

## Review of the Astronesthid Fishes (Stomiiformes: Stomiidae: Astronesthinae) from Taiwan with a Description of One New Species

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**Yun-Chih Liao, Li-Shu Chen, and Kwang-Tsao Shao (2006)** Review of the astronesthid fishes (Stomiiformes: Stomiidae: Astronesthinae) from Taiwan with a description of one new species. *Zoological Studies* 45(4): 517-528. A review of the mesopelagic and bathypelagic astronesthid fishes from off Taiwan documented 11 species in 5 genera. Among them, 7 species and 4 genera are newly recorded. These include *Astronesthes indica*, *A. indopacifica*, *A. splendida*, *Borostomias elucens*, *Eupogonesthes xenicus*, *Heterophotus ophistoma*, and *Rhadinesthes decimus*. In addition, 1 new species, *A. formosana* sp. nov. is described. Descriptions, diagnostic keys, line-drawings, and color photographs are provided. <http://zoolstud.sinica.edu.tw/Journals/45.4/517.pdf>

**Key words:** Stomiiformes, Stomiidae, Astronesthinae, Taiwan.

Astronesthids are mainly mesopelagic or bathypelagic fishes, which are found in most temperate and tropical seas. Their diets consist of other mesopelagic fishes and crustaceans (Sutton and Hopkins 1996). Astronesthid fishes are characterized as follows: body size moderate, most < 15 cm standard length; eyes small, < 1/4 of head length; mouth large with large, fanglike teeth; chin barbel present, terminal bulb present and variable in length; dorsal fin near middle of body, its origin over or slightly behind pelvic fin insertion and well in advance of anal fin origin; dorsal fin with 9-21 rays; anal fin with 12-28 rays; caudal fin forked; pectoral fin with 6-9 rays; pelvic fin with 5-9 rays; dorsal adipose fin present (except in *Rhadinesthes decimus*); scales and hexagonal pigment on body absent; suborbital and postorbital photophores present; patches of luminous tissue present on gill cover or body in some species; 2 rows of photophores on ventral body, numerous smaller photophores scattered on head and body; body color black but silvery pigmentation may be present on flank (Harold in Carpenter and Niem 1999).

As considered here, the subfamily Astronesthinae consists of 6 genera: *Astronesthes*, *Borostomias*, *Eupogonesthes*, *Heterophotus*, *Neonesthes*, and *Rhadinesthes*. Parin and Borodulina have published several revisions and described new species and a new genus in the subfamily Astronesthinae over the past 10 yrs (Parin and Borodulina 1993 1994 1996 1997 2003). In total, there are about 49 species in the genus *Astronesthes* with about 60 species in 6 genera in the subfamily worldwide (Parin and Borodulina 2003, FishBase 2006). Parin and Borodulina (2003) divided the *Astronesthes* into 8 distinct individual species with the other species in 9 species groups. Treatment of the family Astronesthidae at the family level was questioned by Fink (1985), who suggested that the astronesthids and other families (such as the Melanostomiidae, Malacosteidae, Idiacanthidae, and Chauliodontidae) should all be placed in the enlarged family Stomiidae to form a monophyletic group. This arrangement was also accepted by Nelson (1994) and in FishBase (Froese and Pauly

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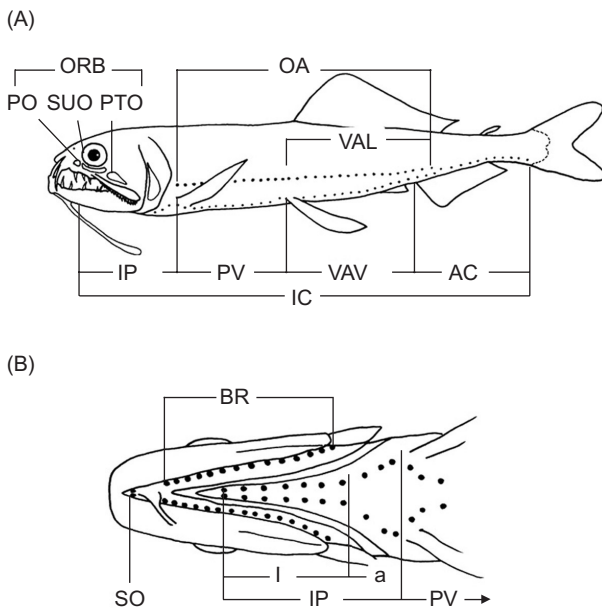
2006). Even though the interrelationships within astronesthids have yet to be resolved, we followed Nelson (1994) here and treated astronesthid fishes as the subfamily Astronesthinae in the Stomiidae.

Prior to this study, only 3 species, *Astronesthes chrysophekadion*, *A. lucifer* and *A. trifibulata*, had been recorded from Taiwan (Gibbs et al. 1984, Shen 1984a b, Chen and Yu 1986, Shen et al. 1993). Unfortunately, voucher specimens of the first species were lost, and only a few specimens of the second species were deposited in Taiwanese museums.

Before 2002, deep-sea fish specimens from Taiwan, including most of the material in this study, were only collected by commercial bottom trawlers. Fishing depths were < 700-800 m at Tashi (on the northeast coast) and < 300-400 m at Tungkang (on the southwest coast) of Taiwan, respectively. It was not until 2002, when an NSC research project on the deep-sea fish diversity was

granted to the 3rd author (KTS), that deep-sea fish specimens could be collected down to 2500 m using a bottom trawl, beam trawl, and IKMT on the *Ocean Research Vessels (R/V OR) 1* and *3*. Intensive collections made since 2002 have recorded more than 150 new records of deep-water species from Taiwan. These include new records and some new species of rattails (Macrouridae) and deep-sea anglerfishes (Ceratioidei) (Chiu et al. 2004 a b, Ho and Shao 2004, Pietsch et al. 2004, Yeh et al. 2005, Liao et al. 2006, Wang et al. 2006).

This paper reviews the subfamily Astronesthinae from these Taiwanese collections, provides keys to all of the species recorded, outlines information on new distributional records for Taiwan, and describes 1 new species of *Astronesthes*. The total number of astronesthids recorded from around Taiwan now comprises 5 genera and 11 species of astronesthines.



**Fig. 1.** Photophores of stomioid fishes: IC, entire ventral row of photophores from the anterior end of the isthmus to posterior of the caudal peduncle (IC = IP + PV + VAV + AC); IP, ventral row of photophores from anterior of the isthmus to a ventral line at the pectoral fin origin (IP = I + a); PV, ventral row of photophores between vertical lines at the origins of the pectoral and pelvic fins; VAV, ventral row of photophores between a vertical line at the origins of the pelvic and anal fins; AC, posterior part of the IC series, from posterior of the VAV series to the posterior part of the caudal peduncle; OA, all large photophores of the lateral series. BR, branchiostegal photophores; ORB, orbital photophores; SO, located near the anterior end or the symphysis of the lower jaw; PO, preorbital photophores; SUO, suborbital photophores; PTO, postorbital photophores (after Nakabo 2002).

## MATERIALS AND METHODS

Specimens were collected mainly by the Laboratory of Fish Ecology and Evolution, Research Center for Biodiversity, Academia Sinica from the harvest of commercial bottom trawlers at the Tashi (in northeastern Taiwan) and Tungkang (in southwestern Taiwan) fishing ports, and deep-sea cruises by the *R/V OR 1* and *3* since 2002. All specimens were photographed fresh before they were preserved in 95% ethanol for further molecular analysis. Several specimens were first preserved in 10% formalin, and then transferred to 75% ethanol for permanent preservation. Vertebral counts of some specimens were taken using x-ray films. Most specimens examined were deposited at the Research Museum of the Research Center for Biodiversity, Academia Sinica (ASIZP), Taipei, Taiwan. Comparative specimens were borrowed from the Fisheries Research Institute (FIRP), Keelung, Taiwan; the National Museum of Marine Science and Technology (NMSMP), Keelung, Taiwan; and the National Museum of Natural History (Smithsonian Institution) (USNM), Washington DC, USA. Images of specimens at ASIZP were digitized and integrated into a curatorial database in the Fish Database of Taiwan (<http://fishdb.sinica.edu.tw>) to allow public access (Shao et al. 2002). The following abbreviations were used: SL, standard length; HL, head length; Vert, vertebral account; and photophores following Nakabo (2002) in figure 1. All

length measurements are given in mm SL except as noted.

### Key to species of Astronesthinae fishes from Taiwan

1. PV photophores (ventral row between vertical lines at origins of pectoral and pelvic fins) arranged in groups of 2-5..... *Heterophotus ophistoma*
- PV photophores arranged in regular intervals ..... 2
2. Maxillary teeth caninelike, distinctly separated, not slanting backward ..... 3
- Maxillary teeth comblike, closely separated and slanting backward ..... 5
3. Dorsal adipose fin absent; body relatively shallow, < 10% SL ..... *Rhadinesthes decimus*
- Dorsal adipose fin present; body relatively deep, > 10% SL ..... 4
4. Body black or dark brown; chin barbel slender, terminal bulb of barbel without filament; last 2 or 3 OA photophores not higher than others; AC photophores continuous, middle arched behind anal base..... *Borostomias elucens*
- Body silvery; chin barbel with prominent swelling; last 2 or 3 OA photophores higher than others; AC interrupted, middle 2 or 3 photophores distinctly higher than others..... *Eupogonesthes xenicus*
5. OA (all large photophores of lateral series, OV+VAL) photophores 11-14 (usually 12), last photophores of OA before origin of anal fin ..... *Astronesthes indica*
- OA photophores more than 30 ..... 6
6. Last 2 or 3 VAL photophores distinctly higher than others (lateral row between vertical line at origin of pelvic fin and end of large photophores of OA series); AC (posterior part of lateral photophores series) discontinuous, middle 2 or 3 large photophores distinctly higher than others ..... 7
- Last 2 or 3 VAL photophores not higher than others; AC photophores continuous or smooth, middle large photophores not distinctly higher than others ..... 8
7. Black band on lower 1/2 of caudal peduncle. Chin barbel longer than head length ..... *A. lucifer*
- Black band on lower 1/2 of caudal peduncle absent. Chin barbel less than head length ..... *A. chrysophekadion*
8. IV photophores (ventral row from anterior end of isthmus to ventral line at pectoral fin origin) almost straight. Opercular luminous tissue absent..... 9



Fig. 2. *Astronesthes chrysophekadion*, ASIZP0063396, 134 mm SL.

- IV photophores arched outward on pelvic fin base. Opercle with large (SL > 50 mm) prominent luminous tissue..... 10
9. Terminal end of barbel with several filaments (mostly 8); middle AC photophores with distinct upward curve..... *A. splendida*
- Terminal end of barbel with 1 long filament; middle AC photophores straight ..... *A. trifibulata*
10. Terminal tip of chin barbel simple, not swollen or rounded, luminous tissue on opercle not extending to level of posterior maxilla ..... *A. indopacifica*
- Terminal tip of chin barbel slightly swollen or rounded, luminous tissue on opercle extending to level of posterior maxilla ..... *A. formosana* sp. nov.

### Systematic Account

#### *Astronesthes* Richardson, 1845

#### *Astronesthes chrysophekadion* (Bleeker, 1849) (Fig. 2)

*Stomianodon chrysophekadion* Bleeker 1849: 10.

*Astronesthes chrysophekadion*: Shen et al. 1993: 154.

*Specimens examined*: 10 (60-134), all collected by commercial bottom trawl off Tungkang, SW Taiwan: ASIZP0063355, (1) 132, 26 Aug. 2001; ASIZP0063393, 1 (76), 23 Mar. 2002; ASIZP0063394, 1 (123), 20 Nov. 2003; ASIZP0063395, 1 (62), 20 Feb. 2004; ASIZP0063396, 3 (84-134), 20 Feb. 2004; ASIZP0063397, 1 (69), 24 Mar. 2004; ASIZP0063398, 2 (60, 74), 24 Mar. 2004.

*Description of specimens examined*: Pectoral rays 6 (7); pelvic rays 7; dorsal rays 11 or 12; anal rays 17-19. Photophores: IP 10; PV 17-19; VAV 21-23; AC 5+2+4 (rarely 5) = 11 or 12; IC 59-63; OA 37-39. Barbel length shorter than head length (about 0.1-0.6 times head length), and increasing with SL; AC photophores discontinuous, 6th to 7th elevated; caudal peduncle lacking black band.

*Distribution*: Indo-West Pacific, recorded from Japan, Taiwan, Papua New Guinea, and Indonesia. Depth range is about 100-1120 m (Parin and Borodulina 1994), in Taiwan depth range of specimens is about 200-400 m.

#### *Astronesthes formosana* sp. nov.

(Figs. 3, 4, 5A; Table 1)

*Specimen examined*: Holotype: ASIZP0063353, 1 (85), Tungkang, SW Taiwan, commercial midwater trawl, 20 Feb. 2004. Paratypes: 14 (36-95). Part collected by commercial midwater trawl off Tungkang, SW Taiwan: ASIZP0063340, 1 (78), 23 Nov. 1997; ASIZP0063349, 1 (84), 20 Nov. 2003;

ASIZP0063351, 1 (81), 15 Jan. 2004; ASIZP0063354, 8 (50-95), 24 Mar. 2004. Others: ASIZP0063341, 1 (62), station CD 124, R/V OR 1, cruise 619, SW Taiwan, from 24°58.85'N, 122°17.59'E to 25°02.73'N, 122°21.60'E; depth range 1165-1129 m, otter trawl, 1 Aug. 2001; ASIZP0063343, 1 (61), Tashi, NE Taiwan, commercial bottom trawl, 4 Oct. 2001; ASIZP0063345, 1 (36), IK 224, R/V OR 1, cruise 692, E Taiwan, from 23°34.141'N, 121°37.037'E to 23°36.595'N, 121°37.672'E, 450 m wire out, IKMT, 30 Aug. 2003.

*Other specimens:* 13 (27.6-94). Part collected by commercial midwater trawl off Tungkang, SW Taiwan: ASIZP0063342, 1 (70), 26 Aug. 2001; ASIZP0063344, 1 (57), 20 July 2003; ASIZP0063347, 1 (27.6), 1 Oct. 2003; ASIZP0063350, 1 (71), 14 Dec. 2003; ASIZP0063352, 1 (44), 20 Feb. 2004; ASIZP0063366, 5 (32-94), 10 Apr. 2004. Others: ASIZP0063346, 2 (28.8, 31), R/V OR 3, SW Taiwan, from 22°11.51'N, 120°14.61'E to 22°08.57'N, 120°23.08'E, 800 m wire out, IKMT, 1

Oct. 2003; ASIZP0063348, 1 (31), R/V OR 3, SW Taiwan, from 22°14.34'N, 120°13.77'E to 22°12.86'N, 120°14.33'E, 740 m wire out, depth 785 m, IKMT, 1 Oct. 2003.

*Comparative material:* 3 (74-98.7); *A. indopacifica*, Holotype, USNM 00256917, 1 (74), Pacific Ocean, 00°18'N, 150°12'W, 9 Dec. 1977; FIRP 094, 1 (98.7), Pacific Ocean, from 14.30°N, 123.35°E to 14.70°N, 123.14°E, 648-660 m depth, bottom trawl, 27 Sept. 1995; *A. lamellosus*, Holotype, USNM 200885, 1 (76), N Indian Ocean, 17°46'N, 65°02'E, 18 May 1964.

*Diagnosis:* IP photophores curved rather than linear. Luminous tissue prominent on gill cover between preopercle and opercle in larger specimens (SL > 50 mm), lower part more prominent than upper. Posterior part of lower jaw with a pair of prominent irregular luminous tissues. Head, jaws, dorsum, and body more luminous. Chin barbel long, about 0.2-0.8 times head length, and increasing with fish size. Terminal end of barbel slightly swollen, apical tip rounded.

*Description:* Maximum body depth about

**Table 1.** Morphological comparisons in the long-chin-barbel species group of *Astronesthes cyaneus*: *A. indopacifica*, *A. formosana* sp. nov., *A. macropogon*, and *A. lamellosus*

	<i>A. indopacifica</i>	<i>A. formosana</i>	<i>A. macropogon</i>	<i>A. lamellosus</i>
Distribution	Indo-Pacific	West-Pacific Ocean (Taiwan)	Atlantic Ocean	North Indian Ocean (Arabian Sea, Bay of Bengal)
Pectoral fin rays	8	8 (rarely 7 or 9)	8	8
Dorsal fin rays	17-20	17-20	18-20	16-19
Anal fin rays	13-16	13-15	13-15	13-15
Chin barbel/head length	0.4-0.6	0.5-0.8	0.4-0.7	0.9-1.0
Barbel	slender and simple	slightly swollen or rounded	slightly swollen	slightly swollen
Vertebrate	45-49	46-48	47-49	42-45
Maxillary teeth	14-19	13-27	6-31	9-23
Maxillary teeth (SL > 70 mm)	19	21-27	23-31	23
Luminous tissue:				
on lower jaw	absent	present	present	absent
Operculum (SL > 50 mm)	not extending to level of lower jaw	extending to level of lower jaw	not extending to level of lower jaw	not extending to level of lower jaw
Position on operculum	middle part	lower part	middle part	middle part
Head, dorsal, jaw	less luminous	more luminous	more luminous	less luminous
Nostril	more compact	smear-like	more compact	more compact
Photophores:				
IP	9 or 10	8-10	9 or 10	9
PV	13 or 14	12-15	13 or 14	12 or 13
VAV	17-21	17-21	17-19	17 or 18
AC	9-11	10-12	10 or 11	9-11
IC	50-54	49-54	51-53	48-50
OA	31-34	31-34	32-34	29-31

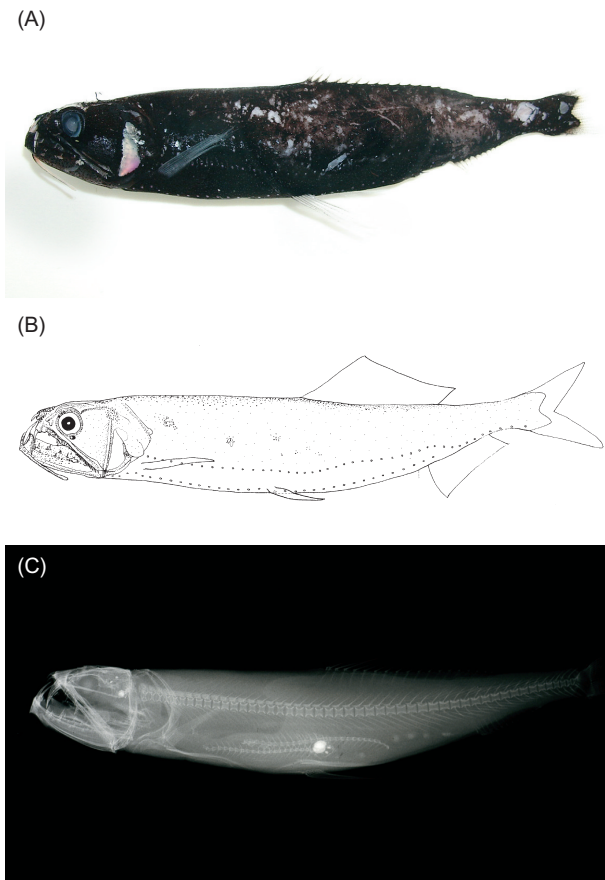
Data source of *A. macropogon* and *A. lamellosus*: Parin and Borodulina 1997.

0.16-0.23 times SL; head length about 0.2-0.3 times SL; eye diameter 0.1-0.2 times head length; caudal peduncle length about 1.7-2.3 times its depth. Chin barbel moderate, about 0.2-0.8 times head length, terminal bulb absent, terminal end of barbel slightly swollen or rounded, barbel stem white with only basal part pigmented, chin barbel length increasing with growth. Gill filament counts 19-24 + 48-57 = 70-79. Vertebrae 46-48. Maxillary teeth 13-27, increasing with growth, 19-27 in larger specimens (SL > 50 mm). Jaws with numerous luminous spots, usually with irregular luminous tissue on posterior dentary of larger specimens (SL > 50 mm). Head with numerous small luminous spots forming irregular luminous patches. Usually 1 or more pairs of luminous patches behind or between nostrils, additional small luminous spots scattered around nostrils and snout. Area above the opercle usually with luminous patches. Dorsum from head to dorsal fin with numerous

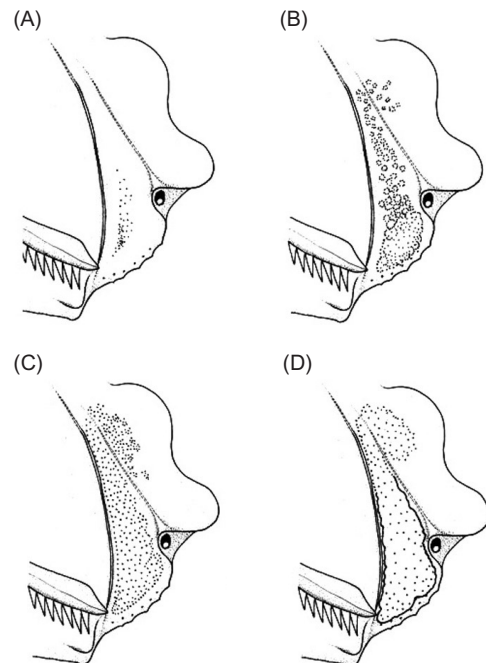
small luminous spots scattered around mid-dorsum line, sometimes forming a cluster of luminous patches. Luminous tissue prominent on gill cover between preopercle and opercle on larger specimens (SL > 50 mm, well-developed; 30-50 mm, underdeveloped; SL < 30 mm, absent) (Fig. 4), the lowest part encompassing most of interopercle, more prominent than upper part, forming a triangular shape. Luminous tissue on body scattered backward from upper part of pectoral fins until caudal peduncle in larger specimens (SL > 50 mm).

**Body color.** Body black or dark brown in preserved specimens. Head, body, and interspace between photophores usually silvery in larger specimens (SL > 50 mm), dark brown in smaller specimens (SL < 30 mm) with metallic color on head and body. Head, nostril, jaws, and dorsum between the head and dorsal fin with numerous small white luminous spots. Luminous tissue on opercle reddish when fresh, turning to creamy-white when preserved. Barbel light-colored with only basal ventral part pigmented. Ventral series of photophores reddish when fresh, white when preserved.

**Remarks:** The species belongs to the long-chin-barbel *A. cyaneus* species group in having a high dorsal-ray count and prominent luminous tis-



**Fig. 3.** *Astronesthes formosana*, sp. nov. Holotype (ASIZP0063353, 85 mm SL). (A) Line drawing; (B) color photograph; (C) x-ray photograph.



**Fig. 4.** Opercular luminous tissue on *Astronesthes formosana* sp. nov. (A) ASIZP0063344, 57 mm SL; (B) ASIZP0063351, 81 mm SL; (C) ASIZP0063350, 71 mm SL; (D) ASIZP0063349, 84 mm SL.

sue on the operculum. Three long-barbeled species are included in the species group: *A. lamellosus*, *A. macropogon*, and *A. indopacifica* (Goodyear and Gibbs 1970, Parin and Borodulina 1997). *Astronesthes formosana* sp. nov. differs from these by the lower part of luminous tissue on the opercle which extends downward to the level of the distal end of the maxilla, and the lower part of the luminous tissue is more prominent than the upper and is usually triangular in shape (Fig. 4); the posterior dentary usually has 1 prominent irregular luminous patch on each side in larger

specimens.

*Astronesthes lamellosus* differs as follows: chin barbel longer, reaching 90%-100% of head length in large specimens (SL > 70 mm) rather than 50%-80%; head, jaws, dorsum, and body less luminous; gill filament counts fewer than 30; and fewer vertebrae (42-45) and IC photophores (48-52) (Table 1). In addition, *A. lamellosus* is found only in the Arabian Sea and Bay of Bengal. *Astronesthes macropogon* differs as follows: head, dorsum, and jaws more luminous; with growth the chin barbel length decreases to 40%-60% of the head length rather than increasing to 50%-80% of the head length. In addition, *A. macropogon* is restricted to warm-water regions of the Atlantic Ocean.

*Astronesthes indopacifica*, differs in the following characters: chin barbel is slender and simple; maxillary teeth 14-19, and 19 in larger specimens (SL > 70 mm); luminous spot on lower jaw absent; prominent operculum luminous tissue in middle part (SL > 50 mm) not extending to level of lower jaw; the area about the head, nostril, dorsum, jaws, and body is less luminous, and the upper nostril has 1 pair of clear distinct luminous spots. However, in *A. formosana* sp. nov., the chin barbel is slightly swollen or rounded; maxillary teeth 13-27, and never fewer than 21 in larger specimens; with 1 prominent irregular luminous spot on the posterior lower jaw; operculum luminous tissue on lower part, extending to the level of the lower jaw; head, nostril, dorsum, jaws, and body are more luminous, and the upper nostril has more than 1 pair or smear-like luminous spots (Table 1, Fig. 5). It is difficult to distinguish smaller specimens (SL < 30 mm) of *A. indopacifica* and *A. formosana* sp. nov. before the operculum luminous tissue is well developed in larger specimens (SL > 50 mm).

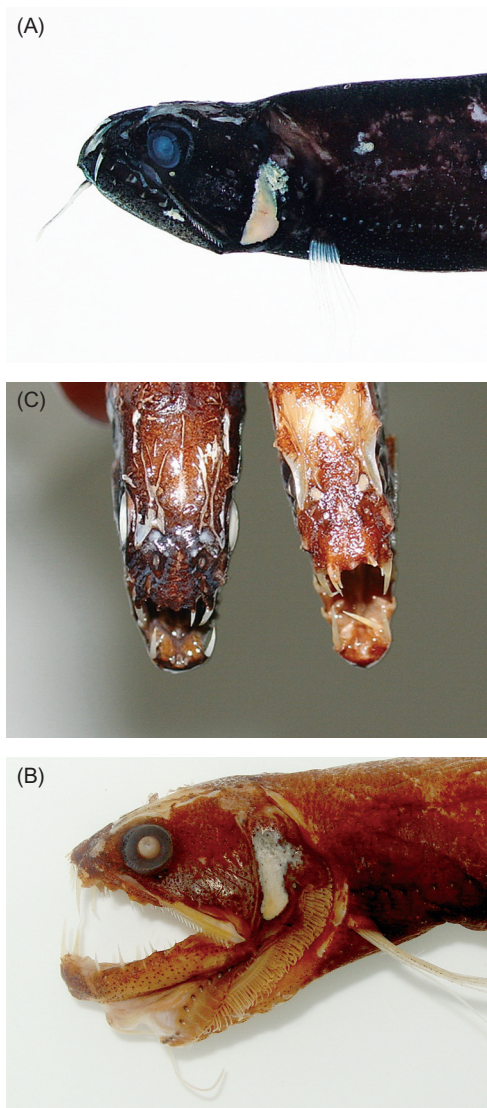
**Distribution:** Known only from around Taiwan, at depths of about 318-1129 m.

**Etymology:** *Astronesthes formosana* is named after Formosa, the historic name of Taiwan due to its restricted distribution off Taiwan.

***Astronesthes indopacifica* Parin and Borodulina, 1997**

(Figs. 5B, 6, Table 1)

**Specimens examined:** 2 (54-98.7). ASIZP0059960, 1 (54), SW Taiwan, 22.47°N, 120.43°E, 150-500 m depth, bottom trawl, 23 Nov. 1997; FIRP 094, 1 (98.7), Pacific Ocean, from 14.30°N, 123.35°E to 14.7°N, 123.14°E, 648-660



**Fig. 5.** Head of *Astronesthes*: (A) *Astronesthes formosana* sp. nov., ASIZP0063353, 85 mm SL, holotype, lateral view; (B) *A. indopacifica*, USNM00256917, 74 mm SL, holotype, lateral view; (C) dorsal view, left, *A. formosana* sp. nov., ASIZP0063341, 62 mm SL, paratype; right, *A. indopacifica*, USNM00256917.

m depth, bottom trawl, 27 Sept. 1995.

*Comparative specimens:* *A. indopacifica*, Holotype, USNM 00256917, 1 (74), Pacific Ocean, 0°18'N, 150°12'W, 9 Dec. 1977.

*Description of specimens examined:* Pectoral rays 8, pelvic rays 7, dorsal rays 17 (17-20), anal rays 15 (13-16). Photophores: IP 9 (9 or 10), PV 13 (13 or 14), VAV 19 (17-21), AC 11 (9-11), IC 52 (50-54), OA 32 (31-34). IP photophores series curved rather than linear. Luminous tissues on head, nostril, opercle, jaws, dorsum, and body. One pair of prominent luminous patches on upper nostril. Prominent luminous tissue on gill cover in larger specimens. No irregular luminous tissue on posterior part of lower jaw. Chin barbel long and slender, about 0.5-0.6 times head length, increasing with growth. Terminal end of barbel simple.

*Body color:* Body dark brown when preserved. Luminous tissues on opercle, head, nostril, and body creamy-white.

*Distribution:* Tropical warm waters of the Indo-Pacific. Depth range is from near the surface to 1300 m (Parin and Borodulina 1997).

*Remarks:* This is the first record from Taiwanese waters.

### ***Astronesthes indica* Brauer, 1902**

(Fig. 7)

*Specimens examined:* 6 (37-141). ASIZP0063399, 1 (141), Tashi, NE Taiwan, commercial bottom trawl, 1 Sept. 2001. Others: 5 (37-59), collected by commercial midwater trawl off Tungkang, SW Taiwan: ASIZP0059961, 1 (59), 23 Nov. 1997; ASIZP0063400, 1 (37), 20 Nov. 2003; ASIZP0063401, 1 (53), 2 Apr. 2004; ASIZP0063402, 1 (47), 2 Apr. 2004; ASIZP0063403, 1 (55), 24 Mar. 2004.

*Description of specimens examined:* Pectoral rays 7; pelvic rays 7; dorsal rays 15-17; anal rays

12-14; Vert 44 (43-46). Photophores: IP 5, PV 6, VAV 7-9, AC 8 or 9, IC 26-28, OA 12. The last OA photophore in advance of both origin of anal fin and last VAV photophores. Serial photophores of ventral row in a straight line between IP and PV. Luminous tissue on gill cover forming a bend on opercle and patch on interopercle in larger specimens. Chin barbel shorter than head, its swollen tip of barbel with riblike structures.

*Color:* Body black. Luminous patches on opercle, interopercle, and along ventral margin of lower jaw pinkish when fresh; whitish when preserved. Chin barbel white on small specimens, its basal part and terminal swollen tip with black pigment. Barbel on large specimens dark, prominent postorbital photophores orange when fresh and yellowish-green when preserved. No additional luminous patches on flanks of body.

*Distribution:* Widely distributed in the Indo-Pacific. Depth range of specimens is from near the surface to at least 200 m.

*Remarks:* This species is recorded for the first time from Taiwan. One specimen (ASIZP0063399, 141 mm SL), differs slightly from the other specimens as follows: with more dorsal soft rays of 17 rather than 14-16 as in the species range, postorbital photophores larger in size and postorbital length shorter than about 0.13 times of head length, and the luminous tissue on the lower part of the operculum has a distinct black margin.

### ***Astronesthes lucifer* Gilbert, 1905**

(Fig. 8)

*Astronesthes lucifer:* Chen and Yu 1984: 159, Shen 1984b: 120, Shen et al. 1993: 154.

*Specimens examined:* 18 (74-125). Part collected by commercial bottom trawl off Tungkang, SW Taiwan: ASIZP0057162, 2 (74-96), 22 Dec.



Fig. 6. *Astronesthes indopacifica*, ASIZP0059960, 54 mm SL.



Fig. 7. *Astronesthes indica*, ASIZP0059961, 59 mm SL.

1992; ASIZP0062176, 1 (107), 20 July 2001; ASIZP0062178, 3 (84-101), 1 July 2001; ASIZP0063406, 2 (118, 125), 26 Aug. 2001; ASIZP0063409, 2 (99, 99), 5 Sept. 2002; ASIZP0063410, 1 (103), 9 Sept. 2003; ASIZP0063411, 1 (118), 20 Feb. 2004; ASIZP0063412, 1 (92), 18 Nov. 2001; NMSMP 609, 1 (90) I, 21 Nov. 1990. Others: 5 (56-93), ASIZP0063404, 1 (56), CD-123, R/V OR 1, cruise 619, NE Taiwan, from 24°52.02'N, 122°01.33'E to 24°48.92'N, 122°01.24'E, otter trawl, 1 Aug. 2001, depth 423-538 m; ASIZP0063405, 1 (76), CD-137, R/V OR 1, cruise 629, SW Taiwan, from 22°12.92'N, 120°25.93'E to 22°13.14'N, 120°19.59'E, otter trawl, 23 Nov. 2001, depth 316-477 m. Commercial bottom trawl off Tashi, NE Taiwan: 2 (76, 93), ASIZP0063407, 1 (76), 28 Oct. 2001; ASIZP0063408, 1 (93), 21 Mar. 2002.

*Description of specimens examined:* Pectoral rays 6 (7), pelvic rays 7, dorsal rays 11-13, anal rays 17-19. Photophores: IP 10, PV 19 or 20, VAV 21-24, AC 11 or 12, IC 61-65, OA 38-40. Barbel length about 1-1.6 times longer than head length. Ventral series of AC photophores discontinuous, 2 or 3 photophores ranging from 5th to 8th elevated higher than others. A prominent black band extending from ventral to mid-lateral side of caudal peduncle.

*Distribution:* Indo-Pacific: including Japan, Taiwan, Australia, off the Hawaiian Is., and the Timor Sea. In Taiwan, the depth range of specimens is about 200-538 m.

*Remarks:* Parin and Borodulina (1994) indicated that *A. ijimai* differs from *A. lucifer* because of the following: the caudal peduncle length is about 1.2-1.8 times its depth in *A. ijimai* rather than 1.9-2.2 times in *A. lucifer*, and *A. ijimai* has dark transverse bands on the body that are formed by melanophore aggregations around the accessory photophores. However, the specimens examined

in this study revealed that the caudal peduncle length ranges 1.31-2.33 times its depth. In addition, all specimens examined from Taiwan had dark transverse bands formed by melanophore aggregations around the accessory photophores on the body. Since Parin and Borodulina reported considerable geographic variations in these 2 species, it will probably be necessary to conduct a detailed range-wide review of both species.

### *Astronesthes splendida* Brauer, 1902

(Fig. 9)

*Specimens examined:* 9 (43-63). Part collected by commercial midwater trawl off Tungkuang, SW Taiwan: ASIZP0063413, 5 (43-52), 15 Jan. 2004; ASIZP0063414, 3 (54), 24 Mar. 2004. Other: ASIZP0063356, 1(63), South China Sea, commercial bottom trawl, 15 May 1993.

*Comparative specimens:* 5 (36-59), *A. splendida*, USNM 200901, 1 (42), Western Indian Ocean, 12°10'S, 64°54'E, IKMT, 0-798 m depth, 4 June 1964; USNM 301045, 2 (36, 48), Western Indian Ocean, 2°3'N, 65°4'E, 0-817 m depth, 26-27 May 1964; USNM 200900, 1 (50), Western Indian Ocean, 5°55'S, 64°48'E, IKMT, 0-746 m depth, 31 June-1 July 1964; USNM 301081, 1(43), Western Indian Ocean, 7°14'N, 59°53'E, 0-2250 m depth, 16 Aug. 1963.

*Description of specimens examined:* Pectoral rays 8; pelvic rays 7; dorsal rays 13 or 14; anal rays 16-18. Photophores: IP 10, PV 16 or 17, VAV 19-21, AC 11 or 12, IC 56-59, OA 36 or 37. Luminous patch on operculum absent. AC photophores on caudal peduncle distinctly curved upward. Photophores series of IP and anterior of PV forming straight line rather than outward in a V shape. Barbel black with white terminal bulb bearing several filaments (almost 8). Maxillary teeth 15.



Fig. 8. *Astronesthes lucifer*, ASIZP0063411, 118 mm SL.



Fig. 9. *Astronesthes splendida*, ASIZP0063356, 63 mm SL.



**Color:** Body uniformly black. Chin barbel black with white terminal bulb. Anterior 1-4 rays of dorsal and 1-3 rays of anal fin dark. About 3-6 rays of pectoral fins and 2-7 rays of pelvic fins with several small photophores with peripheral black pigments, all anal rays with white luminous-like tissue. Photophores series reddish when fresh.

**Distribution:** Indo-Pacific, tropical waters of North Pacific and Indian Ocean. Depth range in Taiwan is near the surface to about 400 m.

**Remarks:** This is the first record from Taiwanese waters.

***Astronesthes trifibulata* Gibbs, Amaoka and Haruta 1984**  
(Fig. 10)

**Specimens examined:** 4 (33-106). Part collected by commercial midwater trawl off Tungkang, SW Taiwan: ASIZP0057164, 1 (106), 24 Apr. 1992; ASIZP0063415, 1 (42), 8 Sept. 2003; ASIZP0063416, 1 (33), 24 Mar. 2004. Other: ASIZP0063417, 1 (64), IK-186, *R/V OR 1*, cruise 655, South China Sea, from 21°51.20'N, 119°28.16'E to 21°53.03'N, 119°25.30'E, IKMT, 27 Aug. 2002, depth range 695-717 m.

**Description of specimens examined:** Pectoral rays 6-8, pelvic rays 7, dorsal rays 12-14, anal rays 17-20. Photophores: IP 10 or 11, PV 16 or 17, VAV 20-24, AC 11, IC 58-62, OA 37-41. Luminous tissue on head between nostrils and eyes, no luminous patch on opercle. Rows of photophores between IP and PV linear. Posterior OA photophores straight, not higher than others. Barbel longer than head length, terminal tip of bulb with 1 filament. One pair of short filaments situated on each side of middle part of bulb.

**Color:** Body brown with metallic sheen on sides of head and body when preserved. Ventral series of IC photophores with golden-metallic



Fig. 10. *Astronesthes trifibulata*, ASIZP0057164, 106 mm SL.

sheen when fresh. Pectoral and pelvic fin membranes with several small pigmented photophores. Numerous black pigments scattered inside mouth and on brain membrane. Barbel stem black with white bulb.

**Distribution:** Indo-Pacific, in tropical and subtropical waters, including the northwestern Pacific Trough. Depth range off Taiwan is near the surface to 717 m.

***Borostomias* Regan, 1908**

***Borostomias elucens* (Brauer, 1906)**  
(Fig. 11)

*Astronesthes elucens* Brauer 1906: 31.

*Borostomias elucens*: Gibbs 1964: 332.

**Specimen examined:** 1 (185). ASIZP0063418, IK 181, *R/V OR 1*, cruise 655, South China Sea, from 22°21.09'N, 119°36.60'E to 22°20.57'N, 119°35.10'E, IKMT, depth range 812-904 m, 25 Aug. 2002.

**Description of specimens examined:** Pectoral rays 7; pelvic rays 7; dorsal soft rays 14; anal rays 17. Photophores: IP 11; PV 23; VAV 15; AC 11; IC 61; OA 38. AC photophores greatly arched behind



Fig. 11. *Borostomias elucens*, ASIZP0063418, 185 mm SL.



Fig. 12. *Eupogonesthes xenicus*, ASIZP0063419, 86 mm SL.

anal fin base. Maxillary teeth 11 or 12, caninellike, separated. Stem of chin barbel black, terminal tip forming a small, spherical white bulb. Body moderately slender and elongate. Serial photophores not broken into small groups. Body black.

*Distribution:* Widely distributed in the Indo-Pacific and Atlantic Ocean. Depth range in Taiwan is > 500-904 m.

*Remarks:* This is the first record from Taiwanese waters.

### ***Eupogonesthes* Parin and Borodulina, 1993**

#### ***Eupogonesthes xenicus* Parin and Borodulina, 1993**

(Fig. 12)

*Specimens examined:* 2 (73, 86). ASIZP 0063419, Tungkang, SW Taiwan, commercial midwater trawl, 20 Feb. 2004.

*Description of specimens examined:* Pectoral rays 7 or 8, pelvic rays 7, dorsal rays 11, anal rays 16 or 17. Photophores: IP 10 or 11, PV 22 or 23, VAV 21 or 22, AC 12, IC 66-68, OA 39-42, BR 19. The last 3 or 4 OA and 6 or 7 (7 or 8) AC photophores elevated higher than others. Chin barbel with prominent swelling, thick stem, and shrunken basal part. Anterior part of dorsal, pelvic, and anal fin membranes with black pigment. Dorsal adipose fin black with posterior white margin. No black spot on ventral caudal peduncle behind anal fin.

*Color:* Body sides silvery with aggregates of melanophores around accessory photophores. Dorsal part of body dark from head to caudal peduncle, ventral part between ventral photophore series pigmented. Area above anal fin pigmented, not extending upward to level of last 3 or 4 OA photophores. Anterior distal 1/3 of pelvic fin, anterior dorsal fin, and anal fin membrane black. Dorsal adipose fin membrane black with posterior margin white. Chin barbel pinkish when fresh with basal part of stem black. Terminal part of bulb pigmented with white apical tip.

*Distribution:* Distributed in the Indian Ocean and known from southwestern Taiwan at depth ranges of about 200-600 m.

*Remarks:* New record off Taiwan. One specimen, ASIZP0063419, 73 mm SL, has shrunken or petaloid chin barbel. This could have been damaged during collecting. Former distribution only restricted to the Indian Ocean. This is the first record from the Pacific Ocean.

### ***Heterophotus* Regan and Trewavas, 1929**

#### ***Heterophotus ophistoma* Regan and Trewavas, 1929**

*Specimens examined:* 7 (37-338). Part collected by commercial midwater trawl off Tungkang, SW Taiwan: ASIZP0063421, 3 (37-58), 24 Mar. 2004; ASIZP0063422, 2 (41-48), 10 Apr. 2004. Others: ASIZP0057165, 1 (216), South China Sea, commercial bottom trawl, 15 May 1993; ASIZP0063420, 1 (338), Tashi, NE Taiwan, commercial bottom trawl, date unknown.

*Description of specimens examined:* Pectoral rays 6 or 7; pelvic rays 7; dorsal soft rays 10-12; anal soft rays 13-15. Photophores: IP 9 or 10; PV 32-35; VAV 14 or 15; AC 12 or 13; IC 67-70; OA 47-52. Teeth on jaws short, spinellike; photophores of ventral row excluding AC series arranged in groups of 1 to 5. Barbel length about 0.4-1.5 times head length, flattened and tapering tip. Body black.

*Distribution:* Indo-Pacific and Atlantic Ocean. Depth range in Taiwan is about from near surface to 400 m.

*Remarks:* This is the first record of this species from Taiwanese waters.

### ***Rhadinesthes* Regan and Trewavas 1929**

#### ***Rhadinesthes decimus* (Zugmayer, 1911)**

*Astronesthes decimus* Zugmayer 1911: 80.

*Rhadinesthes decimus:* Regan and Trewavas 1929: 29.

*Specimens examined:* 1 (92). ASIZP0063423, Tashi, NE Taiwan, commercial bottom trawl, 19 May 2002.

*Description of specimens examined:* Pectoral rays 8 (6-8); pelvic rays 7; dorsal rays 9 (11-13); anal rays 18 (18-21); gill rakers 5+12. Photophores: IP 9 (9 or 10); PV 27 (26-31); VAV (23-25); AC (12-14); IC (72-76); OA (50-52); BR 14-17. Teeth on upper jaw short, widely separated; premaxillary teeth 10 to 12, maxillary teeth 14 to 30. Chin barbel length longer than head length. Dorsal adipose fin absent. Body slender and elongated, body depth longer than head length.

*Distribution:* Indo-Pacific and Atlantic Ocean. Depth range in Taiwan is about 400 m.

*Remarks:* The specimen examined was seriously damaged, so the partial ventral photophores counts were uncertain, but we can identify it according to the following diagnostic characters: dorsal adipose fin absent, body slender and elon-

gated, and chin barbel longer than head. This is the 1st record from Taiwanese waters.

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