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ADDITIONS TO THE TAIWAN EEL FAUNA WITH FIVE NEWLY RECORDED SPECIES OF MORAY EELS (ANGUILLIFORMES: MURAENIDAE), AND REDESCRIPTION OF A RARE SPECIES *GYMNOTHORAX SAGMACEPHALUS*

Kar-Hoe Loh[1], Kwang-Tsao Shao[2],Ving-Ching Chong[1,3] and Hong-Ming Chen[4,5]

Key words: Muraenidae, *Anarchias*, *Gymnothorax*, Taiwan.

ABSTRACT

Five rare moray species: *Anarchias cantonensis* (Schultz), *Gymnothorax dorsalis* Seale, *G. intesi* (Fourmanoir and Rivaton), *G. phasmatodes* (Smith) and *G. sagmacephalus* (Böhlke) belonging to subfamilies Uropterygiinae and Muraeninae are reported for the first time off Taiwan. Diagnoses of these five species of moray eels including their fresh coloration and dentitions are provided. A redescription of *G. sagmacephalus* is provided since its description was based on the unique holotype was incomplete, especially due to its damaged tail tip. We add twelve additional specimens, give the statistics of morphological measurements and vertebral formulae for this species, and expand its geographical distribution from Japan to Taiwan.

I. INTRODUCTION

Moray eels live in the tropical and subtropical coastal area, belong to the diverse eel family Muraenidae and comprise as many as 16 genera and 198 species globally [30]. The Taiwan moray eel fauna was comprehensively treated since 18 years ago by Chen et al. [10] reported 9 genera and 42 moray species. During surveys from 2005-2009 under the regional research programme on "Diversity, molecular phylogeny and reproductive ecology of the Anguilliformes fishes of Taiwan and the Western Pacific", we collected many specimens of moray eels from the waters around Taiwan. Among these collections, we found some new species and new records of moray eels [8, 9, 18, 19, 20, 27], and also discovered five rare muraenid species previously unknown from Taiwan. With the additions in this study, the muraenid fauna now comprises 68 species belonging to 13 genera and 2 subfamilies of the family Muraenidae (Table 1).

The aim of this paper is to list the muraenid eels from Taiwan, to describe five newly recorded moray species, and to redescribe the species *Gymnothorax sagmacephalus*. Böhlke [3] described *G. sagmacephalus* based on the unique type specimen, the holotype (collected from Tokyo Bay, Japan), which was missing its tail tip. This species subsequently was reported in Böhlke and Smith [6] "Review of the catalogue of Indo-Pacific Muraenidae" as a valid species, characterized by an elongate body, tannish brown coloration, and vertebral count MVF 7-77-172+. We redescribe this species based on Böhlke's description of the holotype and 12 additional recently collected specimens. Color photographs of a fresh specimen are also provided.

II. MATERIALS AND METHODS

All moray specimens were collected by longlines or using the ichthyocide rotenone off the Taiwan waters. The specimens were fixed with 10 % formalin, then transferred to a 70 % ethanol solution for long-term preservation. The methods of measurements followed Böhlke and Randall [5]. Proportional measurements for the specimens of the moray eels were expressed as percentage of the total length (TL) or the head length (HL). Body depth was measured at the gill openings (DGO) and at the anus (DA) and did not include the fins; snout length was measured from the snout tip to the anterior margin of the eye; upper jaw (UJ) length was from the snout tip to the rictus, lower jaw (LJ) length from the lower jaw tip to the rictus. Counts for the vertebral formulae were obtained from radiographs, as explained in Böhlke [2] and Chen et al. [10, 11]; the mean vertebral formula (MVF) gives the mean values for predorsal-preanal-total vertebrae counts; Preanal vertebrae (PAV); Total vertebrae (TV). Teeth counts following Hatooka [13] were approximate and included sockets of missing teeth. Sexes of the specimens were determined by gross and histological examinations of the gonads. All newly recorded specimens were deposited in the collection of the Laboratory of Aquatic Ecology, Department of Aquaculture, National Taiwan Ocean University (TOU-AE). We also borrowed specimens from the following Institutes: the National Museum of Marine Science and Technology (NMMSTP); the Fisheries Research Institute (FRIP); and the Museum of Research Center for Biodiversity, Academia Sinica (ASIZP).

Comparative materials examined.

Anarchias allardicei – Four specimens (116-154 mm TL),

Paper submitted 04/19/13; revised 12/12/13; accepted 12/27/13. Author for correspondence: Hong-Ming Chen (e-mail: hmchen@mail.ntou.edu.tw).
[1]Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia 50603. [2]Biodiversity Research Center, Academia Sinica, Nankang, Taiwan 115, R.O.C. [3]Institute of Biological Sciences, University of Malaya, Kuala Lumpur, Malaysia 50603. [4]Department of Aquaculture, National Taiwan Ocean University, Keelung, Taiwan 202, R.O.C. [5]Center of Excellence for the Oceans, National Taiwan Ocean University, Keelung, Taiwan 202, R. O. C.

Table 1. The taxonomic works of all muraenid species in Taiwan.

No.	Genus	Scientific name	Chen *et al* ., 1997	Chen and Loh, 2007	Chen *et al* ., 2008	Loh *et al* ., 2008	Shao *et al* ., 2008	Loh *et al* ., 2011	Loh *et al* ., 2012	This study
1	*Echidna*	*Echidna nebulosa*	○				○			
2		*Echidna polyzona*	○				○			
3		*Echidna xanthospilos*	◎							
4	*Enchelycore*	*Enchelycore bayeri*	◎							
5		*Enchelycore bikiniensis*	◎							
6		*Enchelycore lichenosa*	○							
7		*Enchelycore pardalis*	○				○			
8		*Enchelycore schismatorhynchus*	○							
9	*Enchelynassa*	*Enchelynassa canina*							◎	
10	*Gymnomuraena*	*Gymnomuraena zebra*	○				○			
11	*Gymnothorax*	*Gymnothorax albimarginatus*	◎							
12		*Gymnothorax berndti*	○							
13		*Gymnothorax buroensis*	○				○			
14		*Gymnothorax chilospilus*	○				○			
15		*Gymnothorax chlamydatus*	○							
16		*Gymnothorax dorsalis*								◎
17		*Gymnothorax elegans*							◎	
18		*Gymnothorax eurostus*	○				○			
19		*Gymnothorax favagineus*	○							
20		*Gymnothorax fimbriatus*	○				○			
21		*Gymnothorax flavimarginatus*	○				○			
22		*Gymnothorax formosus*	◎							
23		*Gymnothorax fuscomaculatus*							◎	
24		*Gymnothorax gracilicauda*					◎			
25		*Gymnothorax hepaticus*	○							
26		*Gymnothorax herrei*	◎				○			
27		*Gymnothorax intesi*								◎
28		*Gymnothorax javanicus*	◎				○			
29		*Gymnothorax kidako*	○				○			
30		*Gymnothorax prionodon*	○							
31		*Gymnothorax margaritophorus*	◎				○			
32		*Gymnothorax melanosomatus*						●		
33		*Gymnothorax melatremus*	◎				○			
34		*Gymnothorax meleagris*	○				○			
35		*Gymnothorax minor*					○			
36		*Gymnothorax monostigma*					○			
37		*Gymnothorax neglectus*	○				○			
38		*Gymnothorax niphostigmus*	●							
39		*Gymnothorax nudivomer*	◎							
40		*Gymnothorax phasmatodes*								◎
41		*Gymnothorax pictus*	○				○			
42		*Gymnothorax pindae*	○				○			
43		*Gymnothorax polyuranodon*					◎			
44		*Gymnothorax pseudothysoideus*	○				○			
45		*Gymnothorax reevesii*	◎				○			
46		*Gymnothorax reticularis*	○				○			
47		*Gymnothorax richardsoni*	○				○			
48		*Gymnothorax rueppelliae*	○				○			
49		*Gymnothorax sagmacephalus*								◎
50		*Gymnothorax shaoi*		●						
51		*Gymnothorax taiwanensis*			●					
52		*Gymnothorax thyrsoideus*	○				○			
53		*Gymnothorax undulatus*	○				○			
54		*Gymnothorax ypsilon*	○							
55		*Gymnothorax zonipectis*	◎				○			
56	*Pseudechidna*	*Pseudechidna brummeri*	○							
57	*Rhinomuraena*	*Rhinomuraena quaesita*	○				○			
58	*Strophidon*	*Strophidon prolatus*	○				○			
59		*Strophidon sathete*	◎				○			
60	*Anarchias*	*Anarchias allardicei*	○				○			
61		*Anarchias cantonensis*								◎
62	*Channomuraena*	*Channomuraena vittata*	◎				○			
63	*Cirrimaxilla*	*Cirrimaxilla formosa*	●							
64	*Scuticaria*	*Scuticaria tigrina*	◎				○			
65		*Scuticaria marmorata*				○	○			
66	*Uropterygius*	*Uropterygius macrocephalus*	◎				○			
67		*Uropterygius micropterus*	◎				○			
68		*Uropterygius oligospondylus*				●				

○ recorded, ◎ newly recorded, ● new species.

NMMSMP 00885, Tungchi, Penghu County; NMMSMP 01013, Wanlitung, Pingtung County; TOU-AE 1780 Hsiaogang, Taitung County; TOU- AE 4913, Jihuei, Chenkung, Taitung County. *Gymnothorax albimarginatus* – Five specimens (675- 1060 mm TL), all male, TOU-AE 0104, 1638, 1813, from Bisha fishes market, Keelung City; TOU-AE 1034, 4220, Changbin, Taitung County. *G. neglectus* – Three specimens (610-699 mm TL), ASIZP056655, Hopingtao, Keelung City; NMMSTP 00956, Hopingtao, Keelung City; FRIP 20370 Chengkung, Taitung County. *Strophidon sathete* – 12 specimens (526-1470 mm TL), male: TOU-AE 1868, 3458, Changbin, Taitung County; TOU-AE 3026, 4832, 5305, Daxi, Yilan County; female: TOU-AE 0628, Changbin, Taitung County; TOU-AE 3027, 3028, 3990, 4478, 4563, 5306, Daxi, Yilan County.

III. TAXONOMY

Uropterygiinae

Diagnosis – Dorsal and anal fins restricted to tail tip; teeth needle-like and pointed.

Type genus – *Uropterygius* Rüppell, 1838[24].

Anarchias Jordan and Starks in Jordan and Seale, 1906

Diagnosis – A supraorbital pore is adjacent to each posterior nostril, appearing as double pore posterior nostrils.

Type species – *Anarchias allardicei* Jordan and Starks in Jordan and Seale, 1906 [16].

Anarchias cantonensis (Schultz, 1943)
(Figs. 1A, 2A; Table 2)

Uropterygius cantonensis, Schultz, 1943: 27 [25] (Type locality: Phoenix Islands, southern central Pacific).

Anarchias cantonensis (Schultz, 1943): 27 [25]; Böhlke and McCosker, 2001: 73 [4]; Böhlke and Smith, 2002: 157 [6]; McCosker and Stewart, 2006: 86 [22]; Reece et al., 2010: 423-425 [23].

1. Material examined

3 specimens: TOU-AE 4913, 4914, 4915, 97-154 mm TL, females, 31 May 2008, from Jihuei, Chengkung, Taitung County, all rotenone by Ms. Min-Chia Chiang.

2. Diagnosis

A small sized moray, body pale with a network of wide brownish lines arranged into irregular vertical reticulated bars, fins at tip of tail yellow (Fig 1A). Anterior nostril in a short tube, posterior nostril above center of eye, a supraorbital pore adjacent to posterior nostril, for each side appearing as double pore posterior nostrils. Tail length 1.9-2.0 (1.9 ± 0.1), trunk length 2.8-2.9 (2.8 ± 0.1), depth at gill opening 18.5-22.2 (20.8 ± 2.0), body depth at anus 19.2-21.2 (20.0 ± 1.1), head length 7.5-8.1 (7.7 ± 0.3), all in TL. Length of upper jaw 2.5-3.1 (2.8 ± 0.3), length of lower jaw 2.5-3.1 (2.8 ± 0.3), interorbital width 6.4-9.6 (7.7 ± 1.7), snout length 5.7-6.4 (6.1 ± 0.4), eye diameter 8.8-13.8 (11.3 ± 2.5), all in HL. Premaxillary teeth 10-13 each side, median premaxillary teeth 9, maxillary teeth biserial about 2-12 inner row and 24-34 outer row; vomerine teeth uniserial 6-10, dentary teeth biserial about 5-15 inner row and 32-42 outer row. Predorsal vertebrae 86-93, preanal vertebrae 90-95, total vertebrae 100-105; mean vertebral formula 90-92-102.

3. Distribution

Known from the western Pacific, including the South China Sea and Taiwan.

4. Remarks

Species of *Anarchias* are readily identified by a posterior nostril contiguous with an enlarged supraorbital pore on each side, appearing as double pore posterior nostrils. *A. cantonensis* is distinguished from its congener *A. allardicei*, by the head length 12.9 (vs. 10.0) % of TL; snout length 16.5 (vs. 13.2) %, eye diameter 9.2 (vs. 7.6) %, interobital width 13.4 (vs. 9.2) %, all of HL. Böhlke and Smith [6] reported its MVF 91-93-103, which was similar to MVF 91-93-104 reported by Böhlke and McCosker [4]; both data were similar to this study (MVF 90-92-102). The total vertebrae of *A. cantonensis* reported by Reece et al. [22] were more wide-ranging 98-108 than ours (100-105).

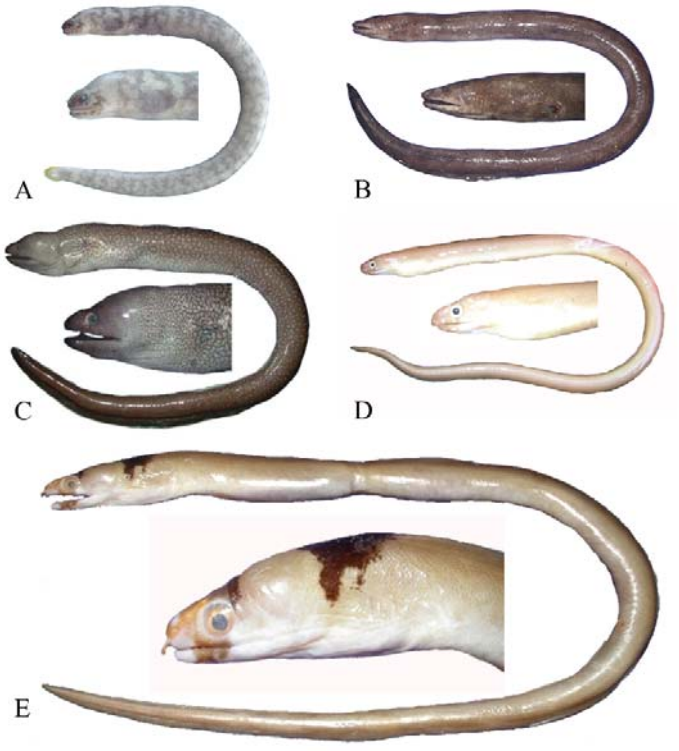

Fig. 1. The newly recorded species, lateral view of body and head. A, *Anarchias cantonensis*, TOU-AE 4913 (93 mm TL); B, *Gymnothorax dorsalis*, TOU-AE 4834 (619 mm TL); C, *G. intesi*, TOU-AE 2774 (533 mm TL); D, *G. phasmatodes*. TOU-AE 0227 (382 mm TL); E, *G. sagmacephalus*. TOU- AE 0226 (464 mm TL).

Muraeninae

Diagnosis – Dorsal-fin origin before or near gill opening; and anal-fin origin just behind anus.

Type genus – *Muraena* Linnaeus 1758 [17].

Gymnothorax Bloch, 1795

Diagnosis – Mouth closing completely; jaws slightly or not curved.

Type species – *Gymnothorax reticularis* Bloch, 1795 [1]

Gymnothorax dorsalis Seale, 1917

(Figs. 1B, 2B; Table 2)

Gymnothorax dorsalis Seale, 1917: 92 [26] (Type locality: Hong Kong); Smith, 1994: 17 [28]; Böhlke, 1997: 96-97 [3]; Böhlke and Smith, 2002: 106 [6].

1. Materials examined

3 specimens: TOU-AE 0157, 1050 mm TL, 18 May 2002; TOU-AE 4834, 619 mm TL, 22 Jan. 2008; TOU-AE 5303, 415 mm TL, 19 Sept. 2008, all were females from Daxi, Yilan County.

2. Diagnosis

Body medium tan-brown, anus before mid-body. Tail length 1.7-1.8 (1.8 ± 0.1), trunk length 3.0-3.2 (3.1 ± 0.1), body depth at gill opening 25.1-28.9 (27.1 ± 1.9), body depth at anus 28.1-31.2 (29.9 ± 1.6), predorsal length 10.5-12.4 (11.5 ± 1.0), head length 9.0-10.6 (9.7 ± 0.8), all in TL. Upper jaw length 2.7-3.1 (2.9 ± 0.2), lower jaw length 2.8-3.3 (3.0 ± 0.2), interorbital width 7.3-10.1 (8.5 ± 1.4), snout length 7.5-8.0 (7.7 ± 0.3), eye diameter 16.8-18.7 (17.5 ± 1.0), all in HL. Premaxillary teeth 5-7 each side, median premaxillary teeth 3; maxillary teeth biserial, 2-5 in the inner row and 15-18 in the outer row, vomerine teeth uniserial 3-7; dentary teeth biserial, 2-5 in the inner row and 18-23 in the outer row. Head pores typical, three supraorbital pores, four infraobital pores, six mandibular pores.

Two branchial pores, branchial pores small, before gill opening. Gill opening below mid-side. Predorsal vertebrae 8-9, preanal vertebrae 66-69, total vertebrae 164-167; mean vertebral formula 9-68-166.

3. Distribution

Known from the western Pacific, including Hong Kong, China, Taiwan and Vietnam.

4. Remarks

Gymnothorax sensu lato is the catch-all genus in the family Muraenidae. In the present paper we are temporarily maintaining the species *Gymnothorax dorsalis* in genus *Gymnothorax*, with the realization that its generic status may change when osteological and phylogenetic studies are undertaken. The overall description of *Gymnothorax dorsalis* is similar to that for *Strophidon sathete*; the anus is well before midbody, the eye is closer to the snout tip than to the rictus, and the jaw teeth are biserial. We think the species *dorsalis* will belong to the genus *Strophidon* in the future.

But *Gymnothorax dorsalis* is still distinguished from *Strophidon sathete*, by the following features: lesser PAV and TV value of MVF 9-68-166 (vs. 9-81-194); greater body depth at gill opening 3.5-4.0 (vs. 1.8-2.9) % of total length.

Gymnothorax intesi (Fourmanoir and Rivaton, 1979)

(Figs. 1C, 2C; Table 2)

Lycodontis intesi Fourmanoir and Rivaton, 1979: 426 [12] (Type locality: Loyalty Islands, South western Pacific).

Gymnothorax intesi (Fourmanoir and Rivaton, 1979): 426 [12]; Böhlke and McCosker, 2001: 80 [4]; Böhlke and Smith 2002: 116 [6].

1. Materials examined

7 specimens: TOU-AE 2774, 533 mm TL, female, 05 Aug. 2006; TOU-AE 4407, 4124, 2 specimens, 454-652 mm TL, females, 12 Feb. 2007; TOU-AE 2773, 2775, 2776, 3 specimens, 343-502 mm TL, males, 05 Aug. 2006; TOU- AE 4128, 613 mm TL, male, 05 Sept. 2006, all were from Taitung County, longline, Captain Jiunn-Shiun Chiou.

2. Diagnosis

An elongate moray, body light brown, with yellow-green mucus when fresh. Head dusky or reticulated, body with irregular pale spots; fins with pale or white margins. Preanal length 1.9-2.0 (1.9 ± 0.1), tail length 2.0-2.1 (2.0 ± 0.1), trunk length 2.5-2.6 (2.5 ± 0.1), body depth at gill opening 13.9-20.5 (16.7 ± 2.4), body depth at anus 20.8-27.0 (24.1 ± 2.0), predorsal length 9.3-13.4 (11.1 ± 1.6), head length 8.4-9.5 (9.0 ± 0.4), all in TL. Upper jaw length 2.3-2.6 (2.4 ± 0.1), lower jaw length 2.4-2.6 (2.5 ± 0.1), interorbital width 5.7-8.9 (7.3 ± 1.2), snout length 4.9-6.5 (5.4 ± 0.5), eye diameter 9.3-10.7 (9.9 ± 0.5), all in HL. Pre-maxillary teeth 11-14 each side, median premaxillary teeth 0-1; maxillary teeth uniserial, about 16-19, vomerine teeth uniserial 11-20, dentary teeth uniserial about 26-40 each side. Head pores typical, two branchial pores. Predorsal vertebrae 5-6, preanal vertebrae 65-70, total vertebrae 149-154; mean vertebral formula 6-67-151.

3. Distribution

Known from the Indian Ocean; central and western Pacific, including Australia, New Caledonia, Japan and Taiwan.

4. Remarks

Gymnothorax intesi is distinguished from its congener *G. neglectus*, by the following features: more total vertebrae 149-151 (vs. 138-142); smaller body depth at gill opening 4.9-7.2 (vs. 7.5-9.4) % of total length; and longer snout length15.5-20.2 (vs. 13.3- 13.9) % of head length.

Gymnothorax phasmatodes (Smith, 1962)

(Figs. 1D, 2D; Table 2)

Lycodontis phasmatodes Smith, 1962: 436 [29] (Type locality: Inhaca Island, Mozambique, western Indian Ocean)

Gymnothorax phasmatodes (Smith, 1962): 436 [29]: Böhlke, 1997: 97-98 [3]; Hatooka et al., 1998: 2-5 [15]; Böhlke et al., 1999: 1649 [7]; Böhlke and Smith, 2002: 137 [6].

1. Materials examined

6 specimens: TOU-AE 0227, 382 mm TL, male, Jul. 2003, Kenting, Pingtung County. TOU-AE 1269, 345 mm TL, female, 08 Aug. 2005; TOU-AE 3271, 334 mm TL, male, 24 Aug. 2006, Chengkung, Taitung County; TOU-AE 3684, 355 mm TL, male, 21 Sept. 2006; TOU-AE 4263, 349 mm TL, male; TOU-AE 4264, 371 mm TL, female, 27 Jul. 2007, Changbin, Taitung County, longline by Captain Jiunn-Shiun Chiou.

2. Diagnosis

An elongate moray with long tapering tail, body yellowish tan, dorsal and anal fins with prominent white margin. Anus just behind midbody. Body elongate with unpatterned coloration. Head long, snout short and blunt, jaws short, eye large. Preanal length 1.8-2.0 (1.9 ± 0.1), tail length 2.0-2.2 (2.1 ± 0.1), trunk length 2.2-2.5 (2.3 ± 0.1), body depth at gill opening 27.8-36.7 (32.4 ± 4.8), body depth at anus 31.6-58.6 (41.8 ± 12.0), predorsal length 13.4-16.1 (14.4 ± 1.2), head length 9.9-10.4 (10.2 ± 0.3), all in TL. Upper jaw length 2.5-2.8 (2.8 ± 0.2), lower jaw length 2.5-3.1 (2.9 ± 0.3), interorbital width 5.8 -9.2 (7.6 ± 1.6), snout length 5.2-5.8 (5.6 ± 0.3), eye diameter 8.9-12.0 (10.3 ± 1.7), all in HL. Premaxillary teeth 6-7 each side, median premaxillary teeth 0-3, maxillary teeth uniserial about 7-12, vomerine teeth uniserial 4-9, dentary teeth uniserial about 12-20 each side. Head pores typical, three supraorbital pores, four infraobital pores, six mandibular pores. Two bran- chial pores, branchial pores small before gill opening. Gill opening below mid-side. Predosal vertebrae 5-6, preanal vertebrae 73-77, total vertebrae 165-168; mean vertebral formula 6-75-166.

3. Distribution

Known from the western Indian Ocean and western Pacific, including Mauritius, Mozambique, Moluccas, Japan and Taiwan.

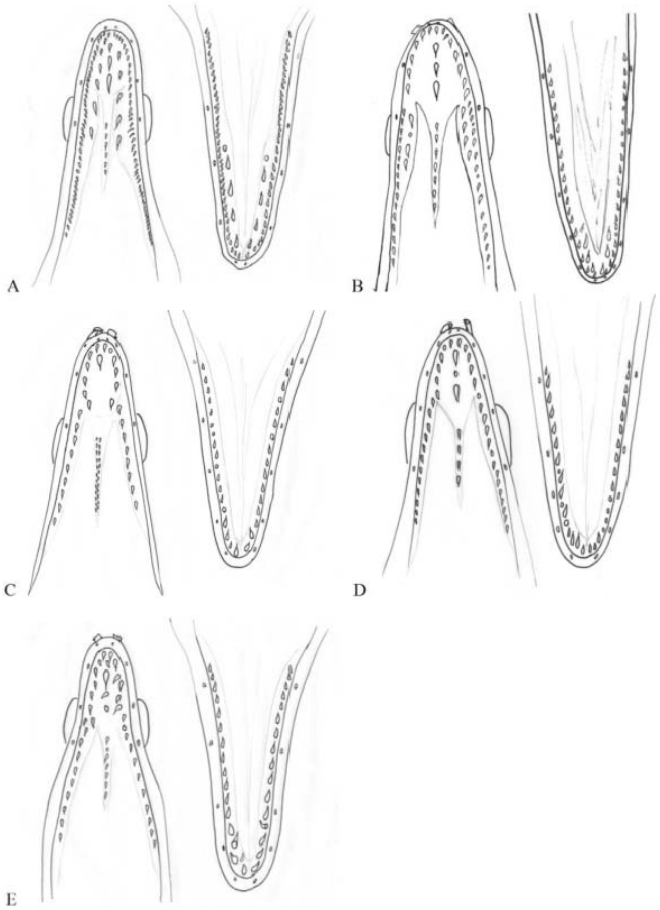

Fig. 2. Dentitions of the five newly recorded species. A, *Anarchias cantonensis*. TOU-AE 4913 (male, 97 mm TL); B, *Gymnothorax dorsalis*, TOU-AE 4834 (female, 619 mm TL); C, *G. intesi*, TOU-AE1958 (male, 439 mm TL); D, *G. phasmatodes*, TOU-AE1269 (female, 189 mm TL); E, *G. sagmacephalus*, TOU-AE1409 (female, 512 mm TL).

4. Remarks

A moderately small species, the largest recorded was 465 mm TL (the holotype, RUSI 108); we have seen no specimens larger than 382 mm TL (TOU-AE 227) in Taiwan. Sexually mature at 345 mm. Sex was determined for six specimens, two of the study specimens (345 and 371 mm) were females, with 0.5-0.7 mm, 1.0-1.2 mm egg diameter and fecundity 1806 ± 120 eggs; other four specimens (334-382 mm) were males.

Böhlke[3] noted on the identity of elongate unpatterned morays, that *Gymnothorax phasmatodes* was similar in coloration, dentition and vertebral formula to *G. verrilli* from the eastern Pacific. But *G. phasmatodes* has blunt jaws and paler body color is different than that of *G. verrilli*. Hatooka et al. [15] reported *G. phasmatodes* as a new record from Japan, and sexual dimorphism occurred in the species; the female had three teeth, but the male had no teeth on the mesial part of premaxillary plate. Their result is similar to the counts for our *G. phasmatodes* specimens.

Gymnothorax sagmacephalus Böhlke, 1997
(Figs. 1E, 2E, 3; Table 2)

Gymnothorax albimarginatus Masuda et al., 1984: plate 28I [21] (Misidentified)

Gymnothorax sagmacephalus Böhlke, 1997: 100-102 [3]. (Type locality: Tokyo Bay, Japan); Böhlke and Smith, 2002: 146 [6].

1. Materials examined

12 specimens: TOU-AE 0226, 464 mm TL, female, Jul. 2003, Kenting, Pingtung County, longline. TOU-AE 1407, 1409-1410, 3 specimens, 422-512 mm TL, females, 08 Aug. 2005; TOU-AE 2728, 2730, 2732, 3 specimens, 375-482 mm TL, males, 31 Jul. 2006; TOU-AE 2726, 2729, 2731, 3 specimens, 413-426 mm TL. females, 31 Jul. 2006; TOU-AE 5099-5100, 395-468 mm TL, males, 06 July 2008, all were from Taitung County, longline by Captain Jiunn-Shiun Chiou.

2. Diagnosis

An elongate brown moray marked with a dusky saddle on top of head just behind eyes, and a large prominent dark triangle just before the dorsal-fin origin (Fig. 3A). Dorsal and anal fins with a white margin. Body light brownish, pale color on the belly side. Dark brown stripe extends below gill opening along the belly back to anus (Fig. 3B).

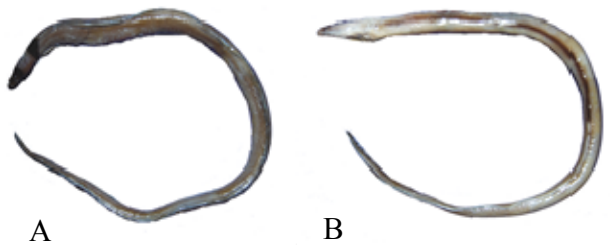

Fig. 3. The specimen (TOU-AE 0226, 464 mm TL) of the redescribed species, *Gymnothorax sagmacephalus*. A, dorsal view; B, ventral view, showing the coloration pattern.

3. Description

Table 2. Total lengths, proportions as percent of total length or head length, counts of teeth and vertebrae among the five newly recorded muraenid species from Taiwan.

Species	*Anarchias cantonensis*		*Gymnothorax dorsalis*		*Gymnothorax intesi*		*Gymnothorax phasmatodes*		*Gymnothorax sagmacephalus*	
Number of Specimens	3		3		7		6		12	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Total Length (mm)	97-154		415-1050		343-652		268^{+}-382		375-512	
Proportions as percent of total length										
Preanal length	47.5-48.7	48.2 ± 0.6	41.0-44.3	42.9 ± 1.7	50.0-50.0	50.3 ± 0.3	50.4-54.5	52.3 ± 1.9	50.4-52.8	51.2 ± 0.8
Tail length	51.3-52.6	51.8 ± 0.7	55.7-59.1	57.1 ± 1.7	49.1-50.0	49.7 ± 0.3	45.5-49.6	47.7 ± 1.9	47.2-49.6	48.8 ± 0.8
Trunk length	34.3-36.4	35.3 ± 1.1	31.4-33.6	32.6 ± 1.1	39.1-40.1	39.5 ± 0.4	40.9-44.6	43.0 ± 1.6	39.7-43.6	41.3 ± 1.1
Depth at gill opening	4.5-5.4	4.8 ± 0.5	3.5-4.0	3.7 ± 0.3	4.9-7.2	6.1 ± 0.8	2.7-3.6	3.1 ± 0.5	2.9-3.8	3.4 ± 0.3
Depth at anus	4.7-5.2	5.0 ± 0.3	3.2-3.6	3.4 ± 0.2	3.7-4.8	4.2 ± 0.4	1.7-3.2	2.5 ± 0.6	2.2-3.6	2.8 ± 0.3
Predorsal length	--	--	8.1-9.6	8.8 ± 0.7	7.5-10.8	9.2 ± 1.3	6.2-7.5	7.0 ± 0.6	6.4-10.0	8.1 ± 1.0
Head length	12.3-13.4	12.9 ± 0.6	9.5-11.1	10.4 ± 0.8	10.6-12.0	11.2 ± 0.6	9.6-10.1	9.8 ± 0.2	9.7-11.5	10.6 ± 0.6
Proportions as percent of head length										
Upper jaw	32.2-39.9	35.7 ± 3.9	32.0-36.7	34.2 ± 2.3	39.2-43.2	41.8 ± 1.5	35.2-40.4	35.9 ± 2.8	34.0-45.3	38.2 ± 3.0
Lower jaw	31.9-39.8	35.6 ± 4.0	30.6-35.9	33.4 ± 2.6	38.2-57.4	43.2 ± 6.5	32.6-40.4	34.7 ± 3.3	32.2-44.9	37.4 ± 3.3
Interobital width	10.5-15.6	13.4 ± 2.6	9.9-13.7	12.0 ± 1.9	11.2-17.4	14.1 ± 2.4	10.9-17.3	13.8 ± 3.2	12.2-16.7	14.4 ± 1.4
Snout length	15.7-17.6	16.5 ± 1.0	12.5-13.4	13.0 ± 0.5	15.5-20.2	18.5 ± 1.6	17.1-19.1	17.9 ± 1.0	15.5-19.7	18.0 ± 1.2
Eye diameter	7.3-11.3	9.2 ± 2.0	5.4-5.9	5.7 ± 0.3	9.4-10.8	10.2 ± 0.5	8.3-11.2	9.9 ± 1.5	9.2-11.8	10.3 ± 0.8
Teeth										
Premaxillary	10-13		5-7		11-14		6-7		5-7	
Median premaxillary	9		3		0-1		0-3		0-3	
Maxillary-inner	2-12		2-5		-		-		-	
Maxillary-outer	24-34		15-18		16-19		7-12		6-10	
Vomerine	6-10		3-7		11-20		4-9		3-8	
Dentary-inner	5-15		2-5		-		-		-	
Dentary-outer	32-42		18-23		26-40		12-20		9-18	
Vertebrae										
Predorsal	86-93	90	8-9	9	5-6	6	5-6	6	6-7	6
Preanal	90-95	92	66-69	68	65-70	67	73-77	75	74-78	76
Total	100-105	102	164-167	166	149-154	151	165-168	166	170-176	173

Preanal length 1.9-2.0 (2.0 ± 0.1), tail length 2.0-2.1 (2.0 0.1), trunk length 2.3-2.5 (2.4 ± 0.1), body depth at gill opening 26.4-34.9 (29.4 ± 2.6), body depth at anus 28.0-45.0 (36.7 ± 4.3), predorsal length 11.4-14.4 (12.9 ± 0.9), head length 8.7- 10.3 (9.5 ± 0.5), all in TL. Upper jaw length 2.2-2.9 (2.6 ± 0.2), lower jaw length 2.2-3.1 (2.7 ± 0.2), interorbital width 6.0-8.2 (7.0 ± 0.7), snout length 5.1-6.4 (5.6 ± 0.4), eye diameter 8.5- 10.9 (9.8 ± 0.8), all in HL. Premaxillary teeth 5-7 each side, maxillary teeth uniserial about 6-10, vomerine teeth uniserial 3- 8; median premaxillary teeth counts are somewhat different in each sex, 2-3 in female and 0 in male; dentary teeth of mandible in a single row 11-18 on left and 9-17 on right side, it were also different in sex, female 13-18 are more than male 10-14. Head pores typical, three supraorbital pores, four infraorbital pores, six mandibular pores. Two branchial pores, branchial pores small before gill opening. Gill openings small, just below mid- side of body. Predosal vertebrae 6-7, preanal vertebrae 74-78, total vertebrae 170-176; mean vertebral formula 6-76-173.

4. Distribution

The species was previously known from Japan, the present record for Taiwan being new.

5. Remarks

A small to moderate-sized moray, the largest known is 534 mm TL (the holotype, USNM 149777). Sexes were determined by 12 specimens, eight of the study specimens (395-512 mm TL) were females, four specimens (422-512 mm TL) had ripe eggs with 1.0-1.2 mm egg diameter, and fecundity 3959 ± 622 eggs; the other four specimens (375-482 mm TL) were males.

This is a new record for Taiwan. Hatooka [14] reported a "*Gymnothorax sagmacephalus* pattern" as a young fish stage of *G. albimarginatus*. This coloration was also illustrated on pl. 28, fig. I in Masuda et al. [21] and named as *G. albimarginatus* from Japan. It appears to be *G. sagmacephalus* and showed the prominent triangular saddle on the top of head, as well as the anterior dusky area behind the eyes extending onto the lower jaw. Böhlke [3] noted that the saddle of *G. sagmacephalus* was so heavily pigmented that it could hardly have been overlooked in any description of the species, and it had not faded in the holotype which was taken 90 years ago. *G. sagmacephalus* could also be differentiated from *G. albimarginatus* by the position of the anus (at mid-body in *sagmacephalus*, well behind mid-body in *albimarginatus*) and the mean vertebral formula (6-76-173 vs. 5-86-187 respectively).

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