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A NEW SPECIES OF *RHINOGOBIUS* GILL, 1859 (TELEOSTEI: GOBIIDAE) FROM THE BONIN ISLANDS, JAPAN

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Key words: Gobiidae, *Rhinogobius ogasawaraensis* sp. nov., egg size, amphidromous, fish taxonomy, West Pacific.

ABSTRACT

A new freshwater goby, *Rhinogobius ogasawaraensis* was collected from streams of the Bonin Islands (Ogasawara Group), Japan. The species can be distinguished from all congeneric species by the following combination of characters: (1) meristic features: second dorsal fin rays I, 8-9; pectoral fin rays 18-20; predorsal scales 7-16; longitudinal scale rows usually 32-34; vertebral count 26; and (2) specific colouration: check with some red spots, nape with several longitudinal dark stripes, upper part of pectoral fin base with a horizontal deep brown bar, intermittent dark dotted rows along middle axis of body, no saddle shaped patch of dark dots on dorsal side of body, ventral side of body yellowish white, caudal fin with some dark dotted rows on middle region and the base with a pair of dark brown bars which vertically to each other. The ripe oocyte diameter of this new species suggests that it belongs to a member of typical amphidromous species.

I. INTRODUCTION

The Asiatic freshwater goby genus *Rhinogobius* Gill, 1859 [16] is widely distributed on islands of the West Pacific, including Japan (Akihito *et al.* [1, 2]; Masuda *et al.* [24]); Taiwan (Aonuma and Chen [3]; Chen and Shao [13]; Lee and Chang [22]; Chen *et al.* [11]); Hainan (Wu and Ni [50]; Chen *et al.* [12]); and the Philippines (Herre [18]; Chen in preparation), and also in continental Asia in Russia, Korea, China, Vietnam, Laos, Cambodia, and Thailand (Kottelat [21]; Chen and Miller [10]; Chen *et al.* [9, 14, 15]; Chen and Kottelat [6, 7,

8]; Chen and Fang [5]; Huang and Chen [19]). The life histories of *Rhinogobius* species indicate that the genus comprises amphidromous species, nondiadromous, fluvial species and lentic species (Mizuno [26]; Mizuno and Goto [27]; Takahashi and Okazaki [42]; Akihito *et al.* [2]).

In Japan, there are at least 15 discrete species have been recorded and accounted including *R. flumineus* (Mizuno, 1960 [26]), *R. giurinus* (Rutter, 1897 [33]), *R. sp. BB* (Blue belly), *R. sp. BF* (Banded fin), *R. sp. BI* (Bonin Islands), *R. sp. BW* (Lake Biwa), *R. sp. CB* (Cross band), *R. sp. CO* (Cobalt), *R. sp. DA* (Dark), *R. sp. DL* (Depressed large dark), *R. sp. LD* (Large dark), *R. sp. MO* (Mosaic), *R. sp. OR* (Orange), *R. sp. TO* (Tokai), and *R. sp. YB* (Yellow belly). They can be grouped in *R. brunneus* (Temminck and Schelegel, 1845 [47]) species complex with normal vertebral count 26 except the fluvial species of *R. flumineus* (Mizuno, 1960 [26]) as high vertebral count up to 27-28 and *R. giurinus* (Akihito *et al.* [2]; Suzuki *et al.* [39]; Suzuki and Sakamoto [40]; Suzuki and Shibukawa [41]; Takahashi and Okazaki [42]). In Taiwan, all nine nominal *Rhinogobius* species are endemic to the island including except *R. giurinus* (Lee and Chang [22]; Chen and Shao [13]; Chen and Fang [4]).

There are seven nominal species of *Rhinogobius* which have been described so far in Japan: *R. brunneus* (Temminck and Schelegel) from Bay of Nagasaki, Nagasaki Pref., the East China Sea coast of Kyushu; *R. similis* Gill, 1859 [16] from Shimoda, Izu Prov., Shizuoka Pref., the Pacific coast of Honshu; *R. nagoyae* Jordan & Seale, 1906 [20] from Nagoya, Aichi Pref., the Pacific coast of Honshu; *R. kurodai* (Tanaka, 1908 [45]) from Tokyo Pref., the Pacific coast of Honshu; *R. katonis* (Tanaka, 1908 [45]) from Kanazawa, Ishikawa Pref., the Sea of Japan coast of Honshu; *R. fluviatilis* Tanaka, 1925 [46] from Himeji, Hyogo Pref., the coast of the Inland Sea of Seto in Honshu. *R. flumineus* from Sôshagawa R., Ehime Pref., Shikoku.

More recently in early 2011, Oijen *et al.* [29] have concluded that *R. sp. DA* should be regarded as the earliest published species for the genus, *R. brunneus*; Suzuki and Chen [41] have re-described that both *R. sp. LD* and *R. sp. OR* should be grouped as *R. fluviatilis* and *R. kurodai* respectively.

In Taiwanese waters, nine endemic nominal species of *Rhinogobius* have been described including as follows:

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R. candidianus (Regan, 1908 [32]), *R. formosanus* Oshima, 1919 [30]; *R. rubromaculatus* Lee and Chang, 1996 [22]; *R. gigas* Aonuma and Chen, 1996 [3]; *R. nantaiensis* Aonuma and Chen, 1996 [3]; *R. maculafasciatus* Chen and Shao, 1996 [13]; *R. delicatus* Chen and Shao, 1996 [13]; *R. henchuenensis* Chen and Shao, 1996 [13]; and *R. lanyuensis* Chen *et al.*, 1998 [11].

So-called, “Ogasawara-yosinobori”, *R. sp. BI* is regarded as the “Bonin Islands (Ogasawara group)”-endemic species to be distributed over the Anijima Island, Chichijima Islands, Hahajima Islands and Ootouto Island. *R. sp. BI* is endangered amphidromous goby, and is distinguished from other Japanese *Rhinogobius* complex [34-36, 51-54].

Furthermore, Mukai *et al.* [28] investigated the mitogenetic differentiation between *R. sp. BI* and other congeneric species of the Japan-Ryukyu Archipelagos, and concluded that it has retained its own mtDNA lineage in Ogasawara Group for millions of years.

However, those nominal species are known only from major Japanese Islands, Korean Peninsula and even Taiwan but are never recorded and distributed around the far away area: Bonin Islands (Ogasawara Group). Also *R. giurinus* is distributed on major Japanese Islands and the Ryukyu Islands but it has never distributed over Bonin Islands (Ogasawara Group).

The aim of this paper is to formally describe *R. sp. BI* as a new species under the specific name of *R. ogasawaraensis*.

II. MATERIALS AND METHODS

All type specimens of the new species were collected by hand-net. All counts and measurements were made from specimens preserved in 70% ethanol. Morphometric methods follow Miller [25] and meristic methods follow Akihito *et al.* [1], Chen and Shao [10] and Chen *et al.* [9, 14, 15]. Terminology of cephalic sensory canals and free neuromast organ (sensory papillae) is from Wongrat and Miller [46], based on Sanzo [33]. The oocyte diameter from this new species and 4 typically amphidromous species with small-egg size of Taiwan were measured under the microscope by sampling from adult females. Type specimens are deposited at the Osaka Museum of Natural History, Osaka (OMNH), Japan; Kanagawa Prefectural Museum of Natural History, Kanagawa (KPM), Japan and the Pisces collection of Institute of Marine Biology, National Taiwan Ocean University, Keelung (NTOU P), Taiwan. Meristic abbreviations: A, anal fin; C, caudal fin; D1, and D2, 1st and 2nd dorsal fins respectively; LR, longitudinal scale series; P, pectoral fin; PreD, predorsal scales; SDP, scale series from origin of 1st dorsal fin to upper pectoral fin origin.; TR, transverse scale series from second dorsal to anal fins; V, pelvic fin; VC, vertebral count. All fish lengths are standard length (SL). Colour when fresh is based on the photographs in the Image Database of Fishes in the Kanagawa Prefectural Museum of Natural History (KPM-NR).

III. SYSTEMATICS

Rhinogobius Gill, 1859

Rhinogobius ogasawaraensis sp. nov.

(Japanese name: Ogasawara-yoshinobori)

(Table 1; Figs. 1-5)

Rhinogobius sp. BI Suzuki, 1992 [35]: 5 (Chichijima Island); Masuda and Kobayashi 1994 [23]: 378 (Ogasawara Group); Suzuki, 2001 [36]: 589 (Chichijima Island and Hahajima Island); Suzuki, 2003 [37]: 134 (Anijima Island, Chichijima Island and Hahajima Island); Yokoi and Hosoya, 2003 [52]: 9 (Chichijima Island and Hahajima Island); Suzuki and Shibukawa, 2004 [41]: 454 (Anijima Island, Chichijima Island and Hahajima Island); Yokoi, 2009 [51]: 145 (Chichijima Island, Hahajima Island and Otoutojima Island); Yokoi *et al.*, 2009 [54]: 67 (Anijima Island, Chichijima Island, Hahajima Island and Otoutojima Island).

1. Material examined

Holotype: OMNH-P 8278, 65.1 mm SL, Yatsusegawa River, Chichijima Island, the Bonin Islands (Ogasawara Group), Japan, coll. T. Suzuki & M. Suzuki, 30 July 1992.

Paratypes: NTOU P 2007-02-882 & 2007-02-883, 2 specimens, 39.9-46.5 mm SL, A small stream of Oki village, Hahajima Island, the Bonin Islands (Ogasawara Group), Japan, coll. T. Mukai, 24 November 2001; KPM-NI 3839-3845 (KPM-NR 52867-52873) & 3846, 30 specimens, 15.9-49.7 mm SL, coll. H. Senou, 3 July 1997, other data same as holotype; OMNH-P 8256 (KPM-NR 702), 1 specimen, 29.8 mm SL, Minamifukurozawa stream, 26 July 1992, other data same as holotype; OMNH-P 8257 (KPM-NR 741) & 8258, 2 specimens, 32.3-35.5 mm SL, A small stream of Ohmura village, 28 July 1992, other data same as holotype; OMNH-P 8259-8261 (KPM-NR 746-748), 3 specimens, 40.1-43.5 mm SL, Okumugawa River, 28 July 1992, other data same as holotype; OMNH-P 8262 (KPM-NR 773), 8263-8270, 8274-8277 & holotype; OMNH-P 8272, 1 specimen, 53.8 mm SL, A small stream of Sakaiura 8279-8282, 17 specimens, 36.7-75.2 mm SL, 30 July 1992, other data same as village, 1 August 1992, other data same as holotype; OMNH-P 8273, 1 specimen, 53.6 mm SL, 1 August 1992, other data same as holotype.

2. Diagnosis

Rhinogobius ogasawaraensis is distinguished from all congeneric species by the following unique combination of features: second dorsal fin rays I, 8-9, pectoral fin rays 18-20, predorsal scales 7-16, vertebral count 26, cheek with some red spots, nape with several longitudinal dark stripes, upper part of pectoral fin base with a dark blotch, intermittent dark dotted rows along middle axis of body, no saddle shaped patch of dark dots on dorsal side of body, ventral side of body yellowish white, caudal fin with some dark dotted rows on middle region and the base with a pair of dark brown bars which vertically to each other.

3. Description

Body rather cylindrical anteriorly, compressed posteriorly.

Table 1. Morphometry of *Rhinogobius ogawasaraensis* n. sp.

Sex No. of specimens	Holotype			Paratypes					
	Male 1	min	Male 15 max	Mean	STD	min	Female 9 max	Mean	STD
SL (mm)	65.1	43.5	75.2			29.8	63.8		
% in SL									
Head length	30.3%	29.6%	34.2%	31.7%	1.5%	26.5%	30.0%	28.0%	1.2%
Predorsal length	40.5%	37.8%	41.6%	40.1%	1.0%	36.9%	41.0%	38.9%	1.3%
Snout to 2nd dorsal origin	60.4%	55.8%	61.4%	59.7%	1.3%	57.1%	61.7%	59.9%	1.4%
Snout to anus	59.3%	55.5%	61.6%	58.6%	1.6%	55.0%	60.3%	58.3%	1.9%
Snout to anal fin origin	63.1%	61.0%	64.7%	62.9%	1.1%	59.4%	64.5%	62.5%	1.8%
Prepelvic length	29.7%	28.6%	32.2%	30.5%	1.0%	25.0%	28.7%	27.1%	1.2%
Caudal peduncle length	24.9%	23.3%	26.0%	24.8%	0.8%	23.9%	28.2%	25.7%	1.4%
Caudal peduncle depth	12.7%	12.1%	14.0%	12.8%	0.6%	10.9%	12.8%	12.1%	0.6%
1st dorsal fin base	14.0%	14.0%	17.6%	15.5%	1.0%	12.8%	16.2%	14.9%	1.2%
length of longest D1 ray	20.6%	17.9%	29.1%	23.6%	3.4%	10.7%	16.7%	13.8%	1.8%
2nd dorsal fin base	16.8%	15.9%	18.5%	17.3%	0.8%	14.6%	17.2%	15.9%	0.8%
Length of last D2 ray	17.8%	16.5%	26.4%	21.9%	3.1%	9.6%	13.9%	12.1%	1.5%
Anal fin base	14.1%	12.8%	16.8%	13.7%	1.0%	11.0%	13.7%	12.4%	0.9%
Caudal fin length	21.7%	21.7%	28.2%	25.4%	2.0%	21.6%	25.8%	23.5%	1.4%
Pectoral fin length	19.5%	19.5%	25.8%	22.7%	1.8%	21.4%	26.7%	23.1%	1.5%
Pelvic fin length	13.0%	11.1%	16.3%	14.3%	1.4%	12.8%	17.3%	14.9%	1.5%
Body depth of pelvic fin origin	18.3%	14.8%	18.7%	17.2%	1.1%	14.8%	19.0%	16.7%	1.6%
Body depth of anal fin origin	15.9%	14.3%	17.6%	15.6%	1.0%	13.7%	17.5%	15.2%	1.1%
Body width of anal fin origin	13.7%	9.8%	14.7%	12.3%	1.3%	10.7%	14.6%	12.8%	1.5%
Pelvic fin origin to anus	30.6%	26.3%	32.3%	29.5%	2.0%	25.0%	34.1%	31.6%	2.8%
% in HL									
Snout length	40.5%	35.5%	48.3%	40.6%	3.4%	27.6%	38.3%	35.6%	3.4%
Eye diameter	15.9%	14.5%	18.7%	16.6%	1.2%	18.2%	24.4%	20.9%	2.3%
Postorbital length	47.2%	42.5%	48.8%	45.5%	2.0%	45.4%	51.8%	48.0%	1.7%
Cheek depth	28.4%	23.7%	30.0%	26.1%	1.9%	18.5%	28.2%	24.2%	2.6%
Head width in upper gill opening	48.7%	41.8%	53.4%	45.6%	3.0%	41.7%	58.8%	49.4%	4.8%
Head width in maximum	56.3%	52.7%	64.0%	56.9%	3.1%	53.1%	73.9%	61.9%	6.0%
Bony interorbital width	6.2%	5.8%	10.4%	7.7%	1.2%	5.6%	9.6%	7.7%	1.2%
Fleshy interorbital width	35.6%	28.0%	36.3%	33.0%	2.3%	33.2%	40.6%	37.4%	2.2%
Lower jaw length	39.2%	36.1%	41.5%	39.2%	1.7%	27.3%	34.3%	32.2%	2.2%
% in Caudal peduncle length									
Caudal peduncle depth	51.2%	47.2%	53.5%	51.1%	2.1%	43.1%	51.5%	47.1%	3.0%

Head moderately large, slightly depressed in adult male and sub-cylindrical in female. Eye large, dorsal lateral. Cheek somewhat fleshy in male. Lips thick and fleshy, upper lip somewhat prominent than lower lip. Mouth oblique and the rear margin usually extending near vertical of anterior margin of eye in male, and not extending to the vertical in female. Both jaws with 3-5 rows of conical teeth and outer rows enlarged. Tongue margin somewhat truncate. Anterior nasal opening as a short tube and posterior one as a round hole. Gill-opening extending ventrally slightly beyond the midline vertical of opercle. Isthmus broad. 10 + 16 = 26 vertebrae (n = 10). Body proportions as Table 1.

Fins. – D1 rays VI (n = 28); D2 rays I, 8 (22), I, 9 (6)

(modally I, 8); A rays I, 8 (26), I, 9 (2) (modally I, 8); P rays 18 (15), 19 (32), 20 (9) (usually 18-19); V rays I, 5 (28). D1 always with 2nd spinous ray longest especially in adult male, and the rear tip of D1 extending to base of 2nd to 6th branched rays of D2 when depressed in male; and almost reaching or just beyond origin of D2 when depressed in female. Origin of A inserted below the middle vertical line of 1st and 2nd branched rays of D2. The rear tip of D2 rays when depressed always beyond the procurrent rays of C in male but not reaching this point in female. P large and oblong, its rear extension always close to but not reaching vertical through anus in male, but far from this vertical in female. V disc rounded, spinous rays with pointed membranous lobe, the 1st branched ray longer than the spinous ray. C elliptical, rear edge rounded.

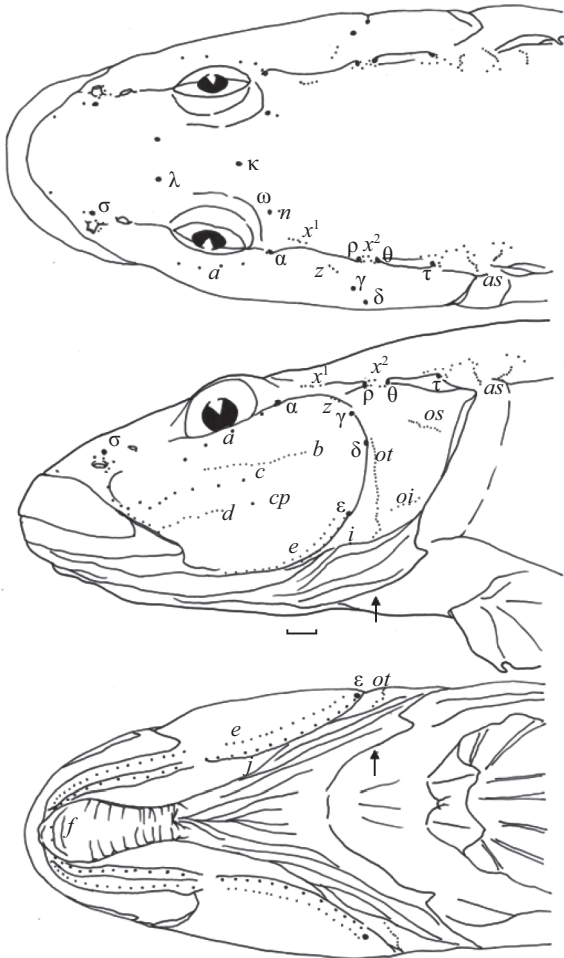


Fig. 1. Head lateral-line system of *Rhinogobius ogasawaraensis*, OMNH-P 8263, male, paratype, 51.7 mm SL. Bar = 1 mm. (Illustration by I-S. Chen)

Scales. – Body with moderately large ctenoid scales on posterior body and smaller cycloid scales on anterior half. Belly with tiny cycloid scales. Anterior predorsal region naked. LR 31 (1), 32 (14), 33 (25), 34 (14), 35 (2) (usually 32-34); TR 11 (20), 12 (8) (modally 11); PreD 7 (1), 8 (4), 9 (2), 10 (4), 11 (2), 12 (3), 13 (4), 14 (4), 15 (2), 16 (2); SDP 9 (1), 10 (16), 11 (11) (modally 10). Head and prepelvic region naked. Predorsal squamation with trifurcate anterior edge and anterior extension of middle series usually extending to the vertical through upper origin of gill-opening in male, and usually with further extension forward around the midline vertical of opercle in female.

Head lateral-line system. (Fig. 1) Canals. – Nasal extension of anterior oculoscapular canal with terminal pore σ located above the cross-line of rear margin between two anterior nostrils. Anterior interorbital sections of oculoscapular canal separated, with paired pore λ . A single pore κ in posterior region. Pore ω present near posterior edge of eye. Lateral section of anterior oculoscapular canal with corner pore α and

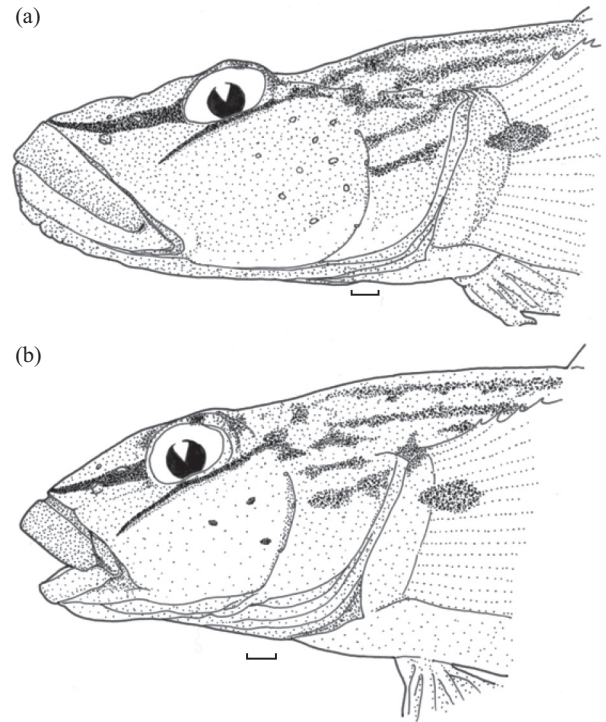


Fig. 2. Head pigmentation pattern of *Rhinogobius ogasawaraensis*, (a) male, OMNH P8272, paratype, 53.8 mm SL; (b) female, NTOU P2007-02-883, paratype, 46.5 mm SL. Bar = 1 mm. (Illustration by I-S. Chen)

terminal pore ρ . Posterior oculoscapular canal with two terminal pores θ and ι . Gap between anterior and posterior oculoscapular canals somewhat smaller than the length of posterior oculoscapular canal. Preopercular canal present, with three pores γ , δ , and ϵ .

Sensory papillae. – Row *a* longitudinal and loosely arranged and extending forward near the vertical through anterior margin of orbit. Row *b* longitudinal and very long as densely set and the length about 1.5 times of orbit diameter. Rows *c* and *d* longitudinal and long, but still not extending beyond vertical line of rear margin of orbit. A single *cp* papilla. Row *f* paired. The anterior edge of opercular rows *oi* and *ot* well separated.

Colouration when fresh. (Figs. 2-5) Body and head light brown to brown. Head light brown to brown. Cheek with 6-10 orange red spots in male, and less than 5 blackish brown to brownish red spots in female. Snout with a pair of broad deep red stripes united on the snout tip. A red to brownish red oblique thin stripe below eye with lower shiny blue margin. Opercle pale brown with two horizontal deep brown stripes on upper region. Nape with several longitudinal reddish brown to deep brown stripes. Branchiostegal membrane without shiny spots and marks in both sexes. Lateral body with a middle series of 8 somewhat rounded grayish brown blotches. First dorsal fin grayish with yellowish anterior region on upper half



Fig. 3. *Rhinogobius ogasawaraensis*, fresh specimens, (a) OMNH-P 8278, male, holotype, 65.1 mm SL; (b) OMNH-P 8262 (KPM-NR 773), male, paratype, 58.3 mm SL, Yatsusegawa River, Chichijima Island, the Bonin Islands (Ogasawara Group), Japan. (Photograph by T. Suzuki)



Fig. 4. *Rhinogobius ogasawaraensis*, fresh specimen, NTOU P 2007-02-88-883, female, paratype, 46.5 mm SL, A small stream of Oki village, Hahajima Island, the Bonin Islands (Ogasawara Group), Japan. (Photograph by T. Suzuki)

of membrane in front of third spine and with deep brown spines. First dorsal fin pale with crescent grayish black region after the spines especially in female. Second dorsal fin with 3-4 longitudinal rows of grayish brown spots in female but always spotless in male. Caudal fin base with a pair of dark brown bars which vertically to each other and more conspicuous larger in female. Caudal fin with 3-5 vertical rows of stripes or spots in middle region. Pectoral fin base with a horizontal, deep black diaper mark in upper half. Anal fin grayish brown with darker rays in male and somewhat translucent and grayish in female. Pelvic fin whitish or grayish brown.

All shiny and brilliant colouration and marks faded after long preservation.

Distribution. This species is only known and possibly merely endemic from Anijima Island, Chichijima Island, Hahajima Island and Otoutojima Island, the Bonin Islands (Ogasawara group), Japan.

Etymology. The specific name, *ogasawaraensis*, refers to the type locality “Ogasawara Group”, Japan.

Ripe egg-size of adult females. From the dissection data of 3 adult female, only two individuals have ripe eggs in their



Fig. 5. Alive colouration of *Rhinogobius ogasawaraensis*, (a) male, OMNH-P 8279; (b) female, OMNH-P 8282. (Photograph by T. Suzuki)

ovaries. This new species was randomly sampled 30 ripe oocytes for measuring the oocyte diameter to be measured and tried to check and estimate the possibility of life history. The ripe oocyte diameter of *Rhinogobius ogasawaraensis* is 0.69-0.88 mm as the average 0.77 mm with standard deviation 0.05 mm. Other comparative studies of four amphidromous *Rhinogobius* species from Taiwan were also conducted here and also some published and even unpublished comparative data from three amphidromous species of mainland Japan from Tamada ([44, 45]; and personal communication). The size of egg of this new species seems to be close to the range but slightly larger among size range of small-egg species with amphidromous life history from other Taiwanese and Japanese species. However, the size is actually still smaller than other several medium-egg species from Okinawa, Japana and Taiwan (Chen, unpubl. data; Suzuki, unpubl. data). It can be strongly suggested as a typically small-egg amphidromous species.

IV. DISCUSSION

1. Morphological Comparison of Related Nominal *Rhinogobius* Species

Rhinogobius ogasawaraensis can be shared the common features as typically longitudinal infraorbital sensory papillae, trifurcate anterior margin of predorsal squamation, snout with red to brownish red stripes on snout, rounded pelvic fin with other typical Yoshinobories which can be immediately separated from *R. giurinus* with transverse infraorbital papillae.

R. ogasawaraensis can be well distinguished from fluvial species, *R. flumineus* by pectoral fin rays 18-20, and vertebral counts 26 vs. pectoral fin rays 15-17, and vertebral counts

usually 27-28. Among them, the species assigned as endemic species of Ryukyu Archipelagos (including *R. sp.* BB, DL, MO, and YB) have been considered as undescribed species; and all Japanese Yoshinobories should be simplified and grouped to eight mainland species (including *R. sp.* BW, BF, CB, CO, DA, LD, TO and three morphotypes of OR) of mainland Japan with low vertebral count 26 as following amphidromous or lacustrine *Rhinogobius* species: six species names as *R. brunneus* (Temminck and Schelegel), *R. similis* Gill, *R. nagoyae* Jordan and Seale, *R. kurodai* (Tanaka), *R. katonis* (Tanaka) (as the junior synonym of *R. nagoyae*), and *R. fluviatilis* Tanaka from mainland Japan (Chen and Suzuki unpublished data).

Among the morphological comparison of congeneric species with vertebral count 26 from mainland Japan, *R. ogasawaraensis* seems to be most similar to *R. brunneus* (Temminck and Schelegel) (= *R. sp.* DA). *R. ogasawaraensis* in having pectoral fin with a horizontal deep brown mark on upper base, and lacking any patches of dark dots on dorsal side of body vs. *R. brunneus* (Temminck and Schelegel) in having pectoral fin with a crescent shaped deep brown mark on base, and four saddle shaped patches of deep brown dots on dorsal side of body. Compared to other remaining nominal and undescribed species, *R. ogasawaraensis* is distinguished from *R. sp.* CB from mainland Japan by cheek without wavy or radiating lines from eye but presence of orange red spots vs. cheek with many wavy or radiating lines from eye; *R. ogasawaraensis* is distinguished from *R. sp.* CO by cheek with orange red spot but lacking cobalt blue spots, and caudal fin with some dotted deep brown rows on middle region vs. cheek merely with several cobalt blue spots, and caudal fin with blackish brown rays; *R. ogasawaraensis* is distinguished from *R. fluviatilis* Tanaka (= *R. sp.* LD) by caudal fin with a pair of dark brown bars which vertically each other and some dotted deep brown rows on middle region vs. caudal fin with a distinct vertical blackish brown band on base and deep gray rays; *R. ogasawaraensis* is distinguished from *R. kurodai* Tanaka, morphotype “Gi-tohsyoku” (= *R. sp.* OR “Gi-tohsyoku”) and *R. sp.* BF by first dorsal fin with elongated spinous rays in male vs. first dorsal fin without elongated spines in male; and *R. ogasawaraensis* is distinguished from *R. kurodai* Tanaka, morphotype “Shinjiko” and “Tohshoku” (*R. sp.* OR morphotype “Shinjiko” and “Tohshoku”) by caudal fin in lacking a large orange mark and deep brown rays vs. caudal fin with a large orange mark on upper basal region and deep brown rays; *R. ogasawaraensis* is distinguished from Biwa Lake endemic *R. sp.* BW by 7-16 predorsal scales vs. always lacking predorsal midline squamation; and *R. ogasawaraensis* is distinguished from *R. sp.* TO by the presence of normal preopercular canal with 3 pores vs. complete reduction and absence of preopercular canal (Akihito *et al.* [2]; Suzuki [35, 36]; Suzuki *et al.* [39]; Suzuki and Sakamoto [40]; Yokoi and Hosoya [52]).

Among the comparison with nine endemic species of *Rhinogobius* from Taiwan, *R. ogasawaraensis* shares the overall

similarity of typically well developed canal system, high pectoral fin rays counts, low vertebral count 26 as well as reproducing small egg-size with following four nominal species: *R. formosanus* Oshima, *R. gigas* Aonuma and Chen, *R. lanyuensis* Chen *et al.*, and *R. maculafasciatus* Chen and Shao. However, it can be well distinguished from *R. formosanus* by cheek and body coloration pattern. *R. ogasawaraensis* seems shared the homology of spotted cheek in male with the remaining three *Rhinogobius* species of Taiwan mentioned above. However, *R. ogasawaraensis* can be easily distinguished from these three species by pectoral fin with a dark horizontal bar; unlike that with three vertical lines in both *R. gigas* Aonuma and Chen and *R. lanyuensis* Chen *et al.*, and that with a dark brown to red vertical stripe or dotted line in *R. maculafasciatus* Chen and Shao.

2. The Egg-Size Comparison among Amphidromous *Rhinogobius* Species of Japan

In Bonin islands (Ogasawara Group) of Japan, the endemic *R. ogasawaraensis* seems to represent the larger oocyte diameter 0.77 mm than any other amphidromous species of mainland Japan with smaller oocyte diameter from 0.53 (for *R. sp.* CO) — 0.72 (for *R. brunneus*) mm (Tamada [43, 44]). However, such size of diameter in *R. ogasawaraensis* seems to be quite smaller than the egg-size of all typical “medium-egg species/morphotype” of both Taiwanese and Japanese freshwaters (Chen, unpubl. data; Suzuki, unpubl. data).

The species origin of endemic *R. ogasawaraensis* may colonize by occasional dispersal of ancestral amphidromous species with long duration postlarval stage. It is very interesting that *R. ogasawaraensis* is not directly evolved from all members of amphidromous *Rhinogobius* species of mainland Japan by mitogenetic survey (Mukai *et al.* [30]), but highly possibly shared common ancestor with other certain species group which far from the Ryukyu isles of Japan, Taiwan or even the Philippines then via the northward dispersal process by Kuroshio current. However, this evolutionary hypothesis will be proved by the further more molecular phylogenetic approach including more comprehensive species among those geographical regions (Chen *et al.*, in prep.).

The currently larger oocyte of *R. ogasawaraensis* may lead to produce its shorter postlarval duration and it would be provided positively impact on good chance of success for locating larval populations nearby the coastal area and then ascending to insular basins while growing and help better achievement on efficient life-history of small-scale amphidromy. Due to already on the red-list of freshwater fish in Japan for such very restricted populations of endemic goby: *R. ogasawaraensis* under the tentatively name as *R. BI* morphotype before (Suzuki [37]), the serious concern for protecting the original vegetation along river bank and natural river channels would be very important to maintain the annually essential recruitment of their larval fish ascending migration to freshwaters to complete their amphidromy in the Bonin islands (Ogasawara Group).

3. Comparative Materials

1) JAPAN

Rhinogobius flumineus: OMNH-P 5628 & 5629, 2 specimens, 43.0-51.8 mm SL, 4 May 1991, Yubune River, Hyogo Pref., Japan; OMNH-P 11929 & 11930, 2 specimens, 42.6-43.1 mm SL, 27 August 1997, Kako River, Hyogo Pref., Japan; OMNH-P 12460, 1 specimen, 33.9 mm SL, 11 June 1997, Tigusa River, Hyogo Pref., Japan; OMNH-P 12795 & 12796, 2 specimens, 40.2-41.4 mm SL, 12 September 1998, Ibana River, Hyogo Pref., Japan; OMNH-P 13296, 1 specimen, 44.4 SL, 21 August 1998, Ibo River, Hyogo Pref., Japan; OMNH-P 15256 & 15257, 2 specimens, 36.4-38.3 mm SL, 28 October 1994, Maruyama River, Hyogo Pref., Japan; OMNH-P 15959 & 15960, 2 specimens, 43.2-46.5 mm SL, 25 July 2002, Yura River, Kyoto Pref., Japan; OMNH-P 18355 & 18356, 2 specimens, 54.5-58.0 mm SL, 26 May 2003, Mizukoe River, Osaka, Japan; OMNH-P 18407 & 18408, 2 specimens, 53.5-56.9 mm SL, 20 October 2003, Takatsu River, Shimane Pref., Japan; OMNH-P 21183, 1 specimen, 34.8 mm SL, 27 October 2005, Hidaka River, Wakayama Pref., Japan; OMNH-P 32002, 1 specimen, 45.5 mm SL, 7 March 2006, Kumozu River, Mie Pref., Japan; OMNH-P 32003 & 32004, 2 specimens, 41.9-44.1 mm SL, 6 May 2001, Ina River, Hyogo Pref., Japan.

Rhinogobius giurinus: OMNH-P 5760 & 5761, 2 specimens, 30.8-31.5 mm SL, 16 June 1991, Yada River, Hyogo Pref., Japan; OMNH-P 7890 & 7891, 2 specimens, 24.2-26.7 mm SL, 7 May 1994, OMNH-P 7960 & 7961, 2 specimens, 63.3-74.8 mm SL, 4 September 1994, Sazu River, Hyogo Pref., Japan; OMNH-P 11892 & 11893, 2 specimens, 42.4-46.6 mm SL, 12 August 1997, OMNH-P 11903 & 11904, 2 specimens, 39.0-49.0 mm SL, 17 August 1997, OMNH-P 12171, 1 specimen, 51.4 mm SL, 16 October 1997, OMNH-P 15679, 1 specimen, 59.5 mm SL, 9 June 2002, Kako River, Hyogo Pref., Japan; OMNH-P 12846, 1 specimen, 39.4 mm SL, 14 May 1999, OMNH-P 12863, 1 specimen, 60.5 mm SL, 13 May 1999, OMNH-P 14918, 1 specimen, 46.9 mm SL, 28 August 1999, Maruyama River, Hyogo Pref., Japan; OMNH-P 13348, 1 specimen, 61.8 mm SL, 18 August 1998, OMNH-P 16014, 1 specimen, 42.4 mm SL, 1 September 2002, Ibo River, Hyogo Pref., Japan; OMNH-P 32000 & 32001, 4 specimens, 34.9-57.1 mm SL, 14 October 2000, Umeda River, Aichi Pref., Japan.

***Rhinogobius* sp. CB**: (types of *Ctenogobis katonis*), ZUMT 2002, holotype, 60.0 mm SL, Kanazawa, Kaga, Japan; ZUMT 57509-11, paratypes, 3 specimens, 43.7-56.8 mm SL, all other data as holotype; OMNH-P 12778, 1 specimen, 38.7 mm SL, 12 September 1998, Sumoto River, Hyogo Pref., Japan; OMNH-P 12784-12786, 3 specimens, 35.7-48.8 mm SL, 12 September 1998, Ibana River, Hyogo Pref., Japan; OMNH-P 15234-15236, 3 specimens, 48.8-57.7 mm SL, 15 September 1995, Maruyama River, Hyogo Pref., Japan; OMNH-P 15244 & 15245, 2 specimens, 37.8-51.7 mm SL, 4 September 1994, Sazu River, Hyogo Pref., Japan; OMNH-P 15252, 1 specimen, 59.4 mm SL, 11 November 1993, Takeno River,

Hyogo Pref., Japan; OMNH-P 15253-15255, 3 specimens, 50.1-67.4 mm SL, 28 October 1994, Maruyama River, Hyogo Pref., Japan; OMNH-P 21179-21181, 10 specimens, 39.3-58.4 mm SL, 27 October 2005, Hidaka River, Wakayama Pref., Japan; OMNH-P 32108 & 32109, 2 specimen, 45.2-45.6 mm SL, 5 May 1985, Seto River, Shizuoka Pref., Japan.

***Rhinogobius* sp. CO**: OMNH-P 11588, 11589, & 11591, 3 specimen, 51.3-68.9 mm SL, 17 September 1998, Nakatsu River, Hyogo Pref., Japan; OMNH-P 11590, 1 specimen, 77.1 mm SL, 17 September 1998, Ai River, Hyogo Pref., Japan; OMNH-P 18426-18428, 3 specimens, 48.4-62.9 mm SL, 24 October 2003, Nabeno River, Kagoshima Pref., Japan; OMNH-P 21177 & 21178, 2 specimens, 48.0-51.0 mm SL, 27 October 2005, Hidaka River, Wakayama Pref., Japan; OMNH-P 32110-32112, 10 specimen, 49.4-72.0 mm SL, 15 September 1981, Nishiurakawachi River, Shizuoka Pref., Japan; OMNH-P 32113 & 31999, 2 specimen, 35.8-46.5 mm SL, 9 June 2001, Nigo River, Hiroshima Pref., Japan.

***Rhinogobius brunneus* (= *R. sp. DA*)**: RMNH 1923, holotype, 46.0 mm SL, Nagasaki Bay, Japan; OMNH-P 8221 & 8222, 2 specimens, 31.6-34.1 mm SL, 14 September 1998, Honjyu River, Hyogo Pref., Japan; OMNH-P 8230 & 8235, 2 specimens, 34.1-67.8 mm SL, 14 September 1998, Oo River, Hyogo Pref., Japan; OMNH-P 8236-8240, 5 specimens, 52.5-66.8 mm SL, 14 September 1998, Habu stream, Hyogo Pref., Japan; OMNH-P 8241, 7 specimens, 46.3-57.2 mm SL, 12 September 1998, Sumoto River, Hyogo Pref., Japan; OMNH-P 11583 & 11584, 2 specimens, 59.3-65.4 mm SL, 16 September 1998, Mihara River, Hyogo Pref., Japan; OMNH-P 12781, 12782, 12788 & 12789, 4 specimens, 47.2-59.0 mm SL, 12 September 1998, Ibana River, Hyogo Pref., Japan; OMNH-P 12808-12810, 3 specimens, 33.0-40.6 mm SL, 14 September 1998, Honjyu River, Hyogo Pref., Japan; OMNH-P 15248, 1 specimen, 78.0 mm SL, 1 September 1994, Sazu River, Hyogo Pref., Japan; OMNH-P 15249, 1 specimen, 69.1 mm SL, 29 August 1993, Nishi River, Hyogo Pref., Japan; OMNH-P 32106 & 32107, 2 specimen, 46.1-50.7 mm SL, 29 July 1985, Suzuri River, Shizuoka Pref., Japan.

***Rhinogobius fluviatilis* (= *R. sp. LD*)**: ZUMT 9108, holotype, 74.5 mm SL, Himenji, Hyogo Prefecture, Japan; OMNH-P 11585-11587, 3 specimens, 52.1-64.5 mm SL, 16 September 1998, Mihara River, Hyogo Pref., Japan; OMNH-P 12791-12793, 3 specimens, 34.9-57.0 mm SL, 12 September 1998, Ibana River, Hyogo Pref., Japan; OMNH-P 15251, 1 specimen, 59.0 mm SL, 29 August 1993, Nishi River, Hyogo Pref., Japan; OMNH-P 18391-18394, 4 specimens, 70.1-86.2 mm SL, 9 September 2003, Komenotsu River, Kagoshima Pref., Japan; OMNH-P 18429, 1 specimen, 69.8 mm SL, 24 October 2003, Nabeno River, Kagoshima Pref., Japan; OMNH-P 18436, 1 specimen, 83.9 mm SL, 31 October 2003, Kuzuryu River, Fukui Pref., Japan; OMNH-P 21175, 21176, 21182, 4 specimens, 54.4-72.0 mm SL, 27 October 2005, Hidaka River, Wakayama Pref., Japan; OMNH-P 32104, 32105 & 32114, 10 specimens, 44.9-66.7 mm SL, 15 October 1984, Seto River, Shizuoka Pref., Japan; OMNH-P 32115-32117, 3 specimens,

63.0-70.5 mm SL, 4 September 1995, Kuzuryu River, Fukui Pref., Japan.

***Rhinogobius kurodai* morphotype “Gi-tohsyoku” (= *R. sp. OR* morphotype “Gi-tohsyoku”):** (types of *Ctenogobius kurodai*), ZUMT 2008, holotype, 33.9 mm SL, 27 Sept. 1908, Freshwater pond in garden of Marquis Kuroda, Tokyo, Japan; ZUMT 2009, paratypes, 10 specimens, 20.6-28.9 mm SL, all other data as holotype; OMNH-P 32013-32015, 3 specimens, 36.1-40.4 mm SL, 4 June 2002, Tama River, Tyokyo, Japan; OMNH-P 21132-21136, 5 specimens, 37.3-46.8 mm SL, 20 June 2005, Shiratori Moat, Tyokyo, Japan.

***Rhinogobius kurodai* morphotype “Shinjiko” (= *R. sp. OR* morphotype “Shinjiko”):** OMNH-P 5441 & 5442, 2 specimens, 53.3 & 53.9 mm SL, 26 October 1994, OMNH-P 5411-5415, 7 specimens, 56.5-70.7 mm SL, 11 November 1994, OMNH-P 5416, 5417 & 5419, 3 specimens, 49.1-56.5 mm SL, 12 November 1994, OMNH-P 5423, 15 specimens, 44.7-58.0 mm SL, 15 November 1994, Maruyama River, Hyogo Pref., Japan.

***Rhinogobius kurodai* morphotype “Toshoku” (= *R. sp. OR* morphotype “Toshoku”):** OMNH-P 32005-32009, 5 specimens, 41.7-52.9 mm SL, 19 November 1996, Yasu River, Shiga Pref., Japan; OMNH-P 32010 & 32011, 2 specimens, 35.6, 43.7 mm SL, 29 July 2001, Hino River, Shiga Pref., Japan; OMNH-P 32012, 1 specimen, 65.2 mm SL, 18 September 2002, Jyasa River, Shiga Pref., Japan.

***Rhinogobius sp. BF*:** OMNH-P 5882 & 5883, 2 specimens, 27.9 & 37.0 mm SL, 18 March 1995; OMNH-P 5890-5892 & 8033-8037, 8 specimens, 25.7-37.4 mm SL, 24 March 1995; OMNH-P 8076 & 8077, 2 specimens, 30.0 & 35.0 mm SL, 15 September 1995, Maruyama River, Hyogo Pref., Japan.

***Rhinogobius sp. BW*:** BLIH 20010402-20010408, 11 specimens, 29.1-35.2 mm SL, 1 July 2001, Lake Biwa, Shiga Pref., Japan.

***Rhinogobius sp. TO*:** BLIH 20000256-20000267, 14 specimens, 28.3-37.8 mm SL, 1 April 2000, Yahagi River, Aichi Pref., Japan; BLIH 20000268, 1 specimen, 28.7 mm SL, 1 April 2000, Toki River, Gifu Pref., Japan; BLIH 20000269, 4 specimens, 26.8-32.8 mm SL, 13 September 2000, Pond of Nagakute Cho, Aichi Pref., Japan; BLIH 20010400, 1 specimen, 30.7 mm SL, 6 April 2001, Pond of Toyokawa city, Aichi Pref., Japan; BLIH 20010401, 1 specimen, 33.0 mm SL, 13 November 2001, Ibi River, Gifu Pref., Japan.

2) TAIWAN

All examined materials of nine nominal species of *Rhinogobius* from Taiwan are listed in Aonuma and Chen [3], Chen, Miller and Fang [12] and Chen and Shao [13].

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