Zootaxa 4060 (1): 041–048
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.4060.1.6
http://zoobank.org/urn:lsid:zoobank.org:pub:6FCD98F2-A06B-4FD1-A6D1-A5E5911F80C4

A new genus and species of worm eels, *Sympenchelys taiwanensis* (Anguilliformes: Ophichthidae: Myrophinae), from the northwestern Pacific Ocean

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Abstract

A new genus and species of ophichthid eel, *Sympenchelys taiwanensis* is described. The genus is distinguishable from all other myrophine genera by having neural and haemal spines with well-developed paddle-like tips, and from two closely similar genera, *Mureaenichthys* Bleeker 1853 and *Skythrenchelys* Castle & McCosker 1999, by the following combination of characters: an unconstricted gill opening; a minute flap just posterior to the gill opening; a slender cleithrum; three pre-opercular pores; a slender and distinctly tapered maxilla; an undeveloped supraoccipital crest; and large and recurved teeth on jaws and vomer. *Sympenchelys taiwanensis* is described from five specimens collected from Taiwan, the northwestern Pacific Ocean.

Key words: Ophichthidae, new genus, new species, Taiwan, Japan

Introduction

Worm eels belonging to the subfamily Myrophinae (Anguilliformes: Ophichthidae) are distributed worldwide in tropical and subtropical waters. The Myrophinae currently consists of 14 genera and ca. 70 species, which are defined by having a small but conspicuous caudal fin, more numerous free branchiostegal rays than attached rays, and accessory branchiostegal rays which originate behind the ends of the epihyal (McCosker 1977; Hibino, unpublished data). Although new species from the East Asia area have occurred successively in recent years, the status of the species diversity of Myrophinae is still unclear (Hibino *et al.* 2012, 2013; McCosker *et al.* 2012a, b). A very unique species with well-developed paddle-shaped tips on its neural and haemal spines was collected from Taiwan. It is herein described as a new genus consisting of a single new species. A single unidentifiable juvenile specimen resembling the new genus/species was collected from Japan.

Materials and methods

Measurements were made either with a 300 mm ruler to the nearest 0.1 mm for total and tail lengths and with a digital caliper to the nearest 0.01 mm for all other measurements. Measurements generally follow Castle & McCosker (1999) except for the following measurements; dorsal-fin origin to anus: horizontal distance between the dorsal-fin origin and a vertical through mid-anus; upper-jaw length: from the tip of the snout to the posterior margin of the maxilla, inferred from the surface (confirming by soft-X ray photos and transparent specimens); length of mouth gape: from the tip of the snout to the end of the mouth rictus not including the attached fold behind the rictus. Total and head lengths are abbreviated as TL and HL, respectively. Vertebral counts follow Böhlke (1982); mean vertebral formula (MVF) is expressed as the average of predorsal, preanal, and total vertebrae. Examination and terminology of osteological characters follow McCosker (1977). Vertebral counts and other

Accepted by J. E. McCosker: 11 Aug. 2015; published: 24 Dec. 2015

osteological examinations were made from soft-X ray photos and transparent specimens stained with Alcian Blue and Alizarin Red-S (Dingerkus & Uhler 1977). Sensory-pore counts of head generally follow Castle & McCosker (1999). The median frontal and the mid-temporal pores are not included in these counts. Lateral-line pores before the anus were counted from the pore just behind the lowest supratemporal pore (located at about mid-lateral line) to the pore crossed by a vertical through mid-anus. Cyanin Blue was used for staining pores and some other structures. Institutional abbreviations follow Fricke & Eschmeyer (2014).

Systematics

Sympenchelys gen. nov.

Type species. *Sympenchelys taiwanensis* sp. nov.

Diagnosis. A genus of the family Ophichthidae, subfamily Myrophinae, defined by neural and haemal spines with well-developed paddle-like tips (Fig. 1) and the following combination of characters: anterior nostril tubular; posterior nostril opening outside of mouth, above upper lip, with a short flap anteriorly; eye located above anterior half of upper jaw; teeth on jaws, vomer and intermaxillary region, generally large, recurved and pointed; a single sensory pore located between anterior and posterior nostrils; three preopercular pores; gill opening large, not constricted; pectoral fin absent, but an extremely short dermal flap located just after gill opening; maxilla relatively slender and distinctly tapered posteriorly; supraoccipital crest not developed.

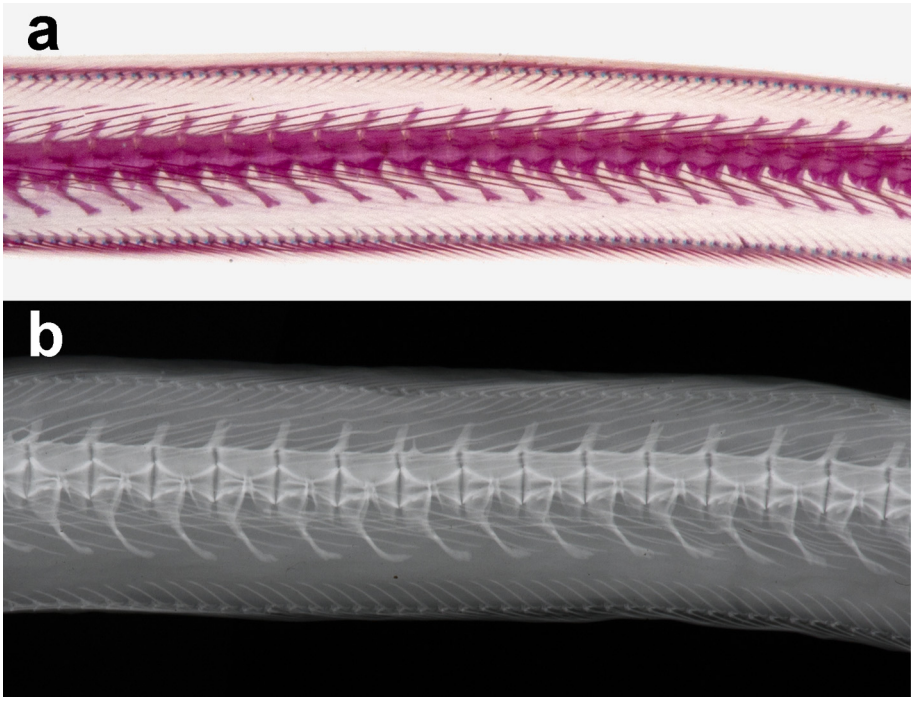

FIGURE 1. Caudal vertebrae of *Sympenchelys taiwanensis* sp. nov. **a** NMMB-P 17554, paratype, 194.0 mm TL (cleared-and-stained); **b** ASIZP 60198, paratype, 279.0 mm TL (soft-X ray photograph).

Description. Body long, extremely compressed laterally, preanal length shorter than tail (Fig. 2). Anterior nostril tubular; posterior nostril opening outside of mouth, above upper lip, with a short flap anteriorly; eye located above anterior half of upper jaw; mouth inferior; mouth large; lips smooth. Teeth on jaws, vomer and intermaxillary region, generally large, recurved and pointed. Gill opening large, not constricted; an extremely short dermal flap located just after gill opening. Median fins low, confluent with caudal fin; origin of dorsal fin located before anus. Sensory pores of head developed, supraorbital, infraorbital, preoperculomandibular, interorbital and supratemporal pores present. Gill arches less developed: first basibranchial ossified, second to fourth

basibranchials cartilaginous; first and second hypobranchials ossified, third cartilaginous; first to fourth ceratobranchials ossified, fifth absent; first to fourth epibranchials ossified; first and second interbranchials ossified; third upper pharyngeal tooth plate with three conical teeth, fourth upper pharyngeal tooth plate with 16 conical teeth arranged as an oval ring along edge of plate and scattered inside, both plates closely sutured but not fused; lower pharyngeal tooth plate with 15 conical teeth in two longitudinal rows. Jaws elongate; maxillae relatively slender and distinctly tapered posteriorly. Eight branchiostegal rays attached to each epihyal with 31 unattached pairs well behind basal arch. Pectoral girdle reduced to extremely slender cleithrum and supracleithum. Supraoccipital crest not developed. Epipleural ribs on all precaudal vertebrae. Neural and haemal spines with well-developed paddle-like tips.

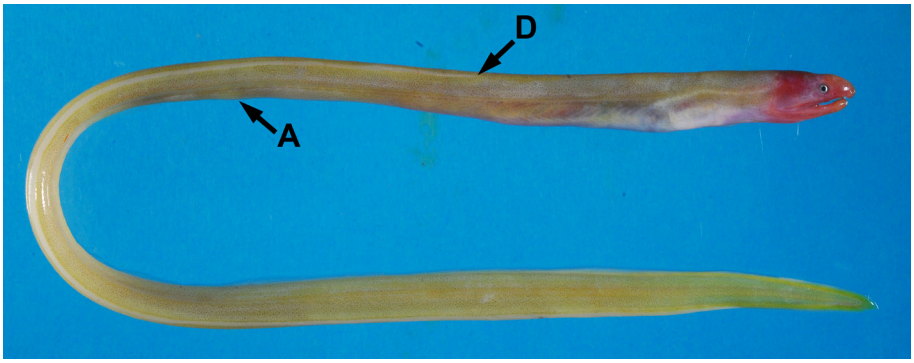

FIGURE 2. Fresh condition of *Sympenchelys taiwanensis* sp. nov., NMMB-P 22188, holotype, 258.8 mm TL, collected from Dong-gang, Taiwan. A, position of anus; D, origin of dorsal fin.

Etymology. The scientific name is derived from its compressed body and neural and haemal spines, the Greek *sympiez* (compress) and *enchelys* (an eel), feminine.

Remarks. The genus can be distinguished from all other myrophine genera by the well-developed neural and haemal spines with paddle-like tips. Although *Muraenichthys gymnopterus* (Bleeker 1853) and *Muraenichthys thompsoni* Jordan & Richardson 1908 have relatively better developed neural and haemal spines, their neural spines have pointed, not paddle-shaped tips.

Sympenchelys is also easily distinguished from eight (*Ahlia* Jordan & Davis 1891, *Asarcenchelys* McCosker 1985, *Benthenchelys* Fowler 1934, *Mixomyrophis* McCosker 1985, *Myrophis* Lütken 1852, *Neenchelys* Bamber 1915, *Pseudomyrophis* Wade 1946, *Pylorobranchus* McCosker & Chen 2012) of 14 genera of Myrophinae by the absence of its pectoral fin. The genus differs from other genera lacking pectoral-fins (*Glenoglossa* McCosker 1982, *Schultzidia* Gosline 1951, *Schismorhynchus* McCosker 1970, and *Scolecenchelys* Ogilby 1897) in the position of the posterior nostril (outside of mouth in *Sympenchelys* vs. within or along upper lip), the position of the eye (anterior to mid jaw vs. posterior to mid jaw except *Glenoglossa*), and the presence of vomerine teeth (present vs. absent in *Glenoglossa* and *Schultzidia*).

The genus resembles *Muraenichthys* Bleeker 1853 and *Skythrenchelys* Castle & McCosker 1999 in the position of the posterior nostril and the eye. However, the former can be distinguished from the latter two genera by having an unconstricted gill opening (vs. constricted in *Muraenichthys*), a minute flap just posterior to the gill opening (vs. absent in *Skythrenchelys*), a slender cleithrum (vs. stout in *Skythrenchelys*), three preopercular pores (vs. two in *Skythrenchelys*), a slender and distinctly tapered maxilla (vs. stout and weakly tapered in *Skythrenchelys*), an undeveloped supraoccipital crest (vs. developed in *Muraenichthys*), and large and recurved teeth on jaws and vomer (vs. blunt or pointed but small conical teeth in *Muraenichthys*).

Sympenchelys has an extremely minute flap just after the gill opening (Fig. 3). Although its shape is similar to a small pectoral fin, it is not regarded as a pectoral fin because of the much reduced elements of the pectoral girdle, absence of fin-rays, the strange position of the flap compared with other Myrophinae, and a vertical membrane connected with the flap from both vertical sides.

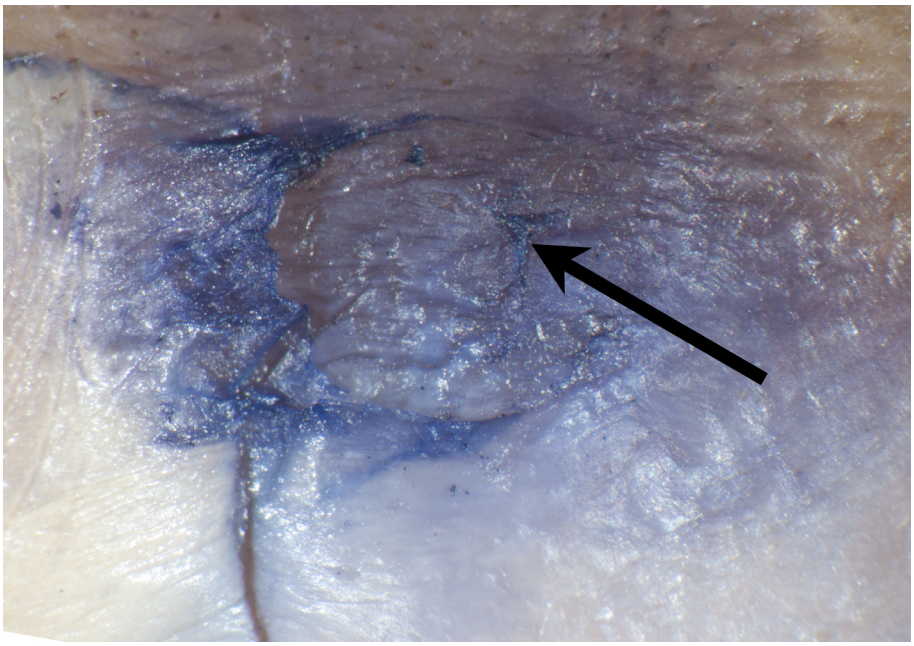

FIGURE 3. Magnification around left gill opening of *Sympenchelys taiwanensis* **sp. nov.**, ASIZP 60198, paratype, 279.0 mm TL. *Arrow* indicates an extremely short dermal flap.

***Sympenchelys taiwanensis* sp. nov.**
New English name: Taiwanese Worm Eel
(Figs. 1–6; Table 1)

Holotype. NMMB-P 22188, 258.8 mm TL, female, Dong-gang, Taiwan, 4 December 2014, bottom trawl, collected by H.-C. Ho.

Paratypes. Four specimens, 165.0–279.0 mm TL. ASIZP 60198, 279.0 mm TL, female, Dashi, Yilan, Taiwan, 15 March 1999, bottom trawl, collected by P.-L. Lin; FRLM 49936, 187.5 mm TL, sex unknown, Dong-gang, Taiwan, 3 November 2011, bottom trawl, collected by H.-C. Ho; NMMB-P 17554, 194.0 mm TL, female, Dong-gang, Taiwan, 9 November 2012, bottom trawl, collected by H.-C. Ho (cleared-and-stained after measurement); NSMT-P 123778 (donated from NMMB), 165.0 mm TL, sex unknown, Dong-gang, Taiwan, 10 March 2015, collected by H.-C. Ho.

Diagnosis. A species of the genus *Sympenchelys* with the following combination of characters: tail 65–66% TL; dorsal-fin origin anterior to mid trunk; lateral-line pores before anus 44–47; predorsal vertebrae 26–28, preanal vertebrae 43–51, and 152–164 total; MVF 27-48-160.

Description. Counts and measurements are shown in Table 1, and characters given in "Description" of the genus are not repeated. Head moderate in size. Snout blunt, equal to or slightly longer than twice eye diameter; distance from tip of snout to anterior tip of lower jaw almost equal to half of eye diameter; no median groove ventrally on snout; eyes small, covered by a transparent skin; teeth on upper jaw biserial, teeth of inner row larger than outers (Fig. 4); teeth on lower jaw uniserial; intermaxillary teeth slightly shorter than jaw teeth, arranged semicircularly; vomerine teeth large, arranged uniserially; interorbital region convex without a median groove; arrangement of sensory pores on head as follows (Fig. 5): one + four on supraorbital, three + two on infraorbital (one between anterior and posterior nostrils), six on lower jaw, three on preopercle, and two on supratemporal; single median interorbital and mid-temporal pores; lateral-line pores small but obvious, almost complete except for near tip of tail.

Coloration. Freshly caught specimens (Fig. 2) uniformly yellowish green with numerous tiny melanophores. Median fins with paler margins, posterior part darkish yellow. Anterior head reddish and anterior region of abdomen silver white. Preserved in 50% isopropanol or 70% ethanol, head and body uniformly yellowish brown or pale whitish brown, small dark spots distributed on lower jaw, tail, and upper half of head and trunk. All fins pale brown.

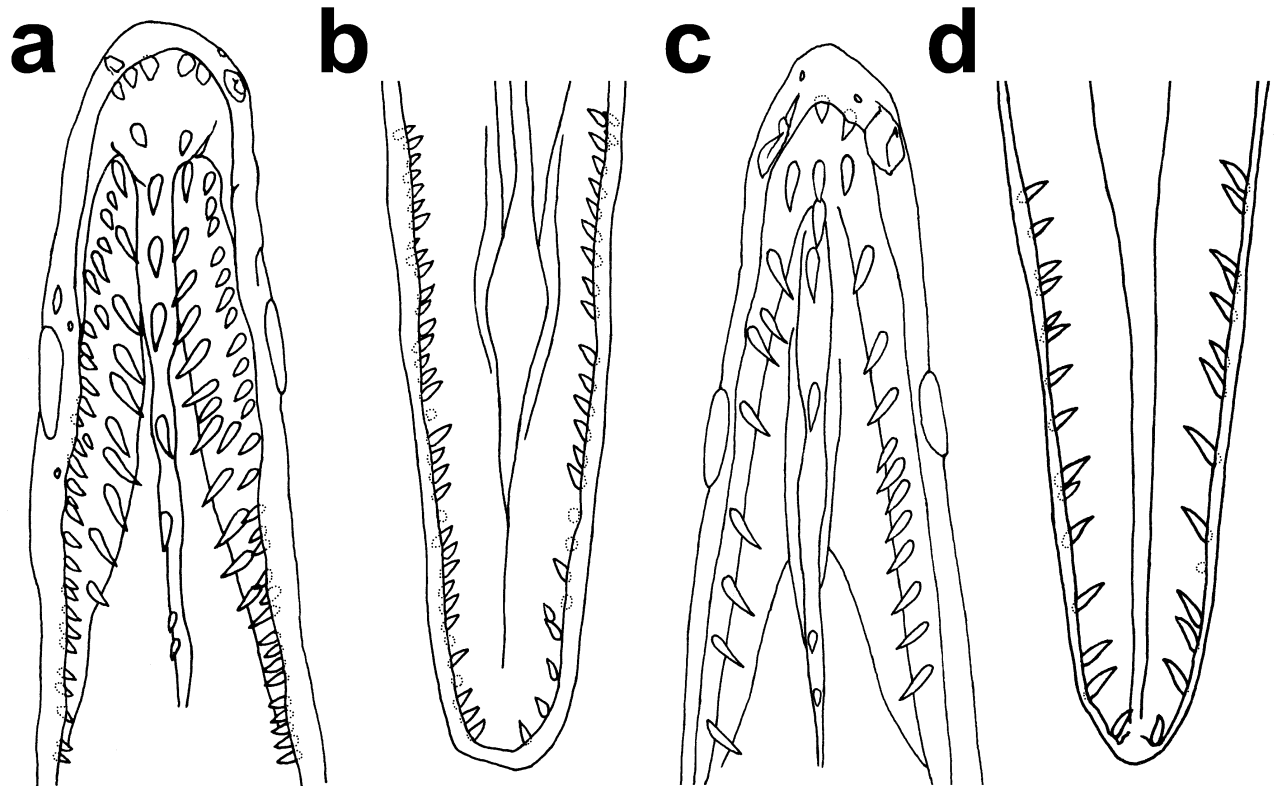

FIGURE 4. Teeth of *Sympenchelys taiwanensis* sp. nov. (**a**, **b**) and the unidentifiable juvenile specimen (**c**, **d**). **a**, **b** ASIZP 60198, paratype, 279.0 mm TL; **c**, **d** KPM-NI 23506, 51.4 mm TL, collected from Shizuoka Prefecture, Japan. *Dotted circles* indicate toothless holes.

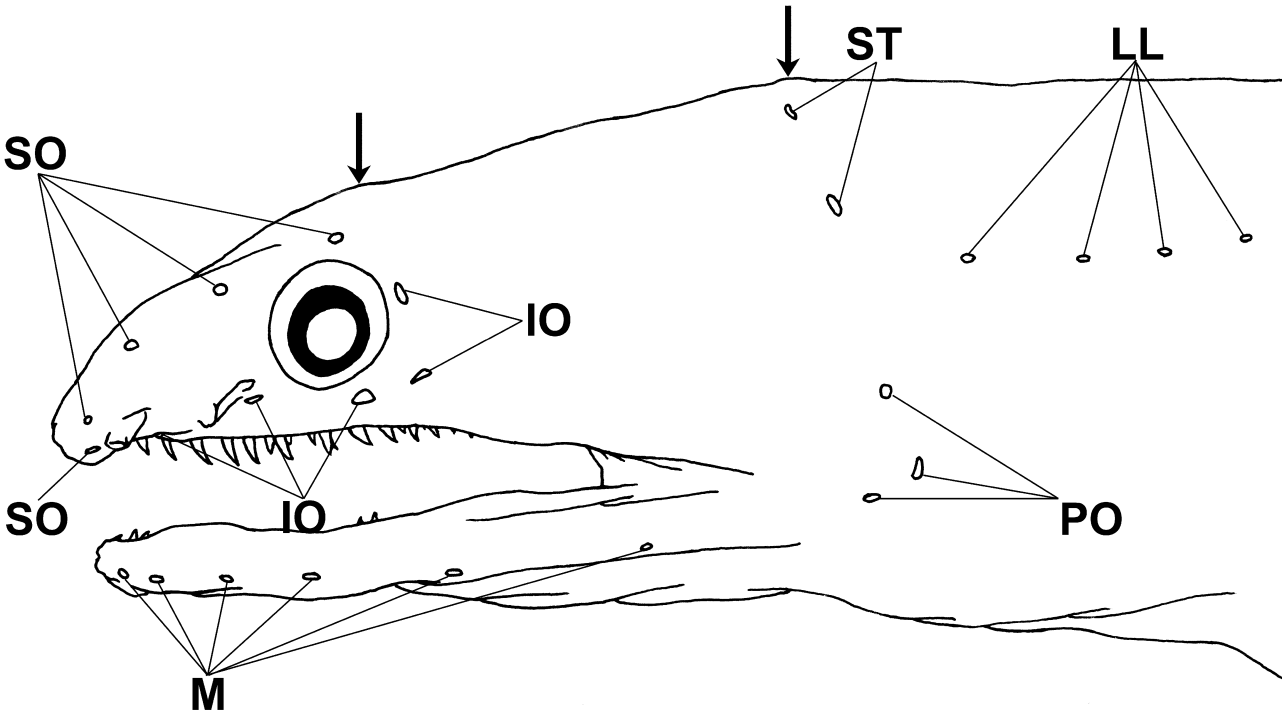

FIGURE 5. Sensory pores on head of *Sympenchelys taiwanensis* sp. nov., ASIZP 60198, paratype, 279.0 mm TL. IO, infraorbital pores; LL, lateral-line pores; M, mandibular pores; PO, preopercular pores; SO, supraorbital pores; ST, supratemporal pores. *Arrows* indicate interorbital and median supratemporal pores.

TABLE 1. Counts and measurements of *Sympenchelys taiwanensis* and the unidentifiable juvenile specimen.

	Holotype		Paratypes			Unidentifiable juvenile specimen
	NMMB-P 22188	ASIZP 60198	NMMB-P 17554	FRLM 49936	NSMT-P 123778	KPM-NI 23506
Total length (mm)	258.8	279.0	194.0	187.5	165.0	51.4
Counts						
Lateral-line pores before anus	49	44	47	48	47	47
Predorsal vertebrae	28	27	26	28	–	24
Preanal vertebrae	50	43	48	51	–	45
Total vertebrae	161	152	162	164	–	148
Measurements						
As % of total length						
Head length	12	10	12	12	12	14
Trunk length	23	24	23	23	23	23
Tail length	65	66	65	65	65	62
Predorsal length	21	21	20	21	19	23
Body depth at gill opening	3.2	3.6	3.0	2.4	3.3	2.9
Body depth at mid-anus	3.0	3.3	2.9	2.1	3.3	2.2
Body width at gill opening	1.9	1.7	1.6	1.1	2.2	1.6
Body width at mid-anus	1.6	1.5	1.6	1.1	2.3	1.5
As % of head length						
Dorsal-fin origin to anus	113	118	123	116	129	101
Upper-jaw length	42	42	48	42	44	45
Length of mouth gape	32	32	38	33	33	34
Snout length	13	14	13	13	12	16
Eye diameter	5.5	5.4	7.0	7.1	8.4	6.4
Interorbital width	4.7	7.5	4.7	3.9	6.1	9.9
Gill-opening length	6.4	7.1	4.8	4.0	3.3	3.5
Body depth at gill opening	27	35	24	20	28	20
Body depth at mid-anus	26	32	23	17	28	16

Distribution and ecological note. Known from northeastern and southwestern Taiwan, possible depth range 100–300 m.

Etymology. The scientific name "*taiwanensis*" is derived from the type locality.

Remarks. Although depth and habitat of adults is unknown, the type series were collected by bottom trawl with green-eyes (*Chlorophthalmus* spp.), lizardfishes (*Saurida* spp.), conger eels, and some shallow water grenadiers (*Coelorinchus* spp.). It is expected that their benthic life occurs at depths between 100 and 300 meters.

A juvenile specimen (KPM-NI 23506, 51.4 mm TL) similar to the new species in general appearance and in the shape of its jaw teeth was collected from central Japan. The specimen also agrees well *S. taiwanensis* in its preanal vertebral count and cephalic sensory-pore counts (Table 1, Fig. 6). However, it lacks paddle-shaped neural and haemal spines and has uniserial teeth on its upper jaw (Fig. 4c). Although the differences between the juvenile specimen and the new species are likely to be considered as ontogenetic variation, we cannot conclude that it is conspecific with *S. taiwanensis*. Medium-sized specimens of the new species or molecular data are needed.

FIGURE 6. Lateral view of the body (**a**) and head (**b**) of the unidentifiable juvenile specimen, KPM-NI 23506, 51.4 mm TL.

Comparative materials. Unidentifiable juvenile specimen: KPM-NI 23506, 51.4 mm TL, juvenile, 0 m (near the surface), Osezaki, Numazu, Shizuoka Prefecture, Japan, 14 November 2008, collected by R. Minemizu. *Ahlia egmontis*: FMNH 99266, two, 252–392 mm TL, Belize, Caribbean Sea. *Asarcenchelys longimanus*: MNHN B. 2994 (paratype), ca. 140 mm TL (damaged), off Belém, Brazil, western Atlantic. *Glenoglossa wassi*: CAS 47049 (holotype), 153.5 mm TL, Tutuila Island, American Samoa; USNM 378662, two of eight, 105.3–112.9 mm TL, Mindoro Island, Philippines. *Mixomyrophis longidorsalis*: HUJ 11651 (holotype), 77.0 mm TL, Israel, Red Sea. *Neenchelys cheni*: NSMT-P 69185, 358.5 mm TL, Nha Trang, Vietnam. *Muraenichthys gymnopterus*: RMNH.PISC. 7165 (holotype), 223.0 mm TL, Java, Indonesia. *Muraenichthys hattae*: FRLM 34541, 303.9+ mm, Owase, Mie Prefecture, Japan (cleared and stained). *Muraenichthys schultzei*: BMNH 1867.11.28.331 (holotype), 94.0 mm TL, Batavia, Java Island, Indonesia. *Muraenichthys thompsoni*: SU 20201 (holotype), 96.0 mm TL, Luzon Island, Philippines; NMMB-P 17508, 174.8 mm TL, Dong-gang, Taiwan; HUMZ 198661, 179.5 mm TL, Panay Island, Philippines. *Myrophis microchir*: CAS 28696, 109.3 mm TL, Guam. *Neenchelys mccoskeri*: NSMT-P 108567 (paratype), 311.0 mm TL, Shizuoka, Japan. *Pseudomyrophis atlanticus*: MNHN 1971-0041 (paratype), 238.0 mm TL, Congo, eastern Atlantic. *Schultzidia johnstonensis*: USNM 409172, 124.2 mm TL, Marquesas Islands, French Polynesia. *Schismorhynchus labialis*: ANSP 124362, two of 37, 112.6–117.8 mm TL, Mombasa, Kenya. *Scolecenchelys australis*: AMS I.16266-001 (syntypes), three, 154.9–246.0 mm TL, Lane Cove River, New South Wales, Australia. *Skythrenchelys macrostoma*: BMNH 1867.11.28.313 (holotype), 223.0 mm TL, Ambon Island, Indonesia; BPBM 29320 (holotype of *Skythrenchelys lentiginosa*), 163.1 mm TL, the Red Sea, Port Sudan Harbor. *Skythrenchelys zabra*: BPBM 38404 (paratype), 185.0 mm TL, Cobourg Peninsula, Northern Territory, Australia; CAS 51992, 136.5 mm TL, Negros Island, Philippines.

Acknowledgments

We are deeply indebted to J. E. McCosker (CAS) and F. Tashiro (FAKU, formerly NSMT) for their valuable comments and discussion of the new species. We wish to express our gratitude to the following for their help with specimen loans and hospitalities during our visits: M. McGrouther (AMS); M. Sabaj (ANSP); K.-T. Shao and P.L. Lin (ASIZP); J. Maclaine (BMNH); J. E. Randall, A. Suzumoto, and L. R. O'Hara (BPBM); J. E. McCosker and D. Catania (CAS); D. Golani (HUJ); M. Yabe, H. Imamura, and T. Kawai (HUMZ); H. Senou (KPM); G. Duhamel, P. Pruvost, and R. Causse (MNHN); R.-R. Chen (NMMBA); G. Shinohara and M. Nakae (NSMT); M. J. P. van Oijen and R. de Ruiter (RMNH); and J. T. Williams (USNM).

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