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A NEW SPECIES OF AMPHIDROMOUS GOBY (TELEOSTEI: OXUDERCIDAE: *Stiphodon*) FROM ENGGANO ISLAND, INDONESIA

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Abstract
A new amphidromous goby species of the genus *Stiphodon* Weber, 1895, is described based on eight specimens collected from Enggano Island, Indonesia. A combination of the following characteristics distinguishes the new species from all other congeners: form of the fourth dorsal spine of the first dorsal fin group elongated, filamentous and without membrane, spotting on head and fin, preanal length 49–55% of standard length (SL), second dorsal length 38−45% of SL, anal fin length 42−47% of SL, caudal fin length 30−34% of SL, number of premaxilary teeth ranging from 25−33, canine-like teeth 2−5, number of scales in transverse forward series 5−9, number of scales in zig-zag series 5−8.

Keywords: freshwater fish, ichthyofauna, migration, morphology, Southwest Sumatra, Sundaland

Introduction

Amphidromous gobies spawn in freshwater rivers, and the freshly hatched larvae migrate to the sea to become pelagic larvae (McDowall 2007). After the pelagic larval phase in the sea, larvae are recruited into freshwater rivers where they grow to maturity and reproduce (McDowall 2007). Juveniles and adults usually feed on algae scraped from the rock surface (Keith 2003, Keith *et al*. 2015, McDowall 2007). Ocean currents can transport larvae to other rivers or islands during the pelagic larval phase. Thanks to their highly developed suction disc, Sicydiinae can climb waterfalls and spread out far upstream on sandy or slightly rocky bottoms (Keith *et al*. 2015). Amphidromous gobies of the subfamily Sicydiinae disperse to remote areas (Maeda *et al*. 2007, Iida *et al*. 2010, Lord *et al*. 2015). The majority of species establish social hierarchies, with dominant males forming sizable groups that include subadult males and females, and reproduce with numerous females throughout the year, often in harems (Keith 2003, Keith *et al*. 2015). Sundaland and Wallacea are biodiversity hotspots in Southeast Asia; they have a large variety of species and host a large number of endemic amphidromous gobies (Kottelat *et al*. 1993, Hubert *et al*. 2015, Jamonneau *et al*. 2024). Additionally, it is known that freshwater fishes in Wallacea and Sundaland exhibit cryptic diversity (Beck *et al*. 2017, Sholihah *et al*. 2021a, 2021b, Jamonneau *et al*. 2024).

The genus *Stiphodon* Weber, 1895 characterized by having three anal pterygiophores anterior to the first haemal spine. In all the other genera belonging to this subfamily, there are only two such pterygiophores (Birdsong *et al*. 1988, Keith *et al*. 2009). In additions *Stiphodon* is also characterized as having several distinctive external morphologies including a narrow base of the pelvic disc and pelvic fin adherent to the belly between the fifth rays, the tongue fused to the floor of the mouth, and the dorsal tip of the ascending process on premaxilla narrower than the process below (Birdsong *et al*. 1988, Keith & Marquet 2007).

The genus *Stiphodon* currently contains thirty-three species and is distributed from southern Japan to Indonesia, Sri Lanka, New Caledonia, and French Polynesia (Jhuang *et al*. 2024). In the Indonesian region, eleven species are known: *S. semoni* Weber, 1895; *S. atropurpureus* (Herre, 1927); *S. pelewensis* Herre, 1936; *S. ornatus* Meinken, 1974; *S. surrufus* Watson & Kottelat, 1995; *S. rutilaureus* Watson, 1996; *S. zebrinus* Watson, Allen & Kottelat, 1998; *S. carisa* Watson, 2008; *S. maculidorsalis* Maeda & Tan, 2013; *S. annieae* Keith & Hadiaty, 2015; and *S. aureofuscus* Keith, Busson, Sauri *et al*., 2015.

Eight specimens of *Stiphodon* were collected from Enggano, approximately 100 kilometers southwest of mainland Sumatra stored at Museum Zoologicum Bogoriense (MZB). The identification of these specimens, which appear to be all males, differs from all valid species of this genus. Thus, the purpose of this paper is to describe a new *Stiphodon* species from Enggano Island, in the western part of Indonesia.

Materials and Methods

All specimens of the new species are deposited in the Museum Zoologicum Bogoriense (MZB), Cibinong, Indonesia. All measurements of the specimens are expressed as standard-length percentages (SL). Specimens were measured point to point with a dial calliper to the nearest tenth of a millimetre (mm) under a stereomicroscope. All counts were taken from the right side. Measurements and counts followed those in Watson *et al*. (1995) and Jhuang *et al*. (2024), with the following modifications. Standard length measured from central hypural base to tip of snout; predorsal length, distance from anterior base of first dorsal fin to tip of snout; preanal length, distance from origin of anal fin to tip of snout; head length, distance from posterior margin of gill cover to tip of snout; jaw length, distance from tip of snout to posterior margin of upper jaw; body depth was measured at both vertical distance between the pelvic and anal fin origins; anus to anal fin length was measured from the centre of the anus to the anal fin origin. caudal peduncle length, distance from posterior base of second dorsal fin to central hypural base; caudal penducle depth, vertical distance at narrowest region of caudal penducle; second dorsal and anal fin lengths, distance from anterior origin of fin to tip of posterior most ray when depressed; caudal fin length, distance from central hypural base to tip of longest ray; interval between the first and second dorsal fin bases was measured from the posterior end of the first dorsal fin base to the second dorsal fin origin; anus to anal fin length was measured from the centre of the anus to the anal fin origin.

Scale and fin ray counts are reported as: anal fin elements (includes flexible spine and segmented rays); dorsal fins (first dorsal fin spines; second dorsal fin elements); pectoral fin rays; caudal fin rays; lateral scale, scale counts in a lateral series are from upper pectoral base and along the middle of the body laterally to the central hypural base; predorsal midline scales counted from scale directly anterior to first dorsal fin insertion to the anteriormost scale; transverse series backward, refers to scales counted from the first scale anterior to second dorsal fin origin, in a diagonal manner, posteriorly and ventrally to the anal fin base or ventralmost scale; transverse series forward, refers to scales counted from the first scale anterior to second dorsal fin origin, in a diagonal manner, anteriorly and ventrally to the centre of abdomen or ventralmost scale; zigzag series, refers to scales on the narrowest region of the caudal peduncle counted from the dorsalmost scale to the ventralmost scale in a zigzag (alternating) manner.

Tooth counts of the upper and lower jaws were taken from the right side of the symphysis, with dentition terms following Watson (1995) and Jhuang *et al*. (2024). Characteristics of male *Stiphodon* are urogenital papilla depressed, same width distally as basally, with two small projections at each side of the tip, and the first dorsal fin elongated, filamentous with or without membrane (Watson 1996, Watson *et al*. 1998). Abbreviations used for the cephalic sensory pore system follow Akihito (1986). Diagrammatic illustrations of the head for showing the cephalic sensory pore system were illustrated with the aid of a stereo-microscope OLYMPUS SZX7, a microscope camera OLYMPUS EP50, and Adobe Photoshop version 22.4 software.

Morphometric analyses were performed using graphs generated in PAST ver. 4.0 to visualize the morphometric relationships among the species of *Stiphodon* from Indonesia and the new species describe below (Fig. 1).

Results

Taxonomy

Stiphodon ***hadiatyae*** sp. nov.
(Figs. 2, 3; Table 1)
[urn:lsid:zoobank.org:act:F1F7F1D4-AD1C-44B8-AE83-02FC43236BC0]

Holotype. MZB 22822 (male, 32.2 mm SL), collected from Sungai Paco (05°22'35.2"S, 102°18'11.05"E; alt. 45 m a.s.l.), anak Sungai Kuala Kecil, Malakoni Village, Bengkulu Province, Sumatra, Indonesia, by Renny K. Hadiaty and Sopian Sauri on 26 April 2015.

Paratypes. MZB 28081–28087 (7 males, 27.9–34.1 mm SL), collected along with the holotype.

Diagnosis. The new species has the fourth spine of first dorsal fin filamentous, without membrane; fourth spine may extend posteriorly to 2–5 rays of second dorsal fin; pectoral fin with 14–15 rays; upper jaw with 25–33 teeth; lateral series scales 22–31; transverse forward series scales 5–9; preanal fin length 49–55% SL; second dorsal fin length 38–45% SL; anal fin length 42–47% SL; caudal fin length 30–34% SL; scales usually not reaching upper pectoral base; head and fin with black spot; faint yellowish longitudinal band from snout through dorsal of head and dorsal fin bases to upper caudal peduncle; caudal peduncle bluish; caudal fin translucent, yellowish base, bluish upper distal margin, with 9–11 dusky transverse stripes.

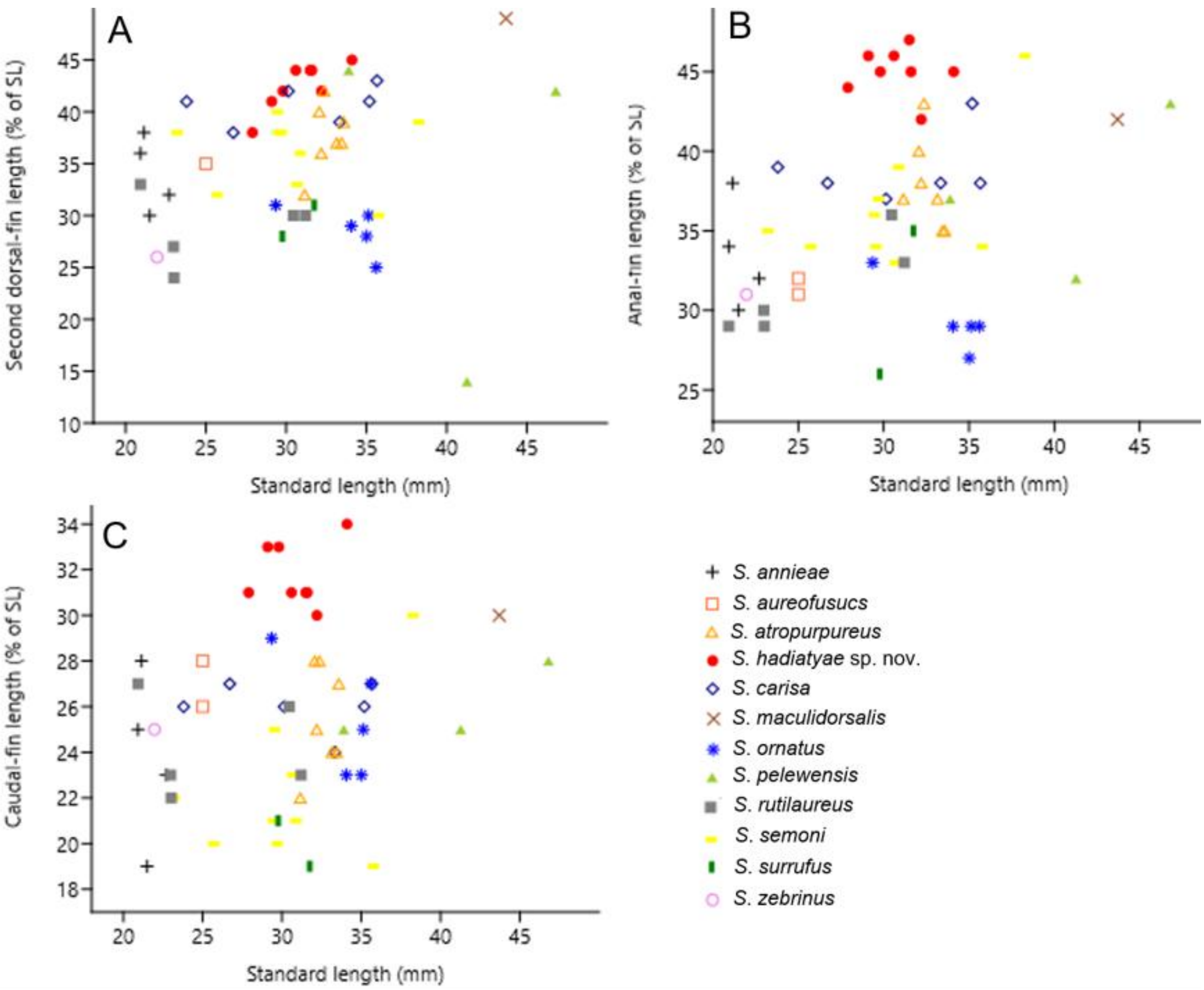

Figure 1. Morphometric relationships (all as % SL to SL) of *Stiphodon* in the Indonesia region: **(A)** second dorsal fin length, **(B)** anal fin length, and **(C)** caudal fin length.

Description of the holotype. Data for the holotype are presented first, followed by paratype data in parentheses if different. Dorsal fins with VI−I, 9; first dorsal fin separate from and slightly higher than second dorsal fin, males with form of the fourth dorsal spine of the first dorsal fin group elongated, filamentous, and without membrane. Anal fin I, 10 is directly opposite second dorsal fin. Pectoral fin oblong with posterior margin rounded, with 15 (14−15) rays. Pelvic disc with 1 spine and 5 stout and heavily branched segmented rays, fifth rays joined together for their entire length forming a strong adhesive disc, disc adherent to belly between fifth rays only, frenum between spines fleshy, strong, and well developed. Caudal fin with 14 (13−16) branched rays, posterior margin rounded.

Scales in lateral series 28 (22−31), not extending to pectoral base, scales present dorsal to pectoral base, caudal peduncle with ctenoid becoming cycloid and smaller closer to pectoral base, scales at hypural base almost always ctenoid with some small cycloid scales posterior to hypural base. Scales in transverse backward series with 7 (6−9) in males. Scales in transverse forward series variable in number 7 (5−9) with scales well developed at origin of second dorsal fin with scales becoming smaller and fewer closer to belly, cycloid scales present along bases of second dorsal and anal fins. Scales in predorsal midline with 6 (6−10), scales when present always cycloid. Scales in zigzag series with 5 (7−8) in males. Distribution of scales on belly of males always without scales. Head, breast, and pectoral base are without scales. Premaxillary teeth 35 (25−36), fine and tricuspid, tridentiform with central cusp longer than lateral cusps. Lower jaw teeth in males with 6 fairly large canine-like teeth (2−5) (Sup. Table 1).

Cephalic sensory pore system always A’, B, C, D, F, H’, K’, L’, N’, and O’, pore D is singular, all others are paired. Oculoscapular canal separated into anterior and posterior canals between pores H’ and K’. Cutaneous sensory papillae well developed over lateral and dorsal surfaces of head (Fig. 2).

Colouration. In life (Fig. 3A), male head including snout, cheek, opercle, and pectoral fin base, dull metallic green to brilliant light blue. Dorsum of head and body greyish, with faint yellowish longitudinal band from snout along dorsal fin bases to upper caudal peduncle. Dorsal fins rosy red, first dorsal fin with blackish spots along spines. Anal fin whitish grey with dark reddish rays. Pectoral fin semi-translucent. Pelvic disc and fin semi-translucent. Caudal fin translucent, yellowish base, bluish upper distal margin, with 9−11 dusky transverse stripes; caudal fin base with indistinct dark spot.

In preservation (Fig. 3B), male body yellowish pale. Head including snout, cheek, opercle and lateral surface with blackish-brown pigmentation. Fins semi-translucent; upper pectoral fin base with brownish pigmentation; caudal fin whitish, with 9−11 dusky transverse stripes; caudal fin base with dark brown spot.

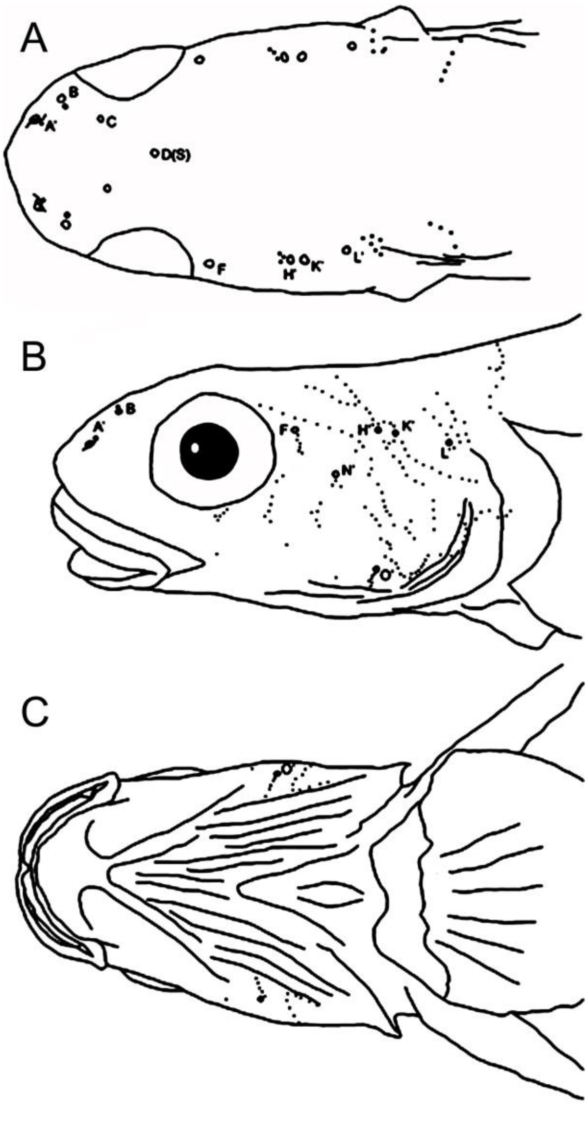

Figure 2. The head of *Stiphodon hadiatyae* sp. nov. (male, holotype MZB 22822): a diagrammatic illustration showing the head pores and sensory papillae in **(A)** dorsal, **(B)** lateral, **(C)** ventral views.

Etymology. The specific epithet is an eponym, latinized as a noun in the genitive singular, honoring late Renny Kurnia Hadiaty, who was a leading international expert on the systematics of the freshwater fishes of Southeast

Asia, especially those from her home country of Indonesia (see Parenti & Wowor 2020). For over three decades, she conducted research as a systematic ichthyologist at the Museum Zoologicum Bogoriense (MZB). The authors express sincere appreciation for her remarkable contribution to systematic ichthyology, including the collection of the samples of this new species from Enggano Island, which is described herein.

Comparisons. Morphometrics characters show that the new species differs from existing *Stiphodon* species based on first dorsal fin with fourth spine elongate, second dorsal length 38−45% of SL, anal fin length 42−47% of SL, and caudal fin length 30−34% of SL. While meristic character differences are the number of premaxillary teeth ranging from 24−36, canine-like teeth 2−5, number of scales in transverse forward series 5−9, number of scales in zig-zag series 5−8. *Stiphodon hadiatyae* sp. nov. male is most similar to *S. sapphirinus* Watson, Keith & Marquet, 2005 in having the first dorsal fin with fourth spine extremely elongate, filamentous, and without a membrane, but can be distinguished in having longer caudal fin length 30−34% of SL (vs 19−25% of SL in *S. sapphirinus*), and 5−8 scales in zigzag series (vs 9–10 in *S. sapphirinus*). The new species is also similar to *S. alcedo* Maeda, Mukai & Tachihara, 2012; *S. caeruleus* Parenti & Maciolek, 1993; *S. elegans* (Steindachner, 1879); *S. imperiorientis* Watson & Chen, 1998; *S. julieni* Keith, Watson & Marquet, 2002; *S. larson* Watson, 1996; *S. niraikanaiensis* Maeda, 2013; *S. Percnopterygionus* Watson & Chen, 1998; *S. pulchellus* (Herre, 1927); *S. palawanensis* Maeda & Palla 2015; *S. ornatus* Meinken, 1974; *S. rutilaureus*, *S. zebrinus*, and *S. chlorestes* Jhuang, Dimaquibo & Liao, 2024 in having fourth spine on first dorsal fin elongate, but can be distinguished by having lower number of premaxillary teeth, 25–33 (vs. 40−59 in *S.caeruleus*, 37−50 in *S. imperiorientis*, 36−54 in *S. larson*, 46 in *S. niraikanaiensis*, 45−71 in *S. palawanensis*, 41−64 in *S. rutilaureus*, 47−54 in *S. zebrinus*, and 39−51 in *S. chlorestes*), number of scales in transverse forward series lower, 5−9 (vs. *S. alcedo* 13−16, *S. percnopterygionus* 14−15, *S. pulchellus* 12−17, and *S. ornatus* 13−16), having longer caudal fin length, 30−34% of SL (vs. *S. elegans* 22% and *S. julieni* 21−25%).

Table 1. Morphometric of *Stiphodon hadiatyae* sp. nov. expressed as a percentage of standard length

Character	Male	
	Holotype	Paratypes (*n*=7)
Standard length (mm)	32.2	27.9−34.1
Head length	22.8	19.7−23.2
Snout length	3.8	3.4−4.6
Eye diameter	6.9	5.8−7.1
Postorbital length of head	10.4	6.7−11.2
Upper jaw length	7.0	7−8.8.0
Body depth at pelvic fin origin	14.7	13.1−15.2
Body depth at anal fin origin	16.4	15.7−17.3
Depth of caudal penducle	11.5	10.9−12.5
Length of caudal penducle	16.6	11.7−15.4
Predorsal length	34.8	33.9−36.0
Length of first dorsal fin base	14.2	10.5−14.5
First dorsal fin length	36.5	26.2−45.7
Length of longest spine of first dorsal fin	29.5	24.7−37.5
Interval between first dorsal fin and second dorsal fin bases	3.5	5.6−9.4
Length of second dorsal fin base	29.2	25.5−31.0
Second dorsal fin length	42.4	37.9−44.6
Length of longest ray of second dorsal fin	14.8	10.5−17.4
Preanal length	53.9	48.6−55.1
Length of anal fin base	32.6	27.4−32.0
Anal fin length	42.2	43.5−46.7
Length of longest ray of anal fin	17.2	10.4−19.0
Length from anus to anal fin	3.6	2.5−4.2
Length of longest ray of pectoral fin	27.6	21.1−26.0
Caudal fin length	30.3	30.3−34.0

Plate 9

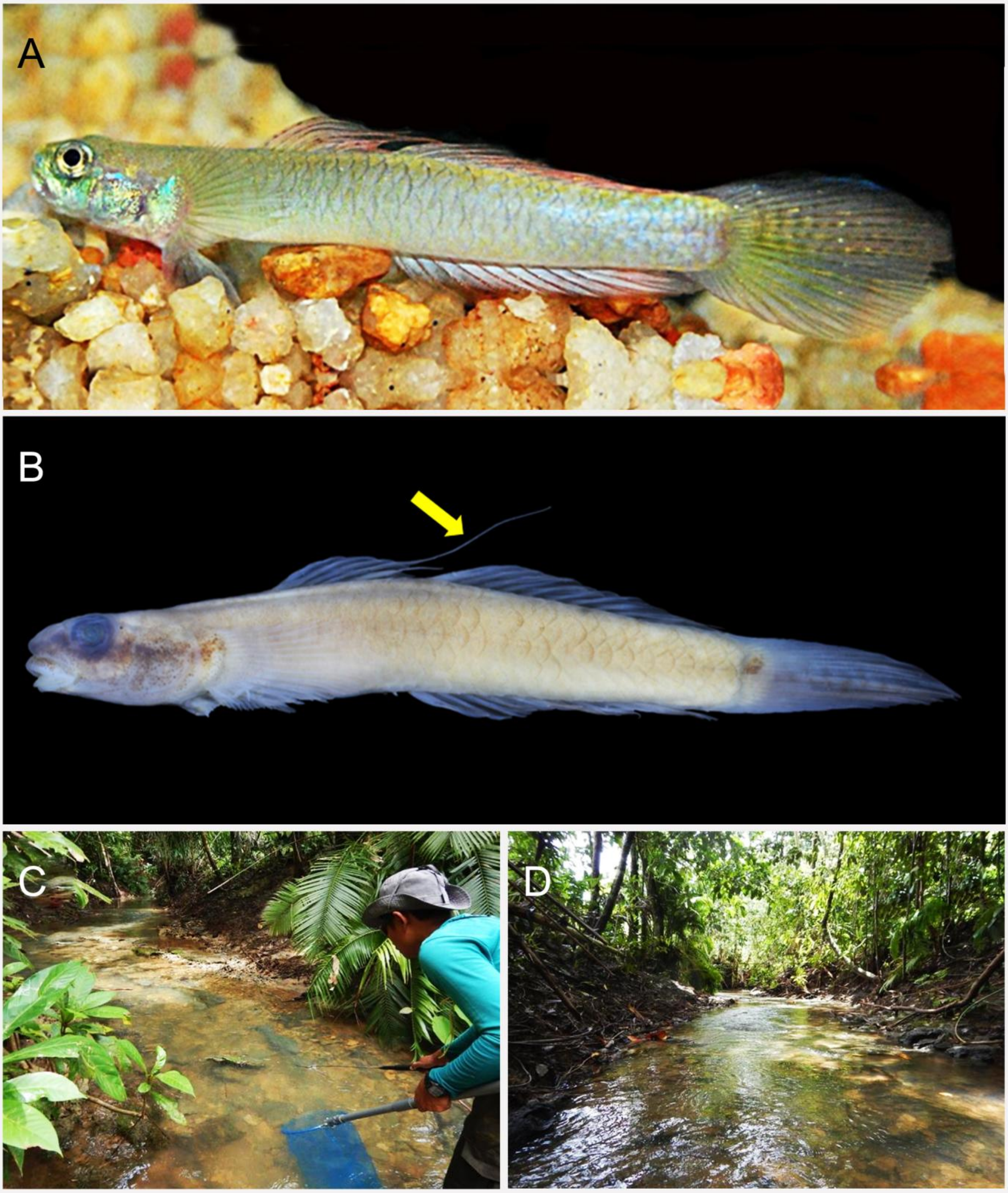

Figure 3. *Stiphodon hadiatyae* sp. nov. **(A)** in life, a male collected from from Sungai Paco, Malakoni Village, Enggano Island, Bengkulu, Sumatra, Indonesia; note this is one of the specimen among the type series collected by R.K. Hadiaty and S. Sauri on 26 April 2015, reprinted from Hadiaty & Sauri (2017) with correcting mirror image correction [*Jurnal Iktiologi Indonesia*, 17(3): 279, fig. 3a] © Photo: R.K. Hadiaty; **(B)** in preservative, male holotype (MZB 22822); note the arrow points at the apparently elongated fourth spine on the first dorsal fin; **(C−D)** the habitat at the type locality, reprinted from Hadiaty & Sauri (2017) [*Jurnal Iktiologi Indonesia*, 17(3): 279, fig. 3b,c]

Stiphodon hadiatyae sp. nov. differs from *S. discotorquatus* Watson, 1995; *S. hydoreibatus* Watson, 1999; *S. multisquamus* Wu & Ni, 1986; *S. oatea* Keith, Feunteun & Vigneux, 2010; *S. tuivi* Watson, 1995; *S. annieae*, *S. carisa*, *S. maculidorsalis*, *S. pelewensis*, and *S. semoni* in having fourth spine on the first dorsal fin elongate (vs third spine elongate). It can also be distinguished from *S. astilbos* Ryan, 1986; *S. kalfatak* Keith, Marquet & Watson, 2007; *S. martenstyni* Watson, 1998; *S. mele* Keith, Marquet & Pouilly 2009; *S. rubromaculatus*, *S. atropurpureus*, *S. surrufus*, and *S. aureofuscus* in having fourth spine elongated (vs. no spine elongated).

Stiphodon hadiatyae sp. nov. can be distinguished from eleven *Stiphodon* species from Indonesia in having lower number of premaxillary teeth, 25–33 (vs. 34−40 in *S. annieae*, 35−40 in *S. aureofuscus*, 42−65 in *S. maculidorsalis*, 47−54 in *S. zebrinus*, 41−59 in *S. carisa*, 36−58 in *S. atropurpureus*, and 41−64 in *S. rutilaureus*), 5−9 scales in tranverse forward series (vs. 13−16 in *S. ornatus* and 12−17 in *S. pelewensis*), and 5−8 scales in zig-zag series (vs 9 in *S. semoni* and *S. surrufus*).

Distribution and habitat. *Stiphodon hadiatyae* sp. nov. is currently known only from the type locality in Sungai Paco (Fig. 3C–D), a tributary of Sungai Kuala Kecil, Malakoni Village, Enggano Island, Bengkulu, Southwest Sumatra (Fig. 4). Specimens were collected from a clear, shallow, and relatively swift rainforest stream with a sandy or slightly rocky bottom.

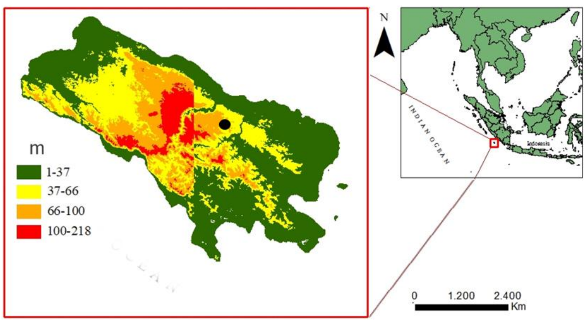

Figure 4. The type locality of *Stiphodon hadiatyae* sp. nov. (black dot): Enggano Island, Sumatra, Indonesia

Artificial key to the genus Stiphodon in Indonesia.

1. a. Upper jaw teeth >33 2
   b. Upper jaw teeth <33 3

2. a. Scales in lateral series <21 .... *S. annieae*
   b. Scales in Lateral series >21 4

3. a. Scales in transverse backward series <10 .... *S. ornatus*
   b. Scales in transverse backward series >10 5

4. a. Scales in transverse forward series <10 .... *S. aureofuscus*
   b. Scales in transverse forward series >10 7

5. a. Zigzag series scale 9 .... *S. pelewensis*
   b. Zigzag series scale <9 6

6. a. Predorsal midline without scales (naked) .... *S. surrufus*
   b. Predorsal midline with scales .... *S. hadiatyae* sp. nov.

7. a. Caudal length <30 %SL 8
   b. Caudal length >30 %SL .... *S. carisa*

8. a. Preanal length >42 %SL 9
   b. Preanal length <42 %SL .... *S. atropurpureus*

9. a. Length of caudal penduncle 19−28 %SL .... *S. semoni*
   b. D2 length <38 %SL .... *S. zebrinus*
   c. D2 length >38 %SL 10

10. a. Caudal length 24−30 %SL ...... *S. maculidorsalis*
    b. Caudal length 19−28 %SL .... *S. rutilaureus*

Author contributions

All the authors contributed equally

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Research permits

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Supplemental data

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Appendix: Comparative materials

Stiphodon annieae. Indonesia: Halmahera: MZB 18930 (holotype); Sulawesi: MZB 22679, Marine Science & Fisheries Lab, Universitas Hasanuddin Indonesia (MSFUH) 1861, 1757.

***S. aureofuscus*.** Indonesia: Java: MZB 22726 (holotype); Bali: MZB 22728.

***S. atropurpureus*.** Indonesia: Java: MZB 22922.

***S. carisa*.** Indonesia: Sumatra: MZB 15194 (holotype), 15195 (paratype)**.**

***S. ornatus*.** Indonesia: Sulawesi: MZB 11819.

S. pelewensis. Indonesia: Maluku: MZB 18724; Sulawesi: MZB 24571, MSFUH 1789.

S. rutilaureus. Indonesia: Maluku: MZB 21679; Sulawesi: MZB 22679, MSFUH 1766.

S. semoni. Indonesia: Sulawesi: MZB 11688, 20373, MSFUH 1789; Papua: MZB 17129, 17145; Maluku: MZB 18709; Java: MZB 21343.

***S. surrufus*.** Indonesia: Sulawesi: MSFUH 1806−1807.

S. zebrinus. Indonesia: Sulawesi: MZB 21895.