	17.5 (16.2–18.9)	0.7	14.5–16.0
Preanal length	46.7 (44.4–49.1)	1.4	46.6 (45.1–48.1)	0.9	43.7–44.8
Trunk length	30.6 (27.7–32.8)	1.4	30.7 (29.0–33.2)	1.1	26.9–27.0
Tail length	53.3 (50.9–55.6)	1.4	53.4 (51.9–54.9)	0.9	55.2–56.3
%HL					
Snout length	20.3 (17.6–22.4)	1.4	20.8 (18.9–24.0)	1.6	21.7–21.8
Eye diameter	22.9 (20.1–25.3)	1.5	22.8 (20.1–25.1)	1.7	19.5–20.2
Interorbital width	14.7 (13.2–16.4)	1.0	15.0 (12.1–18.4)	2.1	16.0–17.0
Upper jaw	28.5 (25.0–31.0)	1.6	27.2 (23.9–30.8)	1.9	27.2–28.3
Gill opening width	10.7 (8.2–15.9)	2.2	12.6 (10.0–16.1)	1.4	12.1–14.0
Interbranchial width	18.8 (15.0–23.0)	3.3	22.3 (15.3–27.4)	3.6	14.1–20.0
Pectoral-fin length	34.1 (31.6–39.3)	2.3	36.4 (30.7–41.8)	3.7	29.2–29.5
Meristics	n=14		n=14		n=2
Predorsal vert.	8–11		10–11		8–9
Preanal vert.	44–47		44–47		58–59
Precaudal vert.	54–58		55–57		82–83
Total vert.	116–120		118–121		161–162
Cephalic pores	6–8		7–8		10
Predorsal pores	8–11		8–10		6–7
Preanal pores	42–47		43–47		59
Total pores	106–116		106–114		151–158

Teeth small, conical, multiserial; maxillary and intermaxillary teeth continuous, those on innermost row of maxillary blunt. Small teeth between intermaxillary and vomerine patches. Vomerine teeth sharp anteriorly, followed by large and stout teeth, forming a narrow elongate patch ending behind midpoint of maxillary tooth patch.

Body uniformly deep grayish dorsally and much paler ventrally, dorsal with very thin black margin and ventral fin usually clear uniformly. Head and snout either light color or with indistinct bands, snout blackish.

Size. A small species, the largest specimen examined is 213 mm. A 190-mm female has numerous ripe eggs, but the actual size at maturity might be smaller.

Distribution. Known from China, Taiwan, Vietnam, and the Philippines. This species appears to be abundant in shallow waters of Vietnam.

Remarks. Our specimens were previously identified as young of other species, mostly as *A. dolichopterum*. However, *A. megalops* has the dorsal-fin origin over or behind the insertion of the pectoral fin (vs. before) and many fewer total vertebrae and lateral-line pores, and can be separated from other Taiwanese species easily. The 182-mm specimen (ASIZP 61840) has both dorsal and anal fins lacking the black margins, whereas the 191-mm

specimen (ASIZP 61841) has the dorsal fin with a narrow black margin and the anal fin uniformly clear. The black margins on dorsal fin may develop with age, and the anal fin is always clear without a black margin.

Ariosoma megalops closely resembles *Ariosoma scheelei*, another small species with a low vertebral count and the dorsal-fin origin over or slightly behind the pectoral-fin base. They are most easily distinguished the number and arrangement of the POM pores. *Ariosoma megalops* has 10 pores: seven in the mandibular section, including one behind the rictus, and three in the preopercular section, all in a longitudinal row. *Ariosoma scheelei* has 12 POM pores: 8 in the mandibular section, with two behind the rictus, and four in the preopercular section, the last one in the ascending branch of the canal above the others. In addition, *A. megalops* has myorhabdoi, and *A. scheelei* does not, but this character can only be seen on a radiograph. These two species are largely allopatric in distribution. *Ariosoma megalops* is known only from China, Vietnam, Taiwan, and a small area in the central Philippines. *Ariosoma scheelei* is widely distributed in the Pacific but has not been recorded north of the Philippines.

Kotthaus (1968) described two small specimens (86 and 142 mm) as “*Ariosoma spec (a)*” and “*Ariosoma spec. (b)*” from off Aden and Somalia. They had 110 and 114 vertebrae, respectively, counts that match only *A. megalops* and *A. scheelei* among known species. One of the specimens, spec (b), had 10 POM pores, which would match *A. megalops*. Without re-examining the specimen, however, we cannot confirm its identification.



FIGURE 11. *Ariosoma megalops* Fowler, 1938, NMMB-P25292, 187 mm TL.

***Ariosoma shiroanago* (Asano, 1958)**

White Short-tail Conger; 銀錐體糯鰻

Figs. 9D, 12; Table 3

Alloconger shiroanago shiroanago Asano, 1958:193 (type locality: off Owashi, Mie Prefecture, Japan).

Ariosoma shiroanago (Asano, 1958): Smith, 1989:495. Ho *et al.*, 2015a: table 3. Ho *et al.*, 2015b:144.

Material examined. 2 specimens, 294–324 mm. NMMB-P 17984 (1, 294), Daxi, 12 Nov. 2012. NMMB-P23978 (1, 324), Ke-tzu-liao, Kaohsiung, 21 Nov. 2016.

Diagnosis. Body and head pale yellowish to light brown, with narrow black margins on vertical fins; snout relatively blunt; vomerine teeth in a long band, about half of length of maxillary teeth.; preanal vertebrae 58–59, precaudal vertebrae 82–83, total vertebrae 161–162; and preanal lateral-line pores 59 and total lateral-line pores 151–158

Description. Body relatively slender, anus slightly before midlength, dorsal-fin origin well before gill opening. Jaws moderately long, upper jaw projecting slightly beyond tip of lower jaw, intermaxillary teeth partly concealed when mouth closed. Eye well developed, middle of eye over rictus. Snout relatively long, blunt distally.

Teeth small, conical, multiserial. Maxillary and intermaxillary teeth continuous. Vomerine teeth sharp anteriorly, followed by large and stout teeth, forming a narrow elongate patch ending behind midpoint of maxillary tooth patch.

Body uniformly whitish or yellowish gray, slightly paler ventrally, dorsal and anal fins with a very thin black margin. Head yellowish brown without any clear band.

Remarks. *Ariosoma shiroanago* is most similar to *A. majus* in having narrow black margins on vertical fins, lighter colored body and blunt snout. It can be separated from *A. majus* in having 58–59 preanal vertebrae (vs. 51–55), 161–162 total vertebrae (vs. 140–149), and total lateral-line pores (151–158 vs. 132–147).



FIGURE 12. *Ariosoma shiroanago* (Asano, 1958), NMMB-P23978, 324 mm TL.

Discussion

Eight species of *Ariosoma* are recognized in Taiwanese waters. Among these, *A. fasciatum* can be separated from the others by the many black patches on the body. The head pore system is also quite different in *A. fasciatum*, which has clusters of pores rather than individual pores on the head.

Ariosoma meeki lacks pores on the interorbital, postorbital, and supratemporal regions. Except for *A. fasciatum*, which has a highly variable pore arrangement on the head, other Taiwan congeners all have typically 6 SO pores, 8 IO pores (4 on the upper jaw, 1 behind the rictus, and 3 behind the eye), 3 ST pores, and 10 POM pores (8 on the mandibular section, including 1 behind the rictus, and 2 on the preopercular section).

The snout and interorbital space are broad in *A. fasciatum*, relatively narrow in *A. meeki*, *A. majus* and *A. shiroanago*, whereas *A. anago*, *A. emmae* and *A. dolichopterum* have a narrow and pointed snout.

Although overlapping, both *A. meeki* and *A. emmae* have a slightly greater head length, 16.6–19.9% (mean 18.3%) TL in *A. meeki* and 16.7–18.4% (mean 17.6%) TL in *A. emmae*, whereas the others have a slightly smaller head, mean head length 16.0–17.3 TL.

The dorsal-fin origin is usually behind the insertion of pectoral fin in *A. megalops*, just over the pectoral-fin base in *A. meeki*, whereas it is far in front of the pectoral-fin base in the other congeners.

The anus is almost at the midpoint of the body in *A. meeki* (mean preanal length 49.6% TL), whereas the other congeners have the anus slightly anterior to the midpoint of the body (mean preanal length 43.4–48.1% TL). Mean tail length is 50.4% TL in *A. meeki* whereas other congeners are 51.9–56.6% TL.

Ariosoma anago, *A. fasciatum* and *A. majus* have a relatively long snout (mean 23.2% HL in all three species), whereas *A. megalops* has shortest snout (mean 20.3–20.8% HL). In other species it is moderately long.

Ariosoma megalops has very large eye (mean eye diameter 22.8%–22.9% HL), whereas *A. emmae*, *A. fasciatum* and *A. dolichopterum* have a relatively small eye, mean eye diameter 17.3%, 15.8% and 16.8% HL, respectively. The other species have a moderately large eye, mean eye diameter 18.6–21.1% HL.

Ariosoma anago and *A. fasciatum* have relatively large upper jaw, mean 31.2% HL and 32.6% HL, respectively, whereas *A. meeki* has shortest upper jaw, mean 26.8% HL. In other species it is moderate in length.

Ariosoma dolichopterum has a very long pectoral fin, its mean length 45.8% HL, whereas *A. fasciatum* has a relatively short pectoral fin, its mean length 28.7% HL. Other congeners have intermediate values, ranging between 29.3–36.4% HL.

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