



Review of the genus *Eustomias* (Stomiiformes: Stomiidae: Melanostomiinae) of Taiwan, with descriptions of three new species

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Abstract

The barbeled dragonfish genus *Eustomias* in Taiwan is reviewed. Five species in three subgenera are recognized, including three new species, a new record, and an unidentified species. *Eustomias* (*Dinematochirus*) *dendrobium* **sp. nov.** can be distinguished from its congener by its unique barbel structure. *Eustomias* (*Haploclonus*) *stamen* **sp. nov.** has a unique barbel structure and diagnostic meristic characters. *Eustomias* (*Nominostomias*) *tritentaculatus* **sp. nov.** has an extremely long barbel and distinct pigmentation, with fin ray counts that are different from most similar species. *Eustomias* (*Nominostomias*) *perplexus* Gibbs, Clarke & Gomon 1983, widespread in the western Pacific Ocean is reported for the first time from Taiwan. Three specimens of *Eustomias* were only identifiable to subgenus *Haploclonus* due to their poor condition.

Keywords: *Eustomias dendrobium*, *Eustomias stamen*, *Eustomias tritentaculatus*, taxonomy, morphology, luminescence, deep sea

Introduction

Eustomias Vaillant 1884 is a genus of small fishes and with more than 100 nominal species it is the most speciose genus within the subfamily Melanostomiinae, as well the expanded family Stomiidae (Fricke *et al.* 2019). As other members of the subfamily Melanostomiinae, the genus has an elongated and completely black colored body, large fangs, serial photophores, other luminescent organs, and a barbel on the lower jaw. *Eustomias* can be separated from all other genera by having the anal-fin base distinctly longer than the dorsal-fin base and a toothless vomer. The genus was subdivided into 10 subgenera based on the barbel structure, the numbers of rays in paired fins, and dentition by Regan & Trewavas (1930), and subsequently modified by Gibbs *et al.* (1983) and Prokofiev (2018). Within these subgenera, most of the species are distinguished by the structure and proportion of their barbels, whereas other morphologic and meristic values rarely are able to differentiate the species. Prior to Beebe & Crane (1939), most species were known from type specimens, lack any additional records, and almost every variation in features of the barbels was considered a separate species. Beebe & Crane (1939), based on only a few more specimens of certain forms, concluded that many differences in barbel structure were either sexual or ontogenetic variations, and reassigned several earlier forms to synonymies. This concept was accepted and followed by Morrow & Gibbs (1964), which was based on rather few additional specimens. However, Gibbs *et al.* (1983) concluded that sexual and ontogenetic differences in barbels were minor based on examination of a large number of specimens of *Eustomias*, and that most diverse forms of *Eustomias* reflect interspecific differences. As has been the case for many other oceanic taxa, investigation of the taxonomy of *Eustomias* in the Indo-Pacific has distinctly lagged behind that of the Atlantic. For example, only a single or no species of *Eustomias* had previously recorded from Taiwan or the South China Sea (Randall & Lim 2000; Shao *et al.* 2008; Shen & Wu 2011).

During an ichthyofaunal fish survey in the southwestern Taiwan, five species of three subgenera in the genus *Eustomias* were obtained at fish-landing ground and museum collections, and three of them belong to undescribed species. Despite the relatively small number of available specimens used in the present, the detailed morphologies of these species are herein described.

Methods and materials

All measurements were made on the left side using digital calipers and rounded to the nearest 0.1 mm. Standard and head lengths are abbreviated as SL and HL, respectively. Rays of vertical fins and vertebrae were counted from radiographs. Terminology of photophores follows Gibbs *et al.* (1983). Descriptions of fresh coloration were based on color photographs of the type specimens collected from Taiwan. Collection abbreviations: Biodiversity Research Center, Academia Sinica, Taipei (ASIZP); Pisces collection of National Museum of Marine Biology & Aquarium, Pingtung (NMMB-P).

Taxonomy

Genus *Eustomias* Vaillant, 1884

Type species: *Eustomias (Eustomias) obscurus* Vaillant, 1884

Distinguishing characters. Body strongly elongated; dorsal and ventral outlines almost straight at abdomen, and gradually becoming shallow at tail. Body and head slightly compressed laterally. Head small, snout moderately pointed. Eye moderately large, circular. Mouth large, weakly oblique, posterior margin of maxilla extending posterior margin of eye. Single row of large and well-separated caniniform teeth on jaws. Body and head uniformly black. Postorbital photophore and body photophores white; fin rays transparent, basally blackish. Coloration changed to blackish brown to dark brown after preservation.

Eustomias (Dinematochirus) dendrobium sp. nov.

Figure 1; Tables 1–2

Holotype. NMMB-P30621, 117.8 mm SL, off Dong-gang (ca. 22°39'N, 120°24'E), Pingtung, South China Sea, Taiwan, 10 Sept. 2018, obtained at fish-landing ground at Dong-gang, collected by commercial mid-water trawling.

Diagnosis. A species of subgenus *Dinematochirus* with a unique barbel structure: barbel short, its length 13.9% SL; three branches arising at distal one-fourth of the barbel stem; distal tip of three branches extend distinctly beyond terminal bulb; medial branch thicker than lateral branches; two long and one very short secondary branches arising from middle of medial branch; two short secondary branches arising from near base of each lateral branch; each branch with 5–14 dendritic appendages comprised 1–15 tiny luminous swellings; terminal bulb simple, lacking terminal filaments; stem and branches solidly pigmented (skin rubbed off in some parts) except for dorsolateral surface of terminal bulb and blotchy unpigmented distal 1/3 of secondary branches of medial branch.

Description. Counts and measurements are given in Tables 1 and 2.

Jaws not curved; 7 teeth on premaxilla, 2nd, 4th, and 5th depressible; 8 strongly oblique comb-like teeth on maxilla; 7 teeth on dentary, all depressible, except for 3rd. Postorbital photophore large, its diameter as same as pupil diameter; dorsal third of postorbital photophore covered by black skin.

Etymology. The specific name of the new species, *dendrobium*, in reference to the diagnostic character of the species, which resembles the flowers of an orchid: branches of barbel with many dendritic appendages of tiny luminous swellings.

Distribution. *Eustomias dendrobium* sp. nov. is currently only known from southwestern Taiwan. The holotype was collected from shallower than 100 m, by a mid-water trawl targeting Sakura-shrimp (*Lucensoergia lucens*).

Remarks. The species of the genus *Eustomias* are difficult to identify because most of the species were described based only on structure of the barbel. The present specimen was identified as a species of the subgenus *Dinematochirus* by the following combination of characters: 3 branches on stem of the barbel; the barbel is uniformly black; photophores of the barbel stem absent; length of the barbel 13.9% SL; pectoral-fin rays 2; pelvic-fin rays 7; number of depressible teeth more than fixed teeth on jaws (Regan & Trewavas 1930; Prokofiev 2018; only typical characters listed).

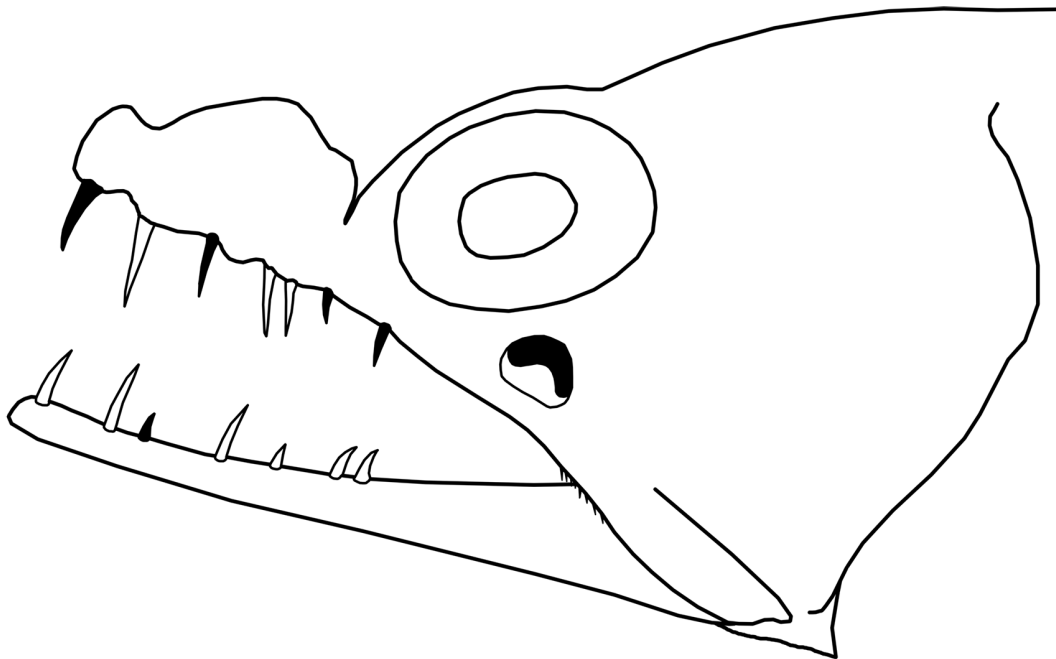


FIGURE 1. *Eustomias (Dinematochirus) dendrobium* **sp. nov.** from Taiwan, NMMB-P30621, holotype, 117.8 mm SL. Top: fresh condition specimen; middle: closeup illustration of distal part of barbel; bottom: diagram of dentition. Black and white color of teeth indicate fixed and movable, respectively.

Although Prokofiev (2018) indicated that terminal filaments of the bulb present in members of the subgenus *Dinematochirus*, are actually absent in *Eustomias (Dinematochirus) bulbiramis* Clarke 2001 and *Eustomias (Dinematochirus) triramis* Regan & Trewavas 1930; they are also absent in our new species. This suggests that a presence of terminal filaments is not diagnostic for the subgenus. Gibbs *et al.* (1983) re-defined the *Dinematochirus* and recognized 12 valid species, of which, 10 were described from the Atlantic. Clarke (1998; 1999; 2000; 2001) subsequently described 26 new species and concluded that some of the species occur in both the Atlantic and the Indo-Pacific.

Of the species previously recognized in the subgenus *Dinematochirus*, the present new species differs in having a distinctly unique structure of the barbel (see Diagnosis). *Eustomias dendrobium* **sp. nov.** is most similar to *E. bulbiramis* and *E. triramis* in always and usually lacking a terminal filament on the terminal bulb on the barbel, respectively. However, *E. dendrobium* differs from them in having the structure of median branch with long secondary branches from the lateral branches (vs. similar), distal tip of branches extending distinctly beyond terminal bulb (vs. reached or distinctly shorter), and almost solidly pigmented branches (vs. unpigmented) (Regan & Trewavas 1930; Clarke 2001). In addition, *E. bulbiramis* has prominent bulblets at about middle of branches, and *E. triramis* has a large subovate terminal bulb, whereas *E. dendrobium* **sp. nov.** lacks both.

Eustomias (Haploclonus) stamen **sp. nov.**

Figure 2; Tables 1–2

Holotype. NMMB-P12724, 102.8 mm SL, off Dong-gang (ca. 22°39'N, 120°24'E), Pingtung, South China Sea, Taiwan, 16 Mar. 2005, obtained at fish-landing ground at Dong-gang, collected by commercial mid-water trawling.

Diagnosis. A species of subgenus *Haploclonus* with a unique barbel structure: barbel short, its length 19.6% SL; terminal bulb rounded and large, its greatest width almost 5 times of stem width; a simple, thin appendage of branch arising near base of terminal bulb with its distal tip extending beyond terminal bulb; two long (longer than terminal bulb) and one short (as long as barbel diameter) filaments on distal tip of terminal bulb; branch and terminal filaments lacking pigments, luminous swellings, and secondary branches; stem unpigmented, axis pigmented. Meristic characters also unique in the subgenus: dorsal-fin rays 20; anal-fin rays 32; IP 8; PV 33; VAV 14.

Description. Counts and measurements are given in Tables 1 and 2.

Lower jaw slightly curved. Seven teeth on premaxilla, 1st and 2nd long and sharp, posterior 4 teeth depressible; 15 strongly oblique comb-like teeth on maxilla; 9 teeth on dentary, 3rd, 4th, 6th, 7th, and 9th teeth depressible. Postorbital photophore oblong and very small, its diameter shorter than anteriormost upper jaw tooth.

Etymology. The specific name of the new species, *stamen*, in reference to the diagnostic character of the species which is a simple, thin appendage of branch arising near base of terminal bulb which looks like a stamen of flower.

Distribution. *Eustomias stamen* **sp. nov.** is currently only known from southwestern Taiwan. The holotype was collected in the upper 100 m by a mid-water trawl targeting Sakura-shrimp.

Remarks. The present specimen was identified as a species of the subgenus *Haploclonus* by the following combination of characters: a simple tapering branch, ending a little before the terminal bulb of the barbel; external pigmentation of the barbel absent; pectoral-fin rays 3; pelvic-fin rays 7; number of teeth on jaws few, 2nd tooth on upper jaw very sharp (Regan & Trewavas 1930; Prokofiev 2018; only typical characters listed). Although Prokofiev (2018) indicated that length of the barbel ranged 25–89% SL for subgenus *Haploclonus*, the present species has a distinctly short barbel (19.6% SL). Regan & Trewavas (1930) recognized 5 species in the subgenus *Haploclonus* and Prokofiev (2018) described a new species from the southeastern Pacific Ocean.

Of the species previously recognized in the subgenus *Haploclonus*, the present new species differs in having a unique structure of the barbel (see Diagnosis). *Eustomias stamen* is most similar to *Eustomias (Haploclonus) enbarbatus* Welsh 1923, which was described on the basis of holotype and a paratype collected from the northwestern Atlantic Ocean. *Eustomias (Haploclonus) brevifilis* Regan & Trewavas (1930) described from northern Atlantic Ocean known as a junior synonym of *E. enbarbatus*, thus the ranges of comparative meristic data of both species are combined below. *Eustomias stamen* **sp. nov.** differ from *E. enbarbatus* in having a large bulb, its greatest width almost 5 times of stem width (vs. small, its greatest width less than twice of stem in *E. enbarbatus*), three unbranched terminal filaments on barbel (vs. four or five filaments, the longest branched), 32 anal-fin rays (vs. 34–36), IP 8 (vs. 7), PV 33 (vs. 26–27), VAV 14 (vs. 11–12) [Regan & Trewavas (1930)].

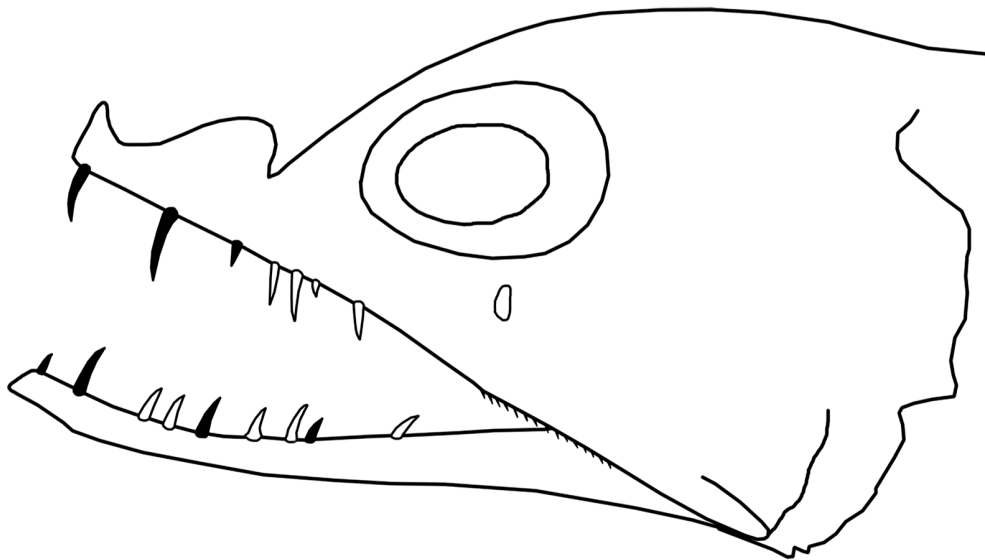


FIGURE 2. *Eustomias (Haploclonus) stamen* sp. nov. from Taiwan, NMMB-P12724, holotype, 102.8 mm SL. Top: preserved specimen; middle: closeup illustration of distal part of barbel; bottom: diagram of dentition. Black and white color of teeth indicate fixed and movable, respectively.

Eustomias (Haploclonus) sp.

Figure 3; Tables 1–2

Eustomias bifilis not Gibbs 1960: Shen & Wu 2011, 196, unnumbered illustration; Shao (2019).

Materials examined. NMMB-P28088, 100.7 mm SL, off Dong-gang (ca. 22°39'N, 120°24'E), Pingtung, South China Sea, Taiwan, 22 Jan. 2018, obtained at fish-landing ground at Dong-gang, collected by commercial mid-water trawling; NMMB-P22420, 126.6 mm SL, same as former, 29 Mar. 2015; ASIZP 64170, 48.6 mm SL, off southwestern Taiwan (ca. 22°04'N, 120°27'E), South China Sea, Taiwan, collected by mid-water trawling, 529–530 m depth, 28 May 2003.



FIGURE 3. *Eustomias (Haploclonus)* sp. from Taiwan. Top: fresh condition specimen, NMMB-P28088, 100.7 mm SL; middle: preserved specimen, NMMB-P22420, 126.6 mm SL; right bottom: diagram of dentition, NMMB-P28088; left bottom: diagram of dentition, NMMB-P22420. Black and white color of teeth indicate fixed and movable, respectively.

Description. Counts and measurements are given in Tables 1 and 2.

Jaws not curved (NMMB-P28088) or lower jaw slightly curved (NMMB-P22420 and ASIZP 64170). NMMB-P28088: 8 teeth on premaxilla, 1st and 2nd long and sharp, 5th, 6th, and 8th teeth movable; 7 strongly oblique comb-like teeth on maxilla; 9 teeth on dentary, 3rd, 5th, 6th, 8th, and 9th teeth movable. NMMB-P22420: 6 teeth on premaxilla, 2nd long and sharp, 2nd, 4th, and 6th teeth movable; 8 strongly oblique comb-like teeth on maxilla; 6 teeth on dentary, 2nd, 4th, and 6th teeth movable. ASIZP 64170: premaxilla damaged; 4 teeth remaining on dentary, 1st fixed. Barbel on lower jaw damaged on halfway, its remaining length 24.4–31.1% SL. Postorbital photophore oblong or rounded, and very small, its diameter shorter than anteriormost upper jaw tooth.

Remarks. Although the present two adult specimens (NMMB-P28088 and NMMB-P22420) have lost the terminal structure of the barbel, which is the most important character to identify the species, it is presumably a species of the subgenus *Haploclonus* because it has the following combination of characters: photophores of the barbel stem present on axis; pectoral-fin rays 3; pelvic-fin rays 7; number of teeth on jaws few, 2nd tooth on upper jaw very sharp (Regan & Trewavas 1930; Prokofiev 2018; only typical characters listed). The juvenile specimen (ASIZP

64170) has lost not only the terminal structure of the barbel but also the premaxilla. However, the counts of body photophores and few teeth counts indicate it should be a species of this subgenus. For example, the specimen has 13 VAV, whereas in the most similar subgenus, *Nominostomias*, the least count known is 15 (mostly more than 16 or 17) (Gibbs *et al.* 1983). Although it is not possible to identify the specimens to species they distinctly differ from *E. stamen* **sp. nov.** in having 33–36 anal-fin rays (vs. 32 in *E. stamen*), PV 28–31 (vs. 33), VAV 12–13 (vs. 14), and a longer barbel, its length at least 24.4–31.1% SL (vs. 19.6% SL without damage). Although the two adult unidentified specimens have no remarkable difference in meristic and morphometric characters, the dentition of the specimens differs substantially (Fig. 3). This suggests that these two adult specimens are different species. The present juvenile was the only specimen previously known from Taiwanese waters. Shen & Wu (2011) identified this specimen as *Eustomias bifilis* Gibbs 1960, which is a very characteristic species has a single long branch from the main stem of the barbel. This identification was followed by Shao (2019). However, the barbel of the specimen was lost and it is not possible to determine the species.

***Eustomias (Nominostomias) tritentaculatus* sp. nov.**

Figure 4; Tables 1–2

Holotype. NMMB-P30396, 130.9 mm SL, off Dong-gang (ca. 22°39'N, 120°24'E), Pingtung, South China Sea, Taiwan, 16 Mar. 2005, obtained at fish-landing ground at Dong-gang, collected by commercial mid-water trawling.

Paratype. NMMB-P22760, 120.4 mm SL, same as holotype, 3 Nov. 2011.

Diagnosis. A species of subgenus *Nominostomias* with a unique barbel structure: barbel moderately long, its length 65.3% SL; terminal bulb small, its length 1.2% SL; three terminal filaments, one of which thicker than others with few pigmentations near base, all filaments simple and lacking bulblets and secondary branches; longest filament length 4.1% SL; axis of stem weakly pigmented; a distinct ring-shaped black spot surrounding base of bulb. Some of the meristic characters are also distinct: anal-fin rays 35; IP 7; PV 34; VAV 19; OV 31; VAL 19.

Description. Counts and measurements are given in Tables 1 and 2.

Jaws not curved. Twelve teeth on premaxilla, anterior 2 teeth (and 6th in paratype) fixed; 8–10 strongly oblique comb-like teeth on maxilla; 15–18 teeth on dentary, all teeth (except for 2nd in holotype) movable. Postorbital photophore rounded and small, its diameter as long as anteriormost upper jaw tooth.

Etymology. The specific name of the new species, *tritentaculatus*, in reference to the three terminal filaments, which is diagnostic of the species.

Distribution. *Eustomias tritentaculatus* **sp. nov.** is currently only known from southwestern Taiwan. The holotype was collected in the upper 100 m by a mid-water trawl targeting Sakura-shrimp (*Lucensosergia lucens*).

Remarks. The present specimens were identified as a species of the subgenus *Nominostomias* by the following combination of characters: a single terminal bulb on barbel; three terminal filaments of the bulb; no tapering branch on the barbel; external pigmentation of the barbel absent (axis pigmented); pectoral-fin rays 3; pelvic-fin rays 7; vertebrae 66–68; number of teeth on jaws high (Regan & Trewavas 1930; Gibbs *et al.* 1983; Prokofiev 2018; only typical characters listed). Gibbs *et al.* (1983) reviewed this subgenus and recognized 38 valid species, 25 of which were described as new. They also separated this subgenus into five species groups on the basis of the structure of the barbels. *Eustomias tritentaculatus* **sp. nov.** has a structure of barbel with the species of their group IV (8 species), species of which have a single terminal bulb with one to three terminal filaments. *Eustomias tritentaculatus* **sp. nov.** is most similar to *Eustomias (Nominostomias) cancriensis* Gibbs, Clarke & Gomon, 1983 from the western and central-north Pacific oceans, but differs in having a longer barbel, its length 65.3% (vs. 47–53% SL in *E. cancriensis*), a distinct ring-shaped black spot at base of bulb (vs. no pigmentation at base of bulb), and fewer anal-fin rays counts 35 (vs. 39) (Gibbs *et al.* 1983). *Eustomias tritentaculatus* **sp. nov.** is also similar to *Eustomias (Nominostomias) gibbsi* Johnson & Rosenblatt, 1971 from the Pacific Ocean; both have a black spot at the base of the bulb. However, *Eustomias tritentaculatus* **sp. nov.** differs from the latter in having three terminal filaments (vs. single in *E. gibbsi*), barbel length 65.3% (vs. 30–52% SL), and a longer terminal filament, its maximum length 4.1% SL (vs. 1.6–2.0 in the similar sized specimens) (Gibbs *et al.* 1983).

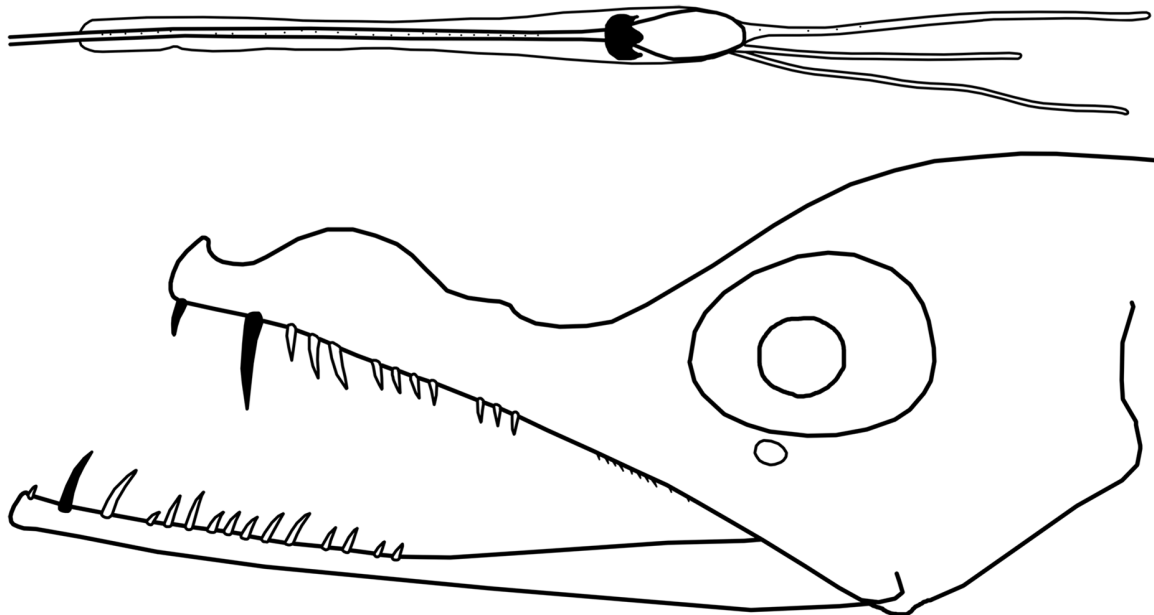


FIGURE 4. *Eustomias (Nominostomias) tritentaculatus* sp. nov. from Taiwan, NMMB-P30396, holotype, 130.9 mm SL. Top: preserved specimen; middle: closeup illustration of distal part of barbel; bottom: diagram of dentition. Black and white color of teeth indicate fixed and movable, respectively.

***Eustomias (Nominostomias) perplexus* Gibbs, Clarke & Gomon 1983**

Figure 5; Tables 1–2

Material examined. NMMB-P12063, 123.1 mm SL, off Dong-gang (ca. 22°39'N, 120°24'E), Pingtung, South China Sea, Taiwan, 28 Jan. 2011, obtained at fish-landing ground at Dong-gang, collected by commercial mid-water trawling.

Diagnosis. A species of subgenus *Nominostomias* with a unique barbel structure: barbel moderately long, its length 72.6% SL; terminal bulb small, its length 0.9% SL, longitudinal length greater than width; a single terminal projection with two horn-shapes, its maximum length 0.3% SL; axis of stem weakly pigmented. Some of the meristic characters are also distinguishable: dorsal-fin rays 23–24; anal-fin rays 35; IP 8; PV 31–34; VAV 17–18; OV 32–33; VAL 17–18.

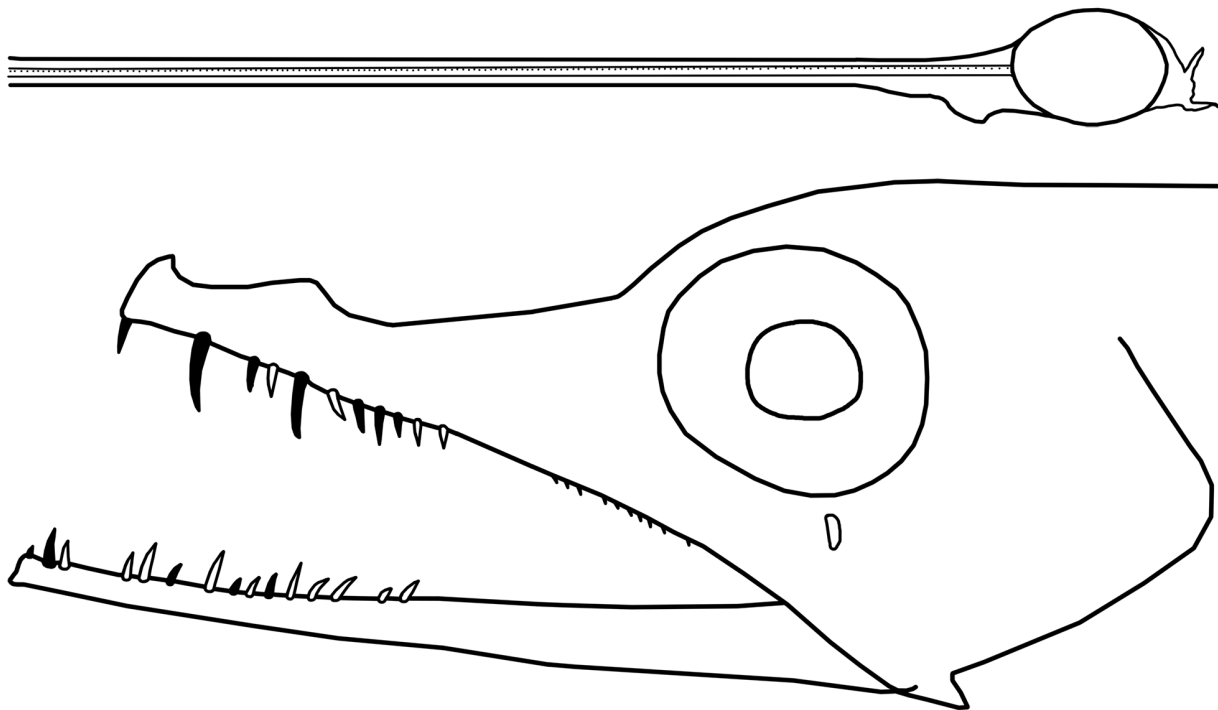


FIGURE 5. *Eustomias (Nominostomias) perplexus* from Taiwan, NMMB-P12063, 123.1 mm SL. Top: preserved specimen; middle: closeup illustration of distal part of barbel; bottom: diagram of dentition. Black and white color of teeth indicate fixed and movable, respectively.

Description. Counts and measurements are given in Tables 1 and 2.

Jaws not curved. Eleven teeth on premaxilla, 1st to 3rd, 5th, 7th–9th fixed; 10 strongly oblique comb-like teeth on maxilla; 15 teeth on dentary, 1st, 2nd, 5th, 7th, and 9th fixed. Postorbital photophore oblong and small, its diameter as long as anteriormost upper jaw tooth.

Distribution. *Eustomias perplexus* **sp. nov.** is widely known from western, central equatorial, and northeastern Pacific Ocean.

TABLE 2. Morphometric data of the specimens of genus *Eustomias* from Taiwan.

Subgenus	<i>Haploclonus</i>			<i>Nominostomias</i>		
	<i>Dinematochirus</i>	<i>E. stamen</i>	<i>Eustomias</i> sp.	<i>E. tritentaclatus</i>	<i>E. perplexus</i>	
Species	<i>E. dendrobium</i>					
Specimen	NMMB-P30621	NMMB-P12724	NMMB-P28088	NMMB-P22420	ASIZP 64170	NMMB-P30396
Standard length (SL)	117.8	102.8	100.7	126.6	48.6	120.4
Measurements (%SL)						130.9
Body depth	8.3	6.3	7.9	7.3	6.0	6.6
Head length (HL)	13.2	13.6	12.2	10.4	14.4	14.1
Snout to vent	69.7	69.5	75.3	73.4	70.2	70.2
Pectoral-fin base to vent	50.5	49.1	56.6	56.3	54.1	52.9
Vent to caudal-fin base	29.5	30.1	29.6	25.9	31.5	27.8
Pre-dorsal-fin length	85.1	86.6	86.9	83.1	83.7	79.2
Pre-anal-fin length	71.7	74.2	75.3	74.6	71.6	70.4
Pre-pelvic-fin length	56.2	58.1	59.6	59.3	57.2	56.8
Barbel length	13.9	19.6	31.1+	24.4+	25.9+	41.1+
Measurements (%HL)						
Snout length	40.6	46.4	29.3	36.4	42.9	38.8
Eye diameter	26.3	22.9	27.6	25.8	27.1	20.6
Body interorbital width	21.1	13.6	17.1	15.9	15.7	12.4
Barbel length	107.5	168.6	254.5+	234.5+	180+	291.1
						449.0
						539.4

Remarks. The present specimen is presumed to be a species of the subgenus *Nominostomias* in having the following combination of characters: a single terminal bulb on barbel; a single terminal projection on the bulb; no tapering branch on the barbel; external pigmentation of the barbel absent (axis pigmented); pectoral-fin rays 3; pelvic-fin rays 7; vertebrae 68; number of teeth on jaws high (Regan & Trewavas 1930; Gibbs *et al.* 1983; Prokofiev 2018; only typical characters listed). *Eustomias perplexus* has a structure of barbel consistent with the species of group V (5 species comprised) of Gibbs *et al.* (1983), which share a single terminal bulb with either a dome-like or finger-like projection at its distal end. *Eustomias perplexus* is most similar to *Eustomias (Nominostomias) longibarba* Parr, 1927 of the Atlantic Ocean. However, Gibbs *et al.* (1983) provided no diagnostic characters, except that the former has a shorter terminal projection on bulb than the latter. Although they indicated the distributional difference between these two species in their “Key to species”, some of the species of genus *Eustomias* were known to have circumglobal distribution in the warm waters. We tentatively identified the Taiwanese specimen as *E. perplexus* on the basis of its very short terminal projection on bulb and the distribution; however, its validity needs further investigation.

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