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Northernmost Record of *Stiphodon multisquamus* (Gobiiformes: Oxudercidae) Based on a Specimen from Wakayama, Japan

Taiga Kunishima[1,4], Ryosuke Tanaka[2], Kentarou Hirashima[1], and Ken Maeda[3]

[1] *Wakayama Prefectural Museum of Natural History, 370-1 Funoo, Kainan, Wakayama 642-0001, Japan*
E-mail: kunishima_t0001@pref.wakayama.lg.jp
[2] *Department of Biology, Graduate School of Science, Kobe University, 1-1, Rokkodai-cho, Nada-ku, Kobe, Hyogo 657-8501, Japan*
[3] *Okinawa Institute of Science and Technology Graduate University, 1919-1 Tancha, Onna, Okinawa 904-0495, Japan*
[4] *Corresponding author*

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One female specimen of *Stiphodon multisquamus* Wu and Ni, 1986 was collected from Arida-gawa River, Wakayama Prefecture, Japan, in November 2018. As the previously known range of this species was from the South China Sea, including Malaysia, Vietnam, and China, to the Ryukyu Archipelago in Japan, this specimen was reported as the first record from the Japanese mainland and the northernmost record of this species. *Stiphodon multisquamus* is an amphidromous fish of which pelagic larvae develop in marine habitats. It was believed that this specimen was transported from the southern region by ocean currents during the pelagic larval phase and recruited into the river in Wakayama Prefecture.

Key Words: amphidromy, Sicydiinae, larval dispersal, Kuroshio Current, WMNH.

Introduction

Amphidromous goby spawns in freshwater rivers, and newly hatched larvae migrate to the sea to develop as pelagic larvae. After the pelagic larval phase in the sea, larvae are recruited into freshwater rivers and grow there to mature and reproduce (Keith 2003; McDowall 2007). During the pelagic larval phase, larvae could be transported to other rivers or islands by ocean currents (Maeda et al. 2007; Iida et al. 2010; Lord et al. 2015). Some studies suggested that amphidromous gobies of the subfamily Sicydiinae could disperse to remote habitats (Hoareau et al. 2007; Maeda et al. 2012; Maeda 2013; Taillebois et al. 2013; Maeda and Saeki 2013, 2018).

The Kii Peninsula is located in southwestern Japan's forearc region, the southernmost area of the temperate Honshu Island (Fig. 1). The peninsula is projecting southward into the Pacific Ocean. Its climate, fauna, and flora are strongly influenced by the warm Kuroshio Current that flows from southwest to northeast off the southern coast of the Kii Peninsula (Nakabo 2015). In Wakayama Prefecture, which is located along the southwestern coast of the Kii Peninsula, rare fish migrants having their home in tropical islands were sometimes found (e.g., Yamamoto et al. 1997; Ishida et al. 1998; Hirashima and Nakatani 2006; Nakao and Hirashima 2012a, b). It was believed that they were transported from the southern regions by the Kuroshio Current. Such records provide useful information to understand the dispersal, recruitment, and survival after the recruitment of aquatic organisms and the basic knowledge of freshwater fish fauna in Wakayama Prefecture.

One female specimen of *Stiphodon multisquamus* Wu and Ni, 1986 (Gobiiformes: Oxudercidae) was collected from Arida-gawa River, a river flowing westward into the Pacific Ocean in the northern part of Wakayama Prefecture. *Stiphodon* Weber, 1895 is a genus of the sicydiine goby, composed of more than 30 species distributed in tropical and subtropical freshwater streams from Sri Lanka and the western coast

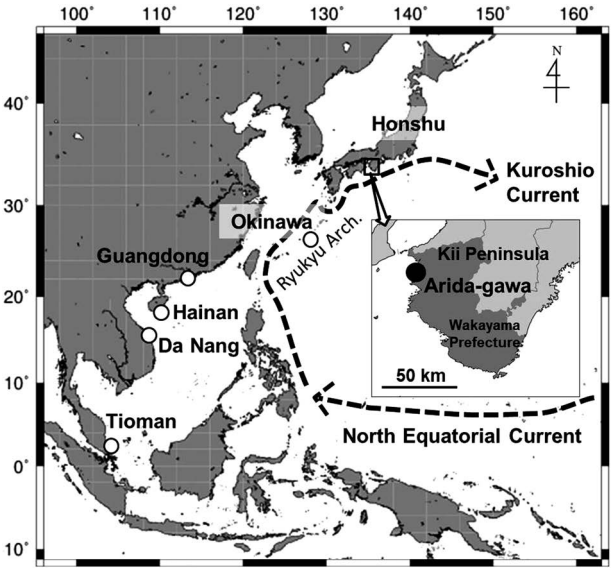

Fig. 1. Map showing the location of the Kii Peninsula (and Wakayama Prefecture), route of the Kuroshio Current, and localities where *Stiphodon multisquamus* was reported. Black and white circles indicate records in the present and previous studies, respectively (Wu and Ni 1986; Chen and Tan 2005; Nip 2010; Maeda and Saeki 2013; Maeda et al. 2015).

of Sumatra in the Indian Ocean to southern Japan, northeastern Australia, and French Polynesia. The gobies of this genus are amphidromous of which their pelagic larvae stay in the sea, and after recruiting into streams, juveniles and adults usually feed on algae scraping from rock surface (Keith et al. 2015). *Stiphodon multisquamus* is a species of the genus previously recorded in Tioman Island in Malaysia (as *Stiphodon aureorostrum* Chen and Tan, 2005; see Chen and Tan 2005; Maeda et al. 2015), Da Nang in central Vietnam (Maeda et al. 2015), Hainan and Guangdong in southern China (Wu and Ni 1986; Nip 2010), and Okinawa-jima Island in Japan (Maeda and Saeki 2013) (Fig. 1). This species is abundant only in Vietnam and rather rare in other regions (Maeda et al. 2015). In this paper, the specimen of *S. multisquamus* collected in Wakayama Prefecture was reported as the first record of this species from the Japanese mainland.

Materials and Methods

The specimen of *S. multisquamus* was collected from the lower reaches of Arida-gawa River (Fig. 1; 34°04′45″N, 135°09′01″E) using a D-frame kick net (see Tanaka et al. 2020 for details of the sampling method). The specimen was stored frozen, then fixed in 10% formalin and preserved in 70% ethanol before deposit at the Wakayama Prefectural Museum of Natural History (WMNH), Kainan, Wakayama Prefecture, Japan. Before fixation, the tip of right Pectoral fin was removed from the fish and stored in 99% ethanol for future molecular analysis. For species identification of the specimen, the counts and measurements were taken according to Maeda and Saeki (2013). Measurements were made to the nearest 0.1 mm with a digital caliper and expressed as a percentage of standard length (SL). The number of teeth in upper and lower jaws was counted from the right side of the symphysis. The cephalic sensory system was observed after staining with a cyanine blue solution, but the sensory papillae arrangement could not be observed because of its damaged condition. The scale arrangement was observed and described, but scale counts were difficult to be performed because of the damages; therefore, they were not provided in this report. The number of vertebrae was counted by soft X-ray radiography (SOFRON SRO-405 A, SOKEN Co., Ltd.). Procedures used to handle fish specimens in our research comply with current laws of Japan and a guideline of the Ichthyological Society of Japan for the use of fishes in research (The Ichthyological Society of Japan 2003).

Taxonomic Accounts

Stiphodon multisquamus Wu and Ni, 1986
(Figs 2, 3)

Material examined. WMNH-PIS10942, female, 29.4 mm SL, 1 November 2018.

Description. The counts and morphometric measurements are provided in Table 1. Body elongate, cylindrical anteriorly and somewhat compressed posteriorly. Head somewhat depressed with a round snout protruding beyond the upper lip. Anterior nostril tubular and short, posterior nostril not tubular. Mouth inferior with the upper jaw protruding beyond the lower jaw. Upper lip thick and smooth with a small medial cleft. Premaxillary teeth 37. Dentary with 35 horizontal teeth and one canine-like symphyseal tooth. First dorsal fin with six spines and second dorsal fin with one spine and nine soft rays. Anal fin with one spine and 10 soft rays. Caudal-fin rounded with 17 segmented rays, including 13 branched rays. Pectoral fin with 16 soft rays. Pelvic fin with one spine and five soft rays; right and left fins joined together to form a cup-like disk with a frenum. Ctenoid scales covering tail and lateral and dorsal sides of the posterior trunk. Cycloid scales covering the belly, lateral side of the anterior trunk, nape, occipital region, first and second dorsal-fin bases, anal-fin base, caudal-fin base, and proximal part of the caudal fin. Scales on the occipital region and nape notably smaller than the lateral scales on the trunk and tail (Fig. 3A). Cephalic sensory pore system with A′, B, C, D(S), F, H′, K′, and L′ in the oculoscapular canal and N′ and O′ in the preopercular canal. Number of vertebrae 10+16 (abdominal and caudal vertebrae). Urogenital papilla plumper and rectangular.

Coloration of the preserved specimen. Background of body whitish; blackish longitudinal stripe extending from the snout to the pectoral-fin base through the suborbital region; stripe continuing from behind the pectoral-fin base to the caudal-fin base through lateral midline. Dorsum dusky with two whitish transverse bars on the occipital region and nape (Fig. 3A). Anal-fin rays translucent with black markings near their translucent tip (Fig. 3B). Caudal-fin translucent with some black spots along its middle rays. Pelvic-fin translucent without pigment.

Habitat. *Stiphodon multisquamus* was collected in a riffle with substrates composed of loose cobbles below a tidal weir, located approximately 5 km upstream from the river mouth. The water depth was about 20–30 cm when the specimen was collected in this study. The sampling site was considered to be influenced by tidal fluctuation, but no salinity was usually detected. There are two fish ways in the tidal weir on both sides of the river. It cohabited with other gobies, including *Rhinogobius nagoyae* Jordan and Seale, 1906, *Sicyopterus japonicus* (Tanaka, 1909), and *Tridentiger brevispinis* Katsuyama, Arai, and Nakamura, 1972, but no other specimen of the genus *Stiphodon* has been found so far.

Discussion

The specimen collected in the present study was identified as *S. multisquamus* based on the second dorsal fin with one spine and nine soft rays, pectoral fin with 16 soft rays, size of the scales on the occipital region and anterior nape (significantly smaller than its lateral scales on the trunk and tail; Fig. 3A), and two light-colored transverse bars on the occipital region and nape (Fig. 3A). Comparative mor-

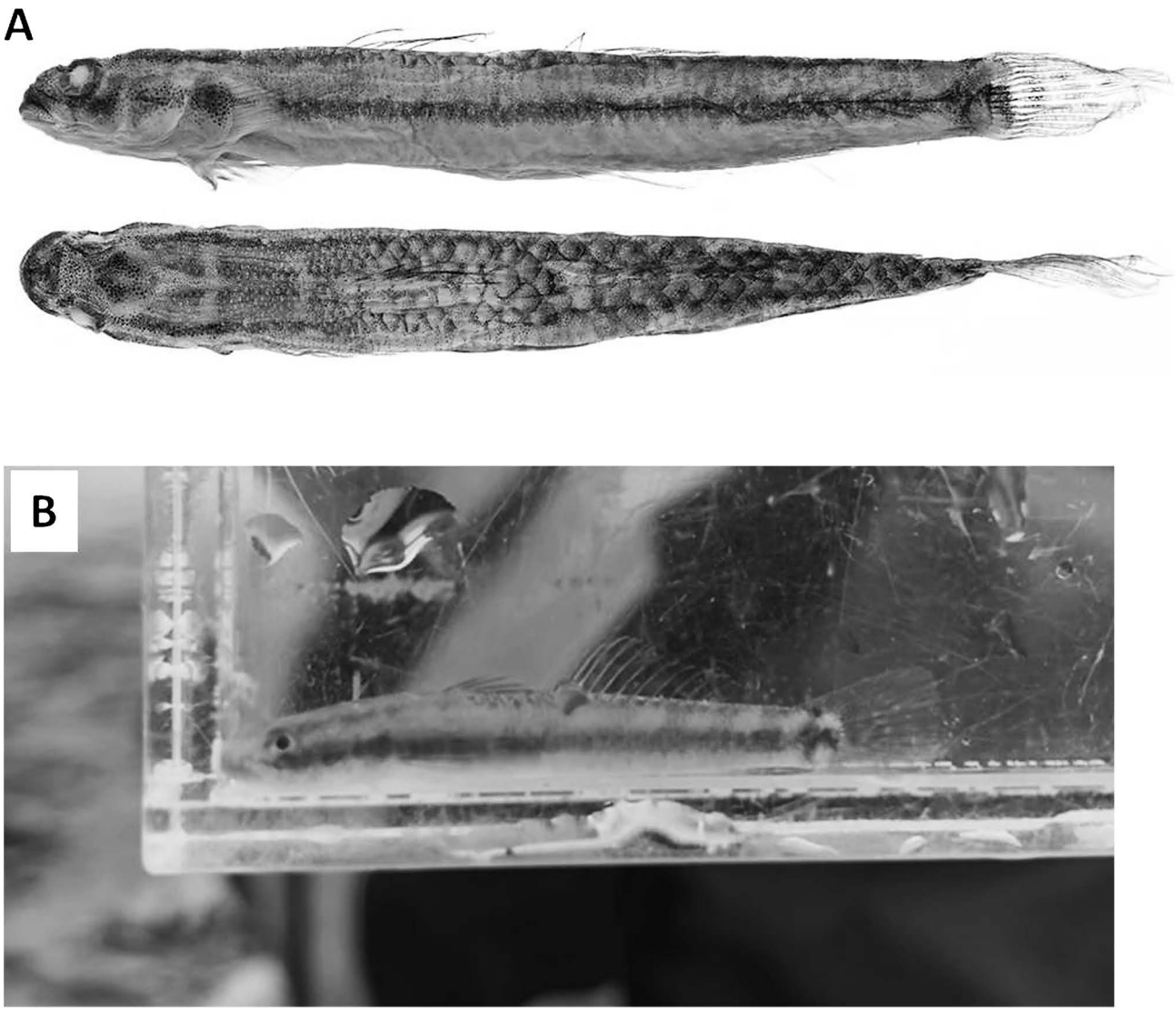

Fig. 2. Photographs of *Stiphodon multisquamus* (WMNH-PIS10942, 29.4 mm SL) collected from Arida-gawa River, Wakayama Prefecture, Japan, on 1 November 2018. A, Specimen, preserved, lateral view (above) and dorsal view (below); B, specimen, alive.

phological descriptions are available from Maeda and Saeki (2013) and Maeda et al. (2015). The morphologies of our material almost corresponded to them. Although the numbers of tricuspid teeth on the premaxilla (37) and horizontal teeth on the dentary (35) were smaller than the previous reports (40–66 and 39–67, respectively; Maeda and Saeki 2013; Maeda et al. 2015), it was probably caused by the smaller body size of our material (29.4 vs. 29.8–64.0 mm SL), as in this genus larger individuals generally have more teeth (Maeda and Palla 2015). Our specimen was identified as female based on a rectangular urogenital papilla, shape and size of the first and second dorsal fins [it is shown in a photograph of the specimen taken when it was alive (Fig. 2B), although fin morphologies of the fixed specimen were difficult to be observed due to their damaged condition], cycloid scales covering on the nape and occipital region, and black stripes through the lateral midlines of the body. Some female-specific diagnostic characters including presence of a symphyseal tooth on dentary and black markings near the translucent tips of each anal-fin ray (markings on the membranes could not be observed because of the damages; Fig. 3B) supported the species-identification of this specimen.

In the genus *Stiphodon*, seven species have been reported in Japan [*S. atropurpureus* (Herre, 1927); *S. multisquamus*; *S. surrufus* Watson and Kottelat, 1995; *S. imperiorientis* Watson and Chen, 1998; *S. percnopterygionus* Watson and Chen, 1998; *S. alcedo* Maeda, Mukai, and Tachihara, 2012; and *S. niraikanaiensis* Maeda, 2013]. Most of them were found in the Ryukyu Archipelago, an island chain in southern Japan (Keith et al. 2015). Even in the Ryukyu Archipelago, only *S. percnopterygionus* is abundant (Maeda 2013). Some species, such as *S. multisquamus* and *S. niraikanaiensis*, are very rare there. They are considered to have been colonized after pelagic larvae were transported from their main range by ocean currents (Maeda 2013; Maeda and Saeki 2013). In Wakayama Prefecture, the Arida-gawa River, where the northernmost specimen of *S. multisquamus* was collected, is located more than 1000 km to the northeast of Okinawa-jima Island. Because this species has never been found during previous surveys in Arida-gawa River (Nakatani et al.

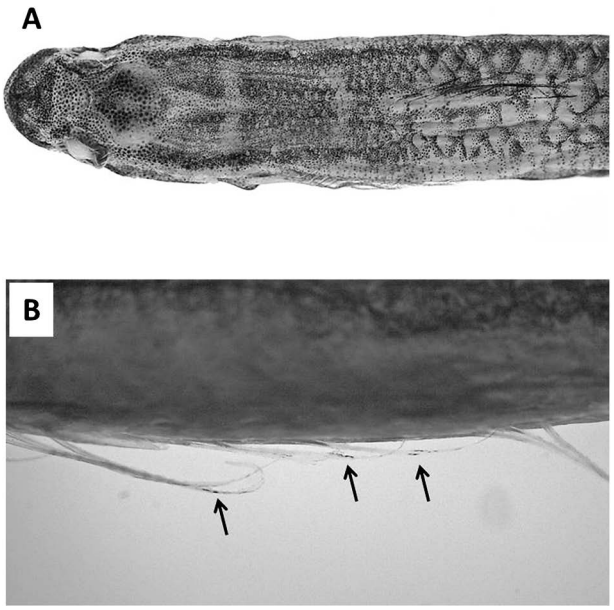

Fig. 3. Preserved specimen of *Stiphodon multisquamus* (WMNH-PIS10942, 29.4 mm SL). A, Anterior half of the body in dorsal view; B, enlarged photo showing black pigments on anal-fin rays (see arrows).

Table 1. Counts and measurements of *Stiphodon multisquamus* (WMNH-PIS10942, female) from Arida-gawa River, Wakayama Prefecture.

Counts	
Dorsal-fin rays	VI, I-9
Anal-fin rays	I-10
Pectoral-fin rays	16
Pelvic-fin rays	I-5
Abdominal vertebrae	10
Caudal vertebrae	16
Total vertebrae	26
Measurements	
Standard length (mm)	29.4
In % of standard length	
Head length	19.0
Snout length	4.0
Eye diameter	2.8
Interorbital width	8.6
Maxillary length	6.8
Body depth at pelvic-fin origin	12.6
Interval between 1st and 2nd dorsal-fin bases	10.2
Predorsal length	32.1
Preanal length	54.8
Length from anus to anal fin	4.5
Caudal-peduncle depth	8.4
Caudal-peduncle length	18.9
Length of 1st dorsal-fin base	13.0
Length of 2nd dorsal-fin base	18.7
Length of anal-fin base	24.7
Caudal-fin length	19.1
Pectoral-fin length	21.1
Pelvic-fin length	11.2

1991; Nakatani and Yoshida 1992, 1993) and other rivers in Wakayama Prefecture (Wakayama Prefecture 2012), and only one individual was found in this survey, it is considered that this species is not a regular member of the freshwater fish fauna in this region. Nakao and Hirashima (2012b) reported that *S. percnopterygionus*, observed from October 2011 to January 2012 in the southern area of Wakayama Prefecture, did not survive after February 2012 when the water temperature dropped to 14.1°C. We collected the specimen of *S. multisquamus* in November, before the water temperature decreases rapidly. It was supposed that survival over winter in Wakayama Prefecture is difficult for this species, too.

Two other species of *Stiphodon*, *S. percnopterygionus* and *S. atropurpureus*, have been reported in the islands to the north of Kyushu (Keith et al. 2015). Probably both species are migrants transported by ocean currents. Because these two species were also reported from Wakayama Prefecture (Nakao and Hirashima 2012a, b), *S. multisquamus* is the third species in this genus in Wakayama Prefecture. Wakayama Prefecture is located in the Kii Peninsula and faces the Pacific Ocean, where Kuroshio Current flows through (Fig. 1), and there are many streams and rivers along its mountainous coastline. Although such a condition makes larvae from southern regions easy to recruit into the streams and rivers, it may be difficult for larvae to survive in low temperatures in winter. Alternatively, domestic fish that occupy the habitat may also prevent the migrants from establishing a new population by competitions for trophic and spatial resources and/or by predation.

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