First Japanese Record of *Muraenichthys gymnopterus* (Anguilliformes, Ophichthidae) from Ishigaki-jima Island, Ryukyu Archipelago

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A single specimen of *Muraenichthys gymnopterus* (Bleeker, 1853) was collected from a sandy intertidal flat having rocks and dead corals in the estuarine area of Nagura Amparu, Ishigaki-jima Island, southern Japan, in October 2020. This specimen collection constitutes the first record of *M. gymnopterus* from Japanese waters. In this study, the diagnostic characters between *M. gymnopterus* and *M. hattae* Jordan and Snyder, 1901 are provided, based on our morphological observations of 37 specimens, including Okinawan specimen, and previous studies, as follows: head length (M. gymnopterus 11.8–15.0% of total length (TL) vs. M. hattae 9.4–11.0%), trunk length (24–25.4% of TL vs. 28–31%), the horizontal distance from the dorsal-fin origin to a vertical line through the anus 73–87% of head length vs. 13–49%), the number of vertebrae (total 129–130 vs. 148–155; predorsal 30 vs. 47–53; preanal 41–44 vs. 51–55), the number of the lateral-line pores before the anus (43–45 vs. 51–55). Additionally, the body depth at the gill opening in TL and the trunk length in TL can also be used to distinguish between these two species (2.8–3.7% of TL vs. 1.4–3.0%). Although *M. gymnopterus* has previously been reported from tropical to temperate regions, we suspect that the records from temperate regions are based on misidentification of *M. hattae*.

Key Words: Myrophinae, new record, estuary, western Pacific Ocean, Yaeyama Islands, Ramsar Convention.

Introduction

The family Ophichthidae, commonly known as the snake or worm eels, has the largest number of anguilliform fishes, comprising 62 genera with 355 species worldwide except polar regions (Fricke et al. 2021). One of these genera, *Muraoenichthys* Bleeker, 1853, belonging to the subfamily Myrophinae, has been reviewed and revised several times (McCosker 1970, 1977; Machida and Ohta 1993; McCosker and Parin 1995; Castle and McCosker 1999; Hibino and Kimura 2015) and currently comprises eight valid species (Hibino and Kimura 2015). Hibino and Kimura (2015) considered *M. hattae* a junior synonym of *M. gymnopterus* without any comments. Alternatively, Hatooka (2013) and Hibino and Kimura (2015) suggested that *M. hattae* should be considered as a valid species based on differences from *M. gymnopterus* in terms of head length (HL) in total length (TL), body depth in HL, and eye diameter in HL. Hibino and Kimura (2016) also treated *M. hattae* a valid species. However, the differences in morphological characteristics between *M. gymnopterus* and *M. hattae* have not been adequately discussed.

During a collecting survey with the principal purpose of updating the Japanese Ministry of Environment’s Red List, a single specimen of *M. gymnopterus* was collected in the Nagura Amparu, a Ramsar Site on Ishigaki-jima Island, subtropical area in Japan (Fig. 1A). Commonly, this species inhabits tropical to subtropical regions, and it has never been reported in Japanese waters to date. Hence, this collected specimen represents the first record of *M. gymnopterus* from Japan. Based on this specimen, this study provides a detailed description of *M. gymnopterus*.
Materials and Methods

The preserved specimen in 70% ethanol after fixed by 10% formalin solution was used for morphological observation. Counts and measurements were obtained from the left side of each specimen, wherever possible, following the methods described by Hibino and Kimura (2015). Almost all measurements were performed to the nearest 0.1 mm using a digital caliper. The measures of the total length and the tail length of the specimens were done to the nearest 1 mm using a ruler, except for the Ishigaki-jima Island specimen. Total and head lengths were abbreviated as TL and HL, respectively. Sensory and lateral-line pores were counted on the left sides of the specimens after staining with cyanine blue following the method described by Hibino and Kimura (2015). The vertebrae were counted using soft X-ray radiography (SOFRON SRO–405A and SOFTEX, TYPE EMB; SOKEN Co., Ltd). The institute codes follow Fricke and Eschmeyer (2021), except for WMNH (Wakayama Prefectural Museum of Natural History, Japan).

Taxonomic Accounts

*Muraenichthys gymnopterus* (Bleeker, 1853)
[New standard Japanese name: Usiba-mimizu-anago (ウシィバーミミズアナゴ)]
(Figs 2, 3; Table 1)

*Muraenichthys gymnopterus* Bleeker, 1853a: 52 (original description; type locality: Jakarta, Java, Indonesia).
*Muraenichthys gymnopterus* Bleeker, 1853a: 71 (Jakarta, Java, Indonesia); Bleeker, 1853b: 506 (Java, Indonesia); Bleeker 1864a: 32, pl. CL, fig. 1 (Java, Indonesia); Günther 1870: 52 (Java, Sulawesi, and Batu Islands, Indonesia); Weber and de Beaufort 1916: 276 (Java and Sulawesi, and Batu Islands, Indonesia; Philippines; Kandavu Island, Fiji); Herre 1923: 155, fig. 2 (in part; Java to China, Philippines, and Fiji); Kottelat 2013: 45 (in part; Southeast Asia); McCosker 2014: 339 (Philippines); Hibino and Kimura 2015: 69 (Java and Batanta islands, Indonesia); Ho et al. 2015: 168 (Taiwan); Mohapatra et al. 2019: 283 (east coast of India); Hibino et al. 2019: 48 (Dumaguete, Negros and Luzon, Philippines; Viti Levu Island, Fiji; Tainan, Taiwan).

*Muraenichthis gijmnopterus* Bleeker 1853a: 71 (Java, Indonesia, incorrect subsequent spelling of *Muraenichthys gymnopterus*).
*Muraenichthys microstomus* Bleeker, 1864b: 39 (type locality: Makassar, Sulawesi, Indonesia); Bleeker 1864a: 32, pl. CL, fig. 2 (Makassar, Sulawesi, Indonesia).

Material examined. WMNH-PIS12244, 174.5 mm TL, Nagura Amparu, Ishigaki-jima Island, Japan, 24°24′ N, 124°08′ E, intertidal sand flat in estuary with rocks and dead corals, 29 October 2020, hand net, coll. K. Maeda.

Description. The counts and measurements are listed in Table 1. Body elongate, subcylindrical; tail relatively long, tapering posteriorly (Fig. 2). Branchial basket swollen. Mouth large, rictus beyond posterior margin of eye and slightly behind end of a vertical line through infraorbital pore. Snout blunt and broad. Outer opening of anterior nostril tubular, located in upper lip beneath eye; posterior nostril outside of mouth, with small projected flap on anterior corner of posterior nostril. Eye moderate in size, 6.7% of HL, covered by transparent skin; eye located anteriorly to above middle point of upper-jaw between tip of snout and end of maxilla. Teeth present on upper and lower jaws, vomer, and intermaxillary areas; lengths less than a half of eye diameter. Teeth generally blunt and granular; those in posterior areas of upper and lower jaws weakly pointed. Teeth in upper and lower jaws arranged mainly in two rows, irregularly in three rows in part, and reduced gradually to posterior end (Fig. 3B). Vomerine teeth multiserial, arranged mainly in three rows, reduced gradually to posterior end; intermaxillary teeth continuous with vomerine teeth, arranged in a circular patch. Cephalic sensory pores small but prominent; arrangement of sensory pores in head as fol-
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Lows (Fig. 3A): one + four supraorbital pores, two + three infraorbital pores (single pore between anterior and posterior nostrils), six + three preoperculomandibular pores, two supratemporal and a single median supratemporal pores, single interorbital pore. Lateral-line above median line of body, running to tip of tail; lateral-line pores developed, 32 anterior to dorsal-fin origin and 45 anterior to anus. Interorbital region flat without distinct groove. Gill opening constricted, located ventrolaterally. Dorsal and anal fins high, height equal to or higher than eye diameter, confluent with caudal fin. Dorsal-fin originating at anterior anus, horizontal length from dorsal-fin origin to vertical line through anus 74.1% in HL. Pectoral fin absent. Caudal fin prominent, tip rounded. Color of head and body (preserved specimen in 70% ethanol, after fixed with 10% formalin; Fig. 2) gray, darker in posterior tail; weakly pale to light gray dorsal, anal, and caud-
Table 1. Counts and measurements of *Muraenichthys gymnopterus*, *Muraenichthys thompsoni* and *Muraenichthys hattae*. Figures in parentheses indicate mean values.

|                  | *Muraenichthys gymnopterus* | *Muraenichthys thompsoni* | *Muraenichthys hattae* |
|------------------|----------------------------|---------------------------|------------------------|
| **Counts**       |                            |                           |                        |
| Holotype RMNH.   | Description of Holotype RMNH. | Bleeker specimens including holotype (n=3) | WMNH-PIS-12244 |
| PISC.7165        | PISC.7165                  | Hibino et al. (2015)      | Hibino et al. (2015)   |
| Hibino et al.    | Hatooka (2013)             | Hibino et al. (2019)      | WMNH-PIS-12244        |
| (2015)           |                           | present study             |                       |
| **Total length (mm)** | 223                    | 223.0–325.0               | 174.5                  |
| **Counts**       |                            |                           |                        |
| Lateral-line pores before anus | 44                    | 43–45                     | 45                     |
| Predorsal vertebrae | 30                    | 30                        | 30                     |
| Preenal vertebrae | 43                      | 41–44                     | 42                     |
| Total vertebrae  | 130                      | 129–130                   | 129                    |
| **Measurements** |                            |                           |                        |
| As % of total length |                        |                           |                        |
| Head length      | 15                        | 11.8–13.6                 | 13–15                  |
| Trunk length     | 24                        | 24                        | 25.4                   |
| Tail length      | 61                        | 61–62                     | 60.9                   |
| Predorsal length | —                        | —                         | 28.6                   |
| Body depth at gill opening | 2.8                  | 2.8–3.5                   | 3.7                    |
| Body depth at mid-anus | 2.8                  | 2.8–3.7                   | 3.9                    |
| Body width at gill opening | 1.6                  | 1.6–2.8                   | 3                      |
| Body width at mid-anus | 2.3                  | 2.3–3.2                   | 3.3                    |
| As % of head length |                        |                           |                        |
| Dorsal-fin origin to anus | 73                    | 73–87                     | 74.1                   |
| Upper-jaw length | 32                        | 32–39                     | 32.9                   |
| Length of mouth gape | 24                    | 24–27                     | 24.8                   |
| Snout length     | 10                        | 10–13                     | 9.9                    |
| Eye diameter     | 4.1                       | 3.2–5.5                   | 6.7                    |
| Interorbital width | 7.4                    | 7.4–11.0                  | 11.3                   |
| Gill opening length | 5.1                    | 5.1–8.2                   | 7.8                    |
| Body depth at gill opening | 19                    | 19–27                     | 26.8                   |
| Body depth at mid-anus | 19                    | 19–27                     | 28.7                   |
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Distribution. Indo-Pacific Ocean, including Bay of Bengal, Philippines, Indonesia, Fiji, Taiwan, and Japan (Bleeker 1853a, b, 1864a; Günther 1870; Weber and de Beaufort 1916; Herre 1923; Kottelat et al. 1993; McCosker 2014; Ho et al. 2015; Hibino and Kimura 2015; Hibino et al. 2019; Mohapatra et al. 2019; present study).

Habitat. To date, accurate information in habitat of Muraenichthys gymnopterus has never been known. The specimen described in this study was collected from an intertidal sand flat having rocks and dead corals in the estuarine area of the Nagura Amparu (Fig. 1B). Thus, this species is considered to inhabit shallow coastal areas including estuaries.

Discussion

The specimen from Ishigaki-jima Island examined in this study is a member of Muraenichthys as its morphological features correspond well with the generic description: the eyes location is anterior to the mid-jaw; the inner hole of the posterior nostril is above the upper lip, and the outer hole is usually outside the mouth, with a prominent but short flap projecting anteriorly; a single infraorbital pore is present between the anterior and posterior nostrils; it possesses three projecting anteriorly; a single infraorbital pore is present usually outside the mouth, with a prominent but short flap posterior nostril is above the upper lip, and the outer hole is features correspond well with the generic description: the study is a member of Muraenichthys as its morphological

Owing to previous concerns on the species identification or misidentification of M. gymnopterus and M. hattae, this study developed a synonym list for M. gymnopterus. Here, we exclude the temperate regions along the coast of China and Korea from the M. gymnopterus global distribution. We determine that some records of M. gymnopterus from China and Korea were M. hattae based only on the literature and characteristic traits (see below in detail). There are additional studies with records of M. gymnopterus, including temperate regions (e.g., mainland of China and Vietnam; Institute of Zoology, Academia Sinica, Institute of Oceanography, Academia Sinica and Shanghai Fisheries University 1962; Tran et al. 2014). However, doubts remain in the determination of identification accuracy from the literature, in addition to that M. gymnopterus and M. hattae were considered to have a synonymous relationship in one period. Therefore, the records of M. gymnopterus from boundary areas between subtropical and temperate regions (e.g., southern China, Taiwan, and northern Vietnam) should be carefully considered.

In this study, we found that some records of M. gymnop- terus from China and Korea contain misidentified results, as for example, the records of M. gymnopterus from Swatow, southern China (Rutter 1897), and from southern and eastern China (Kuang 1991; Zhang et al. 2010). In this study, these are recognized as M. hattae based on the morphological descriptions in these references such as the location of the dorsal-fin origin. In the case of Korea, Hatooka (2013) indicated that, based on the characteristics of HL and body depth, Kim et al. (2008) had misidentified the specimen
of *M. hattae* (FSIU 2144) collected from Korea as *M. gymnopterus*. Similarly, we found that some Korean records of *M. gymnopterus* had misidentified the specimen of *M. hattae*. Ji and Kim (2011) described two specimens of the genus *Muraenichthys* from Korea, including FSIU 2144, as *M. gymnopterus* in their taxonomic review of the family Ophichthidae from Korea. However, the proportional diagnostic characteristics and the vertebral count of both specimens did not match to the range of *M. gymnopterus*. Certainly, vertebral counts in Korean specimens also do not correspond to the diagnosis of *M. hattae* [Table 1; 155–156 reported by Ji and Kim (2011) and 157 vertebrae estimated from myomeres count by Ji and Kim (2012) vs. 148–155 vertebrae in *M. hattae*]. However, given that the numbers are continuous, which can be due to miscounting or geographical variation and these specimens are probably *M. hattae*. Furthermore, Ji and Kim (2012) identified a single leptocephalus collected from Jeju Island, Korea, as *M. gymnopterus* based on molecular analysis. However, the adult specimen of "*M. gymnopterus*" used as a DNA reference in their study was probably identified following their incorrect diagnosis of *M. gymnopterus* based on Kim et al. (2008), although they provided no statement about the identification of reference samples. They have used "*M. gymnopterus*" as an outgroup in subsequent molecular studies (e.g., Ji et al. 2012), but these samples were also probably misidentified. These findings indicate that all specimens of *M. gymnopterus* collected from temperate regions, at least those used by Kim et al. (2008) and Ji and Kim (2011, 2012), might be *M. hattae*.

*Muraenichthys gymnopterus* and *M. hattae* have been reported from Taiwan (Ho et al. 2015). The *M. hattae* record was based on a specimen from Da-xi District, northeastern Taiwan (NTUM 1075). The voucher of *M. gymnopterus* of Chen and Yu (1986) was not found, but a single specimen of *M. gymnopterus* has at least been confirmed (Hibino et al. 2019). Therefore, the records of *M. gymnopterus* and *M. hattae* from Taiwan are reliable. The specimen of *M. gymnopterus* was collected from Tainan (ASIZP 72203), located in southern Taiwan in the subtropical region (Climate-Data.org 2021). Considering that the type locality of *M. gymnopterus* is Indonesia, which is a tropical region (Bleeker 1853a), the species may typically be distributed within tropical regions. Taiwan, which includes subtropical to temperate areas, could be a boundary area of distribution between *M. gymnopterus* and *M. hattae*.

The specimen collected from Ishigaki-jima Island represents the first record of *M. gymnopterus* from the Japanese waters, and the northernmost specimen-based record for this species. A new standard Japanese name, “Usiba-mimizizu-anago”, is proposed here for *M. gymnopterus* based on this specimen from Ishigaki-jima Island (WMNH-PIS12244). The proposed name is a combination of "usiba", which in Yaeyaman dialect means molar tooth and points to a blunt tooth, and "mimizuzu-anago" which is the Japanese general name for the English name “worm eel”. Since the proposed Japanese name of this species is based on the local language, Yaeyaman dialect, to avoid misunderstandings, we indicate how to read in the Japanese characters (see the Taxonomic Accounts).

Comparative materials. *Muraenichthys gymnopterus*: RMNH.PISC.7165, holotype of *Muraena gymnopterus*, 223 mm TL, Java, Indonesia; AMS L.43999, 184 mm TL, Luzon Island, Philippines; AMS L.39103-002, 236 mm TL, Viti Levu Island, Fiji; ASIZP 72203, 375 mm TL, Tainan, Taiwan; BMNH 1867.11.28.301, 325 mm TL, Java, Indonesia (Bleeker specimen); BMNH 1867.11.28.311, 347 mm TL, Makassar, Sulawesi, Indonesia (holotype of *Muraenichthys microstomus*); CAS 98928, 2 specimens, 205–251 mm TL, Negros, Philippines; CAS 213869, 138 mm TL, Airai, Palau; KAUM–I. 20909, 147 mm TL, West Bengal, India, depth 0.5 m; CAS-SU 20114, 305 mm TL, Cavite, Luzon, Philippines; CAS-SU 26839, 209 mm TL, Iba, Luzon, Philippines; CAS-SU 26843, 301 mm TL, Dumaguete, Negros, Philippines; CAS-SU 38864, 148 mm TL, Dumaguete, Negros, Philippines; RMNH.PISC.36265 (ext. RMNH.PISC.7165), 257 mm TL, Java, Indonesia; USNM 135156, 209 mm TL; USNM 135157, 181 mm TL; USNM 135158, 229 mm TL, Luzon, Philippines; USNM 243005, 222 mm TL, Batanta, West Papua, Indonesia, depth 1 m; USNM 243008, 189 mm TL, Misool, West Papua, Indonesia, depth 1 m; USNM 406634, 2 specimens, 169–174 mm TL; USNM 406635, 4 specimens, 156–204 mm TL, Negros, Philippines. *Muraenichthys hattae*: CAS-SU 6473, 331 mm TL, holotype of *Muraenichthys hattae*, Wakanoura, Wakayama Prefecture, Japan; FAKU 121461, 314 mm TL, Tanabe Bay, Wakayama Prefecture, Japan; FRLM 32932, 325 mm TL, Kii-nagashima, Miyake Prefecture, Japan; FRLM 34541, 304+ mm (tail damaged), Owase, Mie Prefecture, Japan (cleared and stained); NTUM 1075, 406 mm TL, Da-xi District, Taiwan; OMNH-P 38345, 329 mm TL, Osaka Bay, Osaka Prefecture, Japan; SNFR 11400, 172 mm TL, Yellow Sea; USNM 86941, 86947, 86948, 3 specimens, 178–272 mm TL, Fujian Province, China.

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References

Bleeker, P. 1853a. Bijdrage tot de kennis der Murauenoiden Symbranchi- 
oiden van den Indischen Archipel. Verhandelingen van het Bat- 
aviaasch Genootschap van Kunsten Wetenschappen 25: 1–62. 
[In Latin and Dutch]
Bleeker, P. 1853b. Diagnostische beschrijvingen van nieuwe of weinig 
bekende vissoorten van Batavia. Tiental I–VI. Natuurkundig 
Tijdschrift voor Nederlandsch Indië 4: 451–516. [In Latin and 
Dutch]
Bleeker, P. 1864a. Atlas ichthyologique des Indes Orientales Néerlandais-
ises, publié sous les auspices du Gouvernement colonial néerlan-
daises. Tome 4. Murènes, Synbranches, Leptocéphales 4: 1–132, 
pls 145–193.
Bleeker, P. 1864b. Poisson inédits indo-archipiélagiques de l’ordre de 
les Murènes. Nederlandsch Tijdschrift voor de Dierkunde 2: 38–54. 
[In Dutch]
Castle, P. H. J. and McCooser, J. E. 1999. A new genus and two new 
pecies of myphrine worm-eels, with comments on Marauenichthys 
and Scolecenchelys (Anguilliformes: Ophichthidae). Records of the 
Australian Museum 51: 113–122.
Chen, J. T. F. and Yu, M.-J. 1986. A Synopsis of the Vertebrates of Taiwan, 
Revised and Enlarged Edition. Commercial Press, Taipei, 1092 pp.
Climate-Data.org. 2021. Köppen climate classification. Available at 
https://ja.climate-data.org/info/sources/ (28 March 2021).
Fricke, R. and Eschmeyer, W. N. 2021. Guide to fish collections. Elec-
tronic Version. Available at https://researcharchive.calacademy.org/
research/ichthyology/catalog/collections.asp (15 May 2021).
Fricke, R., Eschmeyer, W. N., and Fong, J. D. 2021. General/Species by 
Family/Subfamily in Eschmeyer’s Catalog of Fishes, Online Ver-
nue. Available at http://researcharchive.calacademy.org/research/
ichthyology/catalog/SpeciesByFamily.asp (3 August 2021).
Günther, A. 1870. Catalogue of the Fishes in the British Museum. Vol. 8. 
Taylor and Francis, London, xxv + 549 pp.
Hatooka, K. 2013. Myrophinae. Pp. 266–268, 1794–1795. In: Nakabo, T. 
(Ed.) Fishes of Japan with Pictorial Keys to the Species. Tokai Uni-
versity Press, Hadano.
Herre, A. W. C. T. 1923. A review of the eels of the Philippine Archi-
pelago. Philippine Journal of Science 23: 123–236, pls 1–11.
Hibino, Y. and Kimura, S. 2015. A new species of Marauenichthys (An-
guilliformes: Ophichthidae) from the Indo-Pacific, with revised 
generic diagnosis. Zootaxa 4060: 62–70.
Hibino, Y. and Kimura, S. 2016. First records of two snake eels, Phylo-
lophichthys xenodontus and Marauenichthys sibogae (Anguilliformes: 
Ophichthidae), from the Ryukyu Islands, Japan. Japanese Journal of 
Ichthyology 63: 135–142. [In Japanese with English abstract]
Hibino, Y., Ho, H.-C., and McCosker, J. E. 2019. A new species of Mu-
rauenichthys (Anguilliformes: Ophichthidae) from Taiwan, with 
redescription of Marauenichthys thompsoni Jordan & Richardson, 
1908. Zootaxa 4702: 41–48.
Ho, H.-C., Smith, D. G., McCosker, J. E., Hibino, Y., Loh, K.-H., Tighe, 
K. A., and Shao, K.-T. 2015. Annotated checklist of eels (orders 
Anguilliformes and Saccopharyngiformes) from Taiwan. Zootaxa 
4060: 140–189.
Institute of Zoology, Academia Sinica, Institute of Oceanography, Aca-
demia Sinica and Shanghai Fisheries University. (Ed.) 1962. Fishes of 
the South China Sea. Science Press, Beijing, 1184 pp. [In Chinese]
Ji, H.-S. and Kim, J.-K. 2011. Taxonomic review of the snake-eel fam-
ily Ophichthidae from Korea. Korean Journal of Ichthyology 23: 46–60. [In Korean with English abstract]
Ji, H.-S. and Kim, J.-K. 2012. Molecular and morphological identifica-
tion of a Marauenichthys gymnopterus (Ophichthidae: Anguilliformes) 
leptocephalus collected on Jeju island, Korea. Korean Jour-
nal of Fisheries and Aquatic Science 45: 507–512. [In Korean with 
English abstract]
Kim, B.-G., Jeong, C.-H., and Han, K.-N. 2008. New record of a worm 
eel Marauenichthys gymnopterus (Anguilliformes: Ophichthidae: 
Myrophinae) from Korea. Korean Journal of Ichthyology 20: 318– 
323.
Kottelat, M. 2013. The fishes of the inland waters of southeast Asia: a 
catalogue and core bibliography of the fishes known to occur in 
freshwaters, mangroves and estuaries. The Raffles Bulletin of Zo-
ology, Supplement 27: 1–663.
Kottelat, M., Whitten, A. J., Karikasari, S. N., and Wirjoatmodjo, S. 
1993. Freshwater Fishes of Western Indonesia and Sulawesi. Perip-
lus Editions, Hong Kong, 259 pp., 84 pls.
Kuang, Y. 1991. Marauenichthys gymnopterus. Pp. 57–58. In: Pearl River 
Fisheries Research Institute, Chinese Academy of Fisheries Sci-
ence (Competent authority), South China Normal University, Ji-
nan University, Zhanjiang Fisheries College, and Shanghai Fisher-
ies University. (Eds) The freshwater fishes of Guangdong Province. 
Guangdong Science and Technology Press, Guangdong.
Machida, Y. and Ohita, S. 1993. Marauenichthys japonsicus, a new worm 
eel from the Sea of Japan (Ophichthidae: Myrophinae). Japanese 
Journal of Ichthyology 40: 323–326.
McCosker, J. E. 1970. A review of the eel genera Leptenchelys and Mu-
rauenichthys, with the descriptions of a new genus, Schismorrhynchus, 
and a new species, Marauenichthys chilensis. Pacific Science 24: 506–516.
McCosker, J. E. 1977. The osteology, classification, and relationships of 
the eel family Ophichthidae. Proceedings of the California Acad-
emy of Sciences 41: 1–123.
McCosker, J. E. 2014. A gigantic deepwater worm eel (Anguilliformes: 
Ophichthidae) from the Verde Island Passage, Philippine Archi-
pelago. Pp. 333–340. In: Williams, G. C. and Gosliner, T. M. (Eds) 
The Coral Triangle. The 2011 Hearst Philippine Biodiversity Expedi-
tion. California Academy of Sciences, San Francisco.
McCosker, J. E. and Parin, N. V. 1995. A new species of deepwater 
worm-eel, Marauenichthys profundorum (Anguilliformes: Ophich-
thidae), from the Nazca Ridge. Japanese Journal of Ichthyology 42: 
231–235.
Mohapatra, A., Ray, D., and Mishra, S. S. 2019. First record of Marue-
nichthys gymnopterus (Anguilliformes: Ophichthidae) from east 
coast of India, Bay of Bengal. Indian Journal of Geo Marine Sci-
ces 48: 283–285.
Rutter, C. L. 1897. A collection of fishes obtained in Swatow, China, by 
Miss Adele M. Field e. Proceedings of the Academy of Natural Sci-
ces of Philadelphia 49: 56–90.
Tran, D. H. and Thuy, T. T. 2014. Fish diversity and fishery status in the 
Ba Che and Tien Y en Rivers, northern Vietnam, with consider-
ation on factors causing recent decline of fishery products. Kuro-
shio Science 7: 113–118.
Weber, M. and de Beaufort, L. F. 1916. The Fishes of the Indo-Australian 
Archipelago. III. E. J. Brill, Leiden, xxv + 455 pp.
Zheng, C.-G., Tang, W.-Q., Liu, D., Zhang, Z.-L., and Zhang, S.-Y. 2010. 
Fauna Sinica. Ostechthyes. Anguilliformes, Notacanthiformes. Sci-
ence Press, Beijing, 453 pp., 3 pls.