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# Discovery of a substantial continental population of the subfamily Sicydiinae (Gobioidei: Gobiidae) from Vietnam: Taxonomic revision of the genus *Stiphodon* from the western South China Sea

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**Abstract.** *Stiphodon multisquamus* Wu & Ni, 1986 is a sicydiine goby species previously considered to be endemic to Hainan Island, in southern China. Recently, it was also recorded from the southern Chinese mainland and southern Japan, but it is rare in all of these localities. Available morphological data for *S. multisquamus* is derived from a small number of specimens and differences between this species and *S. aureorostrum* Chen & Tan, 2005 from Pulau Tioman, Malaysia are unclear. In the present study, we report on a large population of *S. multisquamus* from Da Nang, central Vietnam, and described the morphology of this species based on 44 Vietnamese specimens as well as nine additional specimens from Pulau Tioman. *Stiphodon multisquamus* is distinguished from congeners by the number of soft rays in the second dorsal (usually nine) and pectoral fins (usually 15 or 16), pointed first dorsal fin with elongate spines in males, relatively high tooth counts, predorsal squamation, and a unique colouration, including two or three conspicuous, light-coloured, transverse bars on the occipital region and nape, with fine black spots on the pectoral-fin rays. *Stiphodon aureorostrum* is considered to represent a junior synonym of *S. multisquamus*. This is the first record of the subfamily Sicydiinae from Vietnam.

**Keywords.** *Stiphodon multisquamus*, *Stiphodon aureorostrum*, Sicydiinae, continental rivers, freshwater fish, diadromy

## INTRODUCTION

Gobies of the subfamily Sicydiinae are distributed in tropical, subtropical, and some temperate freshwater streams in the Indo-Pacific, West African, Central American, and Caribbean areas (Keith & Lord, 2011). *Stiphodon* Weber, 1895 is one of the sicydiine genera containing more than 30 species from the eastern Indian Ocean and the western and central Pacific Ocean (Maeda, 2013). *Stiphodon aureorostrum* Chen & Tan, 2005 and *Stiphodon atropurpureus* (Herre, 1927) have been recorded in Pulau Tioman, Malaysia, and are the only sicydiine gobies known currently to habitat the western part of the South China Sea (Ng et al., 1999; Chen & Tan, 2005). The former species is currently regarded as endemic to Pulau Tioman (Chong et al., 2010). The latter is also known from the Philippines, southern Japan, Taiwan, and mainland China (Guangdong). Pulau Tioman is the southernmost distribution of this species (Watson & Kottelat, 1995; Watson & Chen, 1998; Nip, 2010; Maeda et al., 2012b).

We recently discovered a population of *Stiphodon multisquamus* Wu & Ni, 1986, in central Vietnam. This species was originally described as a new subspecies of *Stiphodon elegans* (Steindachner, 1879) on the basis of a single specimen collected from the southern part of Hainan Island, China. Wu (1991) later recognised it as a distinct species, which he named *S. multisquamus*. Although Wu & Ni (1986) did not sex the holotype of *S. multisquamus*, it is identifiable as a female based on the shape of the first and second dorsal and anal fins. Wu (2008) first described the male morphology based only on one male specimen from southern Hainan. In addition to Hainan Island, Nip (2010) and Maeda & Saeki (2013) reported occurrences of *S. multisquamus* from Guangdong Province in China and Okinawa Island in Japan, respectively.

Taxonomy of the genus *Stiphodon* is not yet well established (Maeda, 2013) and available morphological data from *S. multisquamus* are insufficient to allow comparisons with other species, since this species has been described to date on the basis of only three specimens from Hainan Island (Wu & Ni, 1986; Wu, 1991, 2008) and only four specimens from Okinawa Island (Maeda & Saeki, 2013). Its relationship with *S. aureorostrum* is especially unclear. In the present paper, *S. multisquamus* is re-described on the basis of the new specimens and the taxonomy of the genus *Stiphodon* from the western South China Sea is revised.

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## MATERIAL AND METHODS

Measurements and counts were taken from the right side of each specimen, unless the right side was damaged; then the left side was used. Measurements were made point-to-point, to the nearest 0.1 mm using dial callipers or dividers under a stereomicroscope and expressed as a percentage of standard length (SL). Measurements and counts followed Nakabo (2002), with the following modifications: SL, head length, snout length, predorsal length, and preanal length were measured to the anteriormost point of the protruding snout. Body depth was measured at both the pelvic- and anal-fin origin. First and second dorsal- and anal-fin lengths were measured from the origin of each fin to the farthest point when the fin was depressed. Caudal-fin length was measured as the length of the longest ray in the middle part of the caudal fin. The 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. The anus to anal-fin length was measured from the centre of the anus to the anal-fin origin. Scales in a longitudinal series were counted along a single, contiguous scale row on the lateral midline from the middle of the posterior end of the hypurals to behind the pectoral-fin base. Scales in a transverse series were counted along a diagonal line extending posteriorly and ventrally from the first scale anterior to the second dorsal fin, including one scale on the dorsal midline and another scale at the anal-fin base. Circumpeduncular scales were counted along the circumference of the narrowest point of the caudal peduncle in a zigzag manner. Tooth counts of the upper and lower jaws were taken from the right side of the symphysis, with dentition terms following Watson (2008). Symbolic codes used to represent collections and institutions cited follow Leviton et al. (1985), except BLIH (Biological Laboratory, Imperial Household, Tokyo, Japan), CMK (collection of M. Kottelat, Cornol, Switzerland), URM (General Research Center of Okinawa Churashima Foundation, Okinawa, Japan; this collection was transferred from the University of the Ryukyus); ZMA (Naturalis Biodiversity Center, Leiden, Netherlands; this collection was transferred from Universiteit van Amsterdam, Zoölogisch Museum, Amsterdam), and ZRC (Zoological Reference Collection of the Lee Kong Chian Natural History Museum, Singapore).

## TAXONOMY

### *Stiphodon multisquamus* Wu & Ni, 1986

(Figs. 1–7; Table 1)

*Stiphodon elegans multisquamus* Wu & Ni, 1986: 422 (type locality: Lingshui River, Hainan Island, China).

*Stiphodon multisquamus*: Wu, 1991: 495 (Hainan Island); Wu, 2008: 729 (Hainan Island); Nip, 2010: 1238 (Guangdong, China); Maeda & Saeki, 2013: 216 (Okinawa Island, Japan).

*Stiphodon aureorostrum* Chen & Tan, 2005: 238 (type locality: Pulau Tioman, Malaysia).

**Material examined. Vietnam**: ZRC 50267, 12 males (37.2–64.0 mm SL) and 12 females (37.1–51.4 mm SL), Suoi Mo, Hoa Vang District, Da Nang Province, coll. H. H. Tan, A. D. Tran et al., 27 February 2005; URM-P 48179, 48181, 2 females (29.8–33.8 mm SL), Suoi Mo, Hoa Vang District, Da Nang Province, coll. K. Maeda & H. D. Tran, 12 January 2013; URM-P 48199–48207, 4 males (41.7–61.3 mm SL) and 5 females (40.7–51.9 mm SL), Suoi Hoa, Hoa Vang District, Da Nang Province, coll. K. Maeda & H. D. Tran, 13 January 2013; URM-P 48214–48216, 48218–48221, 48224, 48225, 6 males (31.9–43.2 mm SL) and 3 females (32.4–37.4 mm SL), Suoi Mo, Hoa Vang District, Da Nang Province, coll. K. Maeda & H. D. Tran, 14 January 2013. **Malaysia:** ZRC 45409, 2 females (51.7–58.3 mm SL, paratypes of *S. aureorostrum*), Sungai Keliling, Pulau Tioman, coll. H. H. Tan, 25 June 1999; ZRC 45410, 1 male (45.4 mm SL, paratype of *S. aureorostrum*), Sungai Keliling, Pulau Tioman, coll. P. K. L. Ng et al., 24 June 1999; ZRC 46414, 1 female (42.4 mm SL), Sungai Keliling, Pulau Tioman, coll. H. H. Tan, June 1999; ZRC 54194, 3 males (43.4–44.6 mm SL) and 2 females (42.6–44.0 mm SL), Sungai Keliling, coll. H. H. Tan & B. W. Low, 16 July 2013.

**Diagnosis.** Second dorsal fin usually with one spine and nine soft rays; pectoral fin usually with 15 or 16 soft rays; first dorsal-fin spines in male elongate and tip of the longest spine extending far beyond the second dorsal-fin origin. Premaxilla with 43–66 tricuspid teeth; dentary with 44–67 horizontal teeth. Scales on occipital region and anterior nape significantly smaller than lateral scales on trunk and tail. Scales extending anteriorly to nape or posterior part of occipital region in male, usually extending anteriorly to middle or posterior part of occipital region in female. Predorsal midline with fewer scales than either side of midline, and often naked in male. Nine to 11 dusky, transverse bars laterally on trunk and tail; two or three conspicuous, light-coloured, transverse bars on occipital region and nape; pectoral-fin rays with fine black spots. In male, lateral side of head often bluish; distal part of first and second dorsal fins orange in life. In female, second dorsal-fin spine and soft rays often with two to four black spots; tip of first and second dorsal fins with reddish markings in life; anal fin with a submarginal black line; caudal fin with black spots forming transverse bars.

**Description.** Morphometric measurements given in Table 1. Body elongate, cylindrical anteriorly and somewhat compressed posteriorly. Head somewhat depressed with a round snout protruding beyond upper lip. Anterior nostril tubular and short, posterior nostril not tubular. Mouth inferior with upper jaw projecting beyond lower jaw. Upper lip thick and smooth with small medial cleft. Premaxillary teeth 43–66, fine and tricuspid. Dentary with canine-like symphyseal teeth (number of teeth one to five in male, usually one to three in female; symphyseal teeth absent on right only of one female) and row of 44–67 unicuspid horizontal teeth enclosed in fleshy sheath. Larger individuals have more premaxillary and horizontal teeth than smaller individuals (Fig. 2). Urogenital papilla rounded in male, rectangular with small projection at each corner of posterior edge in female.

First dorsal fin with six spines (one specimen with five spines); second dorsal fin usually with one spine and nine soft rays (two specimens with one spine and ten soft rays). In female, first dorsal fin almost semicircular with second, third, or fourth spine longest; in male, second to sixth spines elongate (usually fourth spine longest) and membranes sometimes notched between third and fourth, between fourth and fifth, or between fifth and sixth spines, but spines not filamentous (Fig. 3). Posteriormost point of first dorsal fin of male (tip of fourth and/or fifth spine) extending to base of second to fifth soft ray of second dorsal fin when depressed. Anal fin with one spine and 10 soft rays. In female, first or second soft rays longest in second dorsal fin, and second or third soft rays longest in anal fin; in male, posterior rays longer than anterior rays in those fins (last ray and/or penultimate ray usually longest). Caudal fin with 17 segmented rays, including 13 branched rays, posterior margin rounded; caudal fin relatively larger in male than in female (caudal-fin length 24–28% of SL in male, 20–23% of SL in female). Pectoral fin with 14 (n=5), 15 (n=29), or 16 (n=10) rays. Pelvic fin with one spine and five soft rays; pelvic fins joined together to form strong, cup-like disk with fleshy frenum.

Scales in a longitudinal series 31 (n=2), 32 (n=1), 34 (n=8), 35 (n=26), 36 (n=13), 37 (n=2), 38 (n=1); scales in a transverse series 10 (n=5) or 11 (n=48); circumpeduncular scales 15


Fig. 1. *Stiphodon multisquamus* collected from Da Nang, Vietnam, after preservation. a, male, 51.3 mm SL (URM-P 48202); b, male, 38.5 mm SL (URM-P 48216); c, female, 49.4 mm SL (URM-P 48206); d, female, 37.4 mm SL (URM-P 48219).

Table 1. Morphometrics of *Stiphodon multisquamus* from Da Nang, Vietnam and Pulau Tioman, Malaysia, expressed as a percentage of standard length.

| | **Da Nang** | | **Pulau Tioman** | |
|---|---|---|---|---|
| Sex | Male | Female | Male | Female |
| Number of specimens measured | 22 | 22 | 4 | 5 |
| Standard length (mm) | 31.9–64.0 | 29.8–51.9 | 42.4–44.6 | 42.4–58.3 |
| Head length | 21.9–24.5 | 21.3–23.7 | 22.4–23.6 | 21.4–22.5 |
| Snout length | 7.6–10.5 | 7.3–9.9 | 8.1–8.5 | 7.5–8.5 |
| Eye diameter | 4.5–6.0 | 4.5–6.4 | 4.5–4.9 | 4.5–5.0 |
| Postorbital length of head | 9.2–11.9 | 9.7–11.4 | 9.8–11.6 | 10.1–10.8 |
| Upper jaw length | 8.2–10.5 | 7.9–9.6 | 9.0–9.4 | 7.8–9.4 |
| Body depth at $P_2$ origin | 12.3–16.1 | 12.3–14.0 | 13.9–14.6 | 13.0–14.4 |
| Body depth at A origin | 13.2–17.1 | 14.2–16.0 | 15.6–16.7 | 16.2–17.7 |
| Depth at caudal peduncle | 9.7–12.3 | 9.6–11.5 | 11.1–11.8 | 10.3–11.8 |
| Length of caudal peduncle | 17.8–20.4 | 17.2–19.3 | 18.2–18.4 | 18.2–19.7 |
| Predorsal length | 32.6–35.7 | 33.4–36.5 | 32.5–34.0 | 33.7–34.5 |
| Length of $D_1$ base | 15.3–20.5 | 16.4–19.8 | 17.0–20.3 | 16.6–19.7 |
| $D_1$ length | 24.7–35.4 | 17.4–21.3 | 31.1–37.3 | 19.5–21.1 |
| Length of longest spine of $D_1$ | 21.2–29.6 | 11.7–16.9 | 25.6–28.8 | 13.9–15.8 |
| Interval between $D_1$ and $D_2$ bases | 3.4–6.8 | 3.4–7.0 | 2.4–5.7 | 4.2–8.2 |
| Length of $D_2$ base | 24.4–26.9 | 22.1–25.7 | 25.8–28.1 | 24.2–25.5 |
| $D_2$ length | 37.2–48.4 | 29.2–35.2 | 47.0–49.8 | 31.5–34.2 |
| Length of longest ray of $D_2$ | 18.8–25.9 | 12.7–15.0 | 23.3–24.2 | 13.0–14.9 |
| Preanal length | 51.9–54.9 | 53.1–56.5 | 49.8–53.0 | 52.0–55.0 |
| Length of A base | 25.2–29.0 | 22.5–26.8 | 27.6–30.2 | 25.6–26.9 |
| A length | 36.9–42.4 | 30.2–33.7 | 42.2–44.3 | 32.4–34.9 |
| Length of longest ray of A | 14.5–18.3 | 11.0–13.9 | 15.9–16.8 | 11.6–13.2 |
| Length from anus to A | 2.2–4.4 | 3.3–5.6 | 2.6–3.6 | 4.0–4.7 |
| Length of longest ray of $P_1$ | 17.8–21.3 | 15.3–19.8 | 20.7–22.4 | 17.0–19.5 |
| C length | 23.6–28.1 | 19.8–23.3 | 27.0–28.3 | 21.1–23.4 |

$D_1$, first dorsal fin; $D_2$, second dorsal fin; A, anal fin; C, caudal fin; $P_1$, pectoral fin; $P_2$, pelvic fin.

(n=2), 16 (n=48), 17 (n=3). Ctenoid scales covering tail and lateral and dorsal sides of posterior trunk. Belly and lateral side of anterior trunk (behind pectoral-fin base) covered by cycloid scales. Scales on nape and occipital region differing between male and female. In male (Fig. 4a, b), scales extended anteriorly to posterior or anterior part of nape or posterior part of occipital region; predorsal midline naked or scaled only on nape. In female (Fig. 4c, d), scales extended anteriorly to middle or posterior part of occipital region (one female without scale on occipital region); whole predorsal midline sometimes naked but posterior part of nape usually scaled. All scales on occipital region and nape cycloid and scales on occipital region and anterior nape notably smaller than lateral scales on trunk and tail. Cycloid scales also occurring on first and second dorsal-fin bases, anal-fin base, caudal-fin base, and proximal part of caudal fin.

Cephalic sensory pore system invariably A′, B, C, D(S), F, H′, K′, L′, N′, and O′. Oculoscapular canal interrupted between pores H′ and K′. Cutaneous sensory papillae developed over dorsal, lateral, and ventral surface of head.

**Colour in preservative.** Sexual dichromatism well developed. In male (Fig. 1a, b), dorsal background dusky, lateral sides light brown, ventral side pale grey; nine to 11 dusky transverse bars laterally on trunk and tail; width of bars and intervals between them differing among bars, and number and arrangement of bars often differing between right and left sides of body; head and pectoral-fin base dusky; two or three conspicuous pale-brown or cream-coloured transverse bars dorsally on occipital region and nape. First dorsal-fin spines black distally and dusky proximally; membranes transparent distally and dusky proximally. Posterior half of first dorsal fin with black blotch. Second dorsal-fin rays dusky; membranes transparent distally and partly dusky proximally. Anal fin dusky. Caudal fin dusky with translucent spots often forming two to 11 transverse bars on middle part of fin; distal margin of upper part of caudal fin translucent. Pectoral-fin membranes translucent; rays with fine black spots, number of spots on longest rays (seventh and/or eighth ray) eight to 16. Middle to proximal part of pelvic-fin rays, fin membranes, and frenum dusky or blackish, distal margin translucent except for dusky edge around fifth soft ray.

In female (Fig. 1c, d), background of body and head cream coloured; blackish longitudinal band extending from snout and upper lip to below eye and to middle of pectoral-fin base, band continuing from behind pectoral-fin base to posterior end of caudal peduncle through lateral midline; nine to 11 dusky

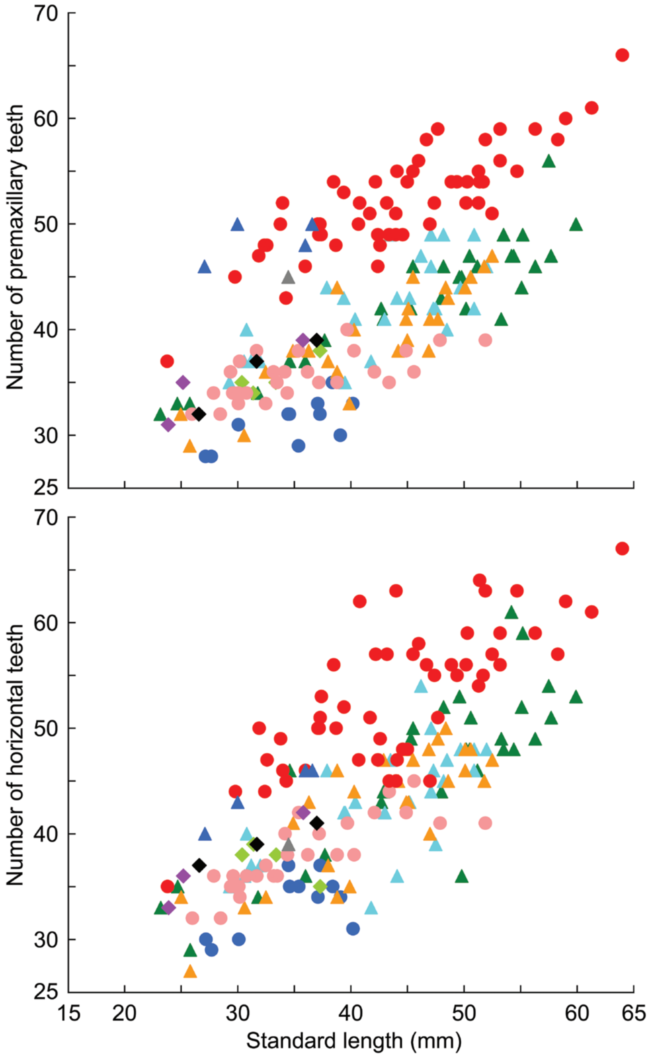


Fig. 2. Number of premaxillary and horizontal dentary teeth of *Stiphodon multisquamus* (red circles), *S. alcedo* (pink circles), *S. atratus* (black squares), *S. elegans* (deep blue circles), *S. imperiorientis* (light blue triangles), *S. martenstyni* (grey triangle), *S. niraikanaiensis* (deep blue triangles), *S. ornatus* (orange triangles), *S. pelewensis* (light green squares), *S. pulchellus* (deep green triangles), and *S. weberi* (purple squares).

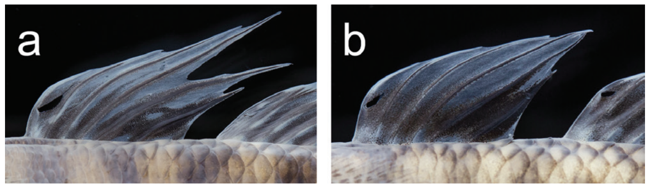


Fig. 3. First dorsal fin of *Stiphodon multisquamus*. a, male, 51.3 mm SL (URM-P 48202); b, male, 38.5 mm SL (URM-P 48216).

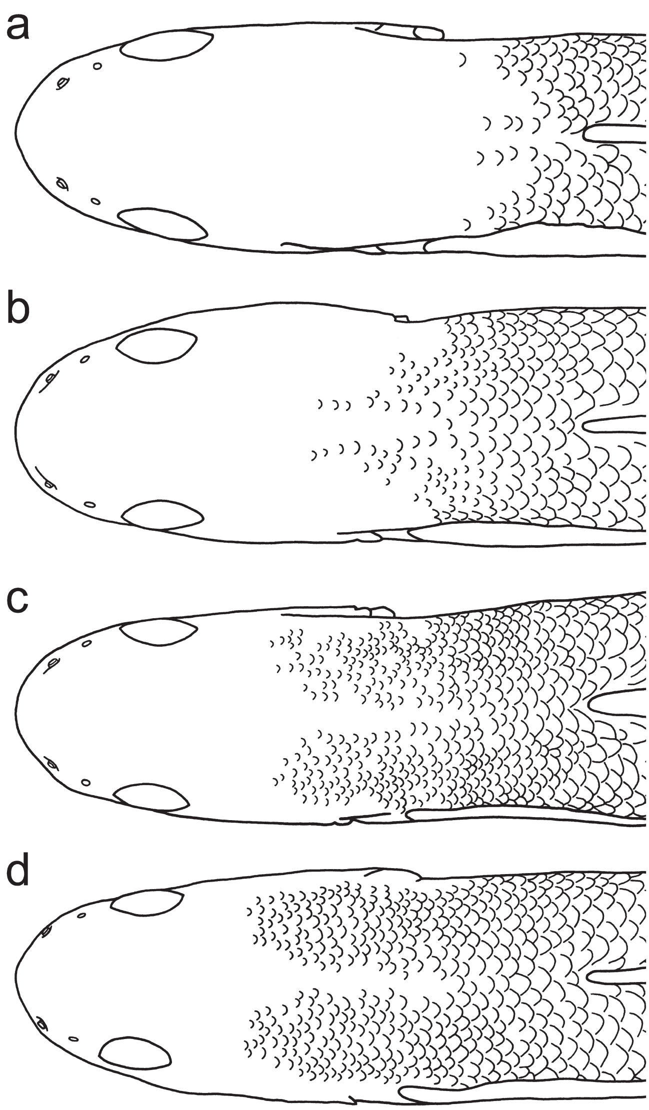


Fig. 4. Dorsal squamation on the head and nape in *Stiphodon multisquamus*. a, male, 38.5 mm SL (URM-P 48216); b, male, 41.7 mm SL (URM-P 48199); c, female, 49.4 mm SL (URM-P 48206); d, female, 40.7 mm SL (URM-P 48200).

transverse bars laterally on trunk and tail. Dorsum dusky with two or three conspicuous cream coloured transverse bars on occipital region and nape. First dorsal-fin membranes almost transparent, but dusky along black spines. Second dorsal fin bordered by narrow transparent margin; two to four black spots often along each spine and soft ray. Anal fin transparent with black line running near transparent margin. Blackish longitudinal band on caudal peduncle extending to proximal part of caudal fin; caudal fin transparent with black spots forming four to seven transverse bars on dorsal and middle parts. Pectoral-fin membranes translucent; rays with fine black spots, number of spots on longest rays (seventh and/or eighth ray) four to 11. Pelvic fin translucent, but middle parts of rays, membranes, and frenum often blackish forming a blackish ring in ventral view.

**Colour in life.** Colour of live males (Fig. 5a–c) variable. Body and fin markings similar to those of preserved specimens, but background yellowish grey to purplish; lateral sides of head yellowish grey to grey, often bluish. Distal part of first and second dorsal fins orange; second dorsal and anal fins with narrow bluish-white edge. Distal part of caudal fin orange or yellowish with narrow bluish-white posterior edge. Pectoral-fin rays with white spots between black spots. Margin of pelvic fin white.

Background of body and head of female (Fig. 5d) cream to light brown; body and fin markings similar to those of preserved specimens; tips of first and second dorsal fins with reddish markings.

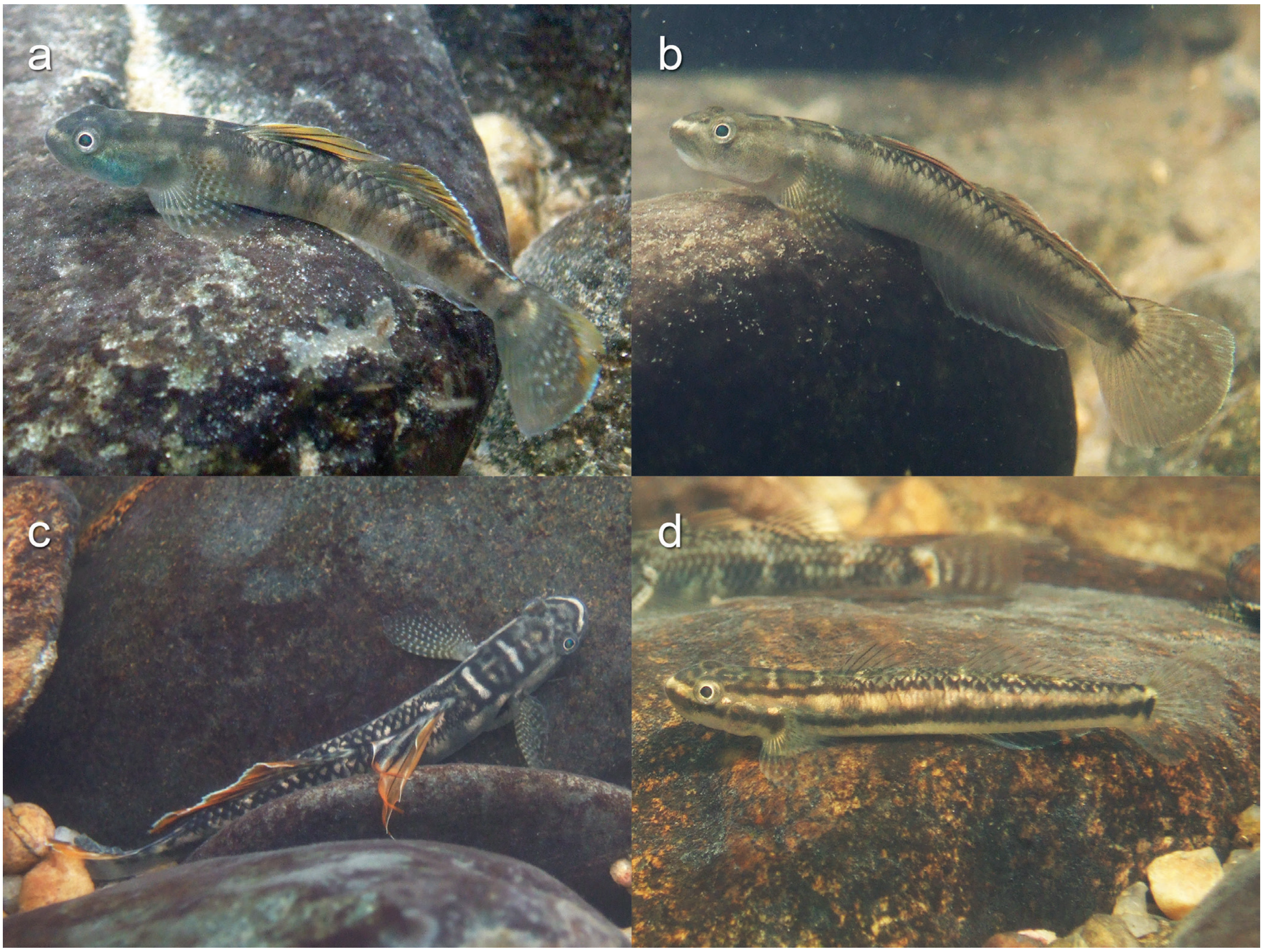

Fig. 5. Live *Stiphodon multisquamus* observed in Da Nang, Vietnam on 12 January 2013 (photo by K. Maeda). a, b, lateral view of male; c, dorsal view of male; d, lateral view of female.

**Habitat in Vietnam.** A population of *S. multisquamus* was found in Da Nang Province, central Vietnam, where the mountains are relatively close to the coast. This species was very abundant at all three sites, along two tributaries of the Han River at the foot of Ba Na Mountain (1,487 m a.s.l.). Collection sites were located from the middle to upper reaches of the tributaries (34–44 km from the mouth of the Han River), and altitudes were 20–210 m a.s.l. *Stiphodon multisquamus* was the only sicydiine species found there. Thirty-three other species of fishes were found syntopically with *S. multisquamus* at these three sites. While *S. multisquamus* and some other gobioid species are considered amphidromous, all others are freshwater fishes without a marine larval phase (Table 2).

**Remarks.** Although the holotype of *S. multisquamus* has been lost (Wu, 2008), and we have not examined specimens from the type locality (Hainan Island), females of the Vietnamese specimens examined in the present study match the original description of *S. e. multisquamus* in Wu & Ni (1986) in all respects, except for the number of scales in a longitudinal series (31–38 in Vietnamese specimens vs. 48 in Wu & Ni, 1986). This difference in scale counts could easily be caused by a difference in counting methods, as discussed in Maeda & Saeki (2013). In fact, Wu (2008) reported 34–35 scales in longitudinal series of two non-type specimens from Hainan. The morphology of the Vietnamese specimens also closely matches the description of four Okinawan specimens (Maeda & Saeki, 2013) and we are confident that they belong to *S. multisquamus*, which could be distinguished clearly from all congeners sharing the second dorsal- and pectoral-fin ray counts (one spine and nine soft rays in the second dorsal fin, and usually 15 or 16 soft rays in the pectoral fin) as follows: from *S. atropurpureus*, *S. carisa* Watson, 2008, *S. kalfatak* Keith, Marquet &Watson, 2007, *S. larson* Watson, 1996, and *S. semoni* Weber, 1895 by having fine black spots on the pectoral-fin rays (vs. without such spots), pointed, triangular-shaped first dorsal fin in male (vs. semicircular fin, except for *S. carisa* males with triangular-fin), and a lack of any special structure behind the pectoral-fin base of male (vs. with a white attachment in males); from *S. alcedo* Maeda, Mukai & Tachihara, 2012a, *S. atratus* Watson, 1996, *S. imperiorientis* Watson & Chen, 1998, *S. martenstyni* Watson, 1998, *S. niraikanaiensis* Maeda, 2013, *S. ornatus* Meinken, 1974, *S. pelewensis* Herre, 1936, *S. pulchellus* (Herre, 1927), and *S. weberi* Watson, Allen & Kottelat, 1998 by features of predorsal squamation [occipital region is often naked in male, and scales on the occipital region and anterior nape significantly smaller than the lateral scales on the trunk and tail, Fig. 4, vs. having larger scales and scaled

Table 2. List of fish species found syntopically with *Stiphodon multisquamus* in Da Nang, Vietnam (three sites along two tributaries of the Han River) in 2005 and 2013 and Okinawa Island, Japan (two sites along different streams on the eastern slope of the island) in 2011 and 2012 (Maeda, unpublished data).

| | Da Nang | Okinawa Island |
|---|---|---|
| **Anguilliformes** | | **Anguillidae**<br>*Anguilla marmorata* |
| **Cypriniformes** | **Cyprinidae**<br>*Barbodes semifasciolatus**<br>*Barbodes* sp.*<br>*Laubuka laubuca**<br>*Microphysogobio* sp.*<br>*Onychostoma* sp.*<br>*Opsariichthys* sp.*<br>*Osteochilus lini**<br>*Poropuntius* sp.*<br>*Rasbora paviana**<br>*Squalidus* sp.*<br>*Tor* sp.*<br>**Cobitidae**<br>*Cobitis laoensis**<br>*Misgurnus anguillicaudatus**<br>**Balitoridae**<br>*Balitora* sp.*<br>**Gastromyzotidae**<br>*Sewellia lineolate**<br>*S. marmorata**<br>**Nemacheilidae**<br>*Micronemacheilus cruciatus**<br>*Schistura carbonaria**<br>*Traccatichthys taeniatus** | **Cyprinidae**<br>*Carassius* sp.* (probably introduced) |
| **Siluriformes** | **Bagridae**<br>*Tachysurus spilotus**<br>**Siluridae**<br>*Pterocryptis cochinchinensis**<br>**Clariidae**<br>*Clarias macrocephalus** | |
| **Mugiliformes** | | **Mugilidae**<br>*Mugil cephalus* |
| **Gasterosteiformes** | | **Syngnathidae**<br>*Microphis leiaspis* |
| **Synbranchiformes** | **Mastacembelidae**<br>*Mastacembelus armatus** | |
| **Perciformes** | **Cichlidae**<br>*Tilapia zillii* (introduced)*<br>**Odontobutidae**<br>*Neodontobutis* sp.*<br>**Eleotridae**<br>*Eleotris melanosoma*<br>**Gobiidae**<br>*Papuligobius* sp.*[?]<br>*Rhinogobius giurinus*<br>*Rhinogobius* sp. 1*[?]<br>*Rhinogobius* sp. 2*[?]<br>*Rhinogobius* sp. 3*[?]<br>**Osphronemidae**<br>*Macropodus spechtii** | **Carangidae**<br>*Caranx sexfasciatus*<br>**Cichlidae**<br>*Oreochromis* sp.* (introduced)<br>**Kuhlidae**<br>*Kuhlia marginata*<br>*Kuhlia rupestris*<br>**Eleotridae**<br>*Eleotris acanthopoma*<br>*Eleotris fusca*<br>*Ophieleotris* sp.<br>**Gobiidae**<br>*Awaous melanocephalus*<br>*Lentipes armatus* |

| | Da Nang | Okinawa Island |
|---|---|---|
| **Perciformes** | **Channidae**<br>*Channa gachua** | *Rhinogobius brunneus*<br>*Rhinogobius giurinus*<br>*Rhinogobius nagoyae*<br>*Rhinogobius* sp. MO<br>*Sicyopterus japonicus*<br>*Sicyopterus lagocephalus*<br>*Sicyopus zosterophorus*<br>*Stenogobius* sp.<br>*Stiphodon alcedo*<br>*Stiphodon atropurpureus*<br>*Stiphodon imperiorientis*<br>*Stiphodon niraikanaiensis*<br>*Stiphodon percnopterygionus*<br>*Tridentiger kuroiwae* |

Species with an asterisk are regarded as freshwater fishes without a marine larval phase. Migratory patterns of species with an asterisk and a question mark are unknown.

area extends anteriorly to middle of the occipital region, as Fig. 2 in Maeda & Tan (2013) and Fig. 2 in Maeda (2013)], and higher teeth counts (Fig. 2; but *S. martenstyni* and *S. niraikanaiensis* also have higher counts); from *S. martenstyni* also by having fine black spots on the pectoral-fin rays (vs. without such spots); from *S. niraikanaiensis* also by lack of black longitudinal band on the second dorsal fin in male (vs. having a broad black band running along the distal margin of the second dorsal fin in male), and having a black line running along the transparent margin of the anal fin in female (vs. no clear markings in female). *Stiphodon multisquamus* has two or three conspicuous light-coloured transverse bars on the occipital region and nape, which is a useful character to distinguish it from *S. maculidorsalis* Maeda & Tan, 2013 (having black spots scattering dorsally on the head and trunk), as well as from all other congeners.

Most species of the genus *Stiphodon* had once been called *S. elegans*, before Watson (1995a) re-described *S. elegans* and showed that it is a species actually restricted to Society, Tubuai, and the Samoa Islands in the South Pacific (Kottelat, 2013). When Wu & Ni (1986) described *S. multisquamus* as a new subspecies of *S. elegans*, they actually compared the holotype with "*Stiphodon elegans elegans* (Steindachner) recorded from Java (Wu & Ni, 1986: 303)". It does not represent true *S. elegans*, from which *S. multisquamus* is distinguished by a higher pectoral-fin ray count (usually 15–16 vs. 14), a greater number of teeth (Fig. 2), and features of predorsal squamation (vs. the nape and posterior half of the occipital region covered by larger scales), as well as by their unique colouration (e.g., *S. elegans* has clear black and white spots alternately arranged along the first and second dorsal fins in both sexes).

## DISCUSSION

*Stiphodon aureorostrum* was described by Chen & Tan (2005) based on five male and six female specimens from Pulau Tioman. According to Chen & Tan (2005), *S. aureorostrum* differs from *S. multisquamus* in the following five characters: 1) larger body size; and more elongated first dorsal fin rays in males; 2) predorsal scales extending more anteriorly; 3) body more slender; 4) absence of any blue on the head and lateral side in male (vs. distinct blue background); and 5) narrower dark transverse bars in former male ["vs. iridescent blue" (sic, probably a misprint)]. However, these differences were represented after a comparison with only two non-type specimens of *S. multisquamus* (38.6 and 45.3 mm SL).

Accordingly, we inspected these five characters in the 44 Vietnamese *S. multisquamus* specimens, and compared them with the description of *S. aureorostrum* in Chen & Tan (2005). 1) SL of the largest specimen from Vietnam (64.0 mm) is almost the same as the largest specimen of *S. aureorostrum* (60.3 mm) in Chen & Tan (2005). The first dorsal-fin length is also not different between them [distal tip of the first dorsal fin of male extending to base of second to fifth soft ray of the second dorsal fin in Vietnamese specimens vs. second to fourth soft ray in *S. aureorostrum* in Chen & Tan (2005)]; 2) Predorsal squamation of Vietnamese specimens exhibits a wide variation (Fig. 4), and covers that described in Chen & Tan (2005) for *S. aureorostrum*; 3) The range of body depth of the Vietnamese specimens exceeds that of *S. aureorostrum* in Chen & Tan (2005) (body depth at pelvic-fin origin, 12.3–16.1 vs. 12.5–15.3% of SL; body depth at anal-fin origin, 13.2–17.1 vs. 14.2–17.5% of SL); 4) Colour of head of Vietnamese male is variable from blue to gold (Fig. 5); 5) The width of transverse bars in Vietnamese male specimens is variable (Fig. 1a, b). Although we also examined nine specimens from Pulau Tioman (including three paratypes of *S. aureorostrum*) (Fig. 6), their morphologies were not different from the Vietnamese specimens. Moreover, we found blue-headed males of *Stiphodon* in Pulau Tioman (Fig. 7). Thus, all five differences between *S. aureorostrum* and *S. multisquamus* mentioned in Chen & Tan (2005) are nothing more than intraspecific variation. No other differences were found in their morphologies. Therefore, we conclude that *S. aureorostrum* Chen & Tan, 2005 is a junior synonym of *S. multisquamus* Wu & Ni, 1986. *Stiphodon multisquamus* is the largest species of *Stiphodon* (up to 64.0 mm SL) known to date and it is distributed on Hainan Island (Wu & Ni, 1986), Guangdong in mainland China (Nip, 2010),


Fig. 6. *Stiphodon multisquamus* collected from Pulau Tioman, Malaysia, after preservation. a, male, 44.6 mm SL (ZRC 54194); b, female, 44.0 mm SL (ZRC 54194).

Fig. 7. A blue-headed male of *Stiphodon multisquamus* observed in the Sungai Keliling, Pulau Tioman, Malaysia, type locality of *Stiphodon aureorostrum*, 12 July 2013 (photo by H. H. Tan).

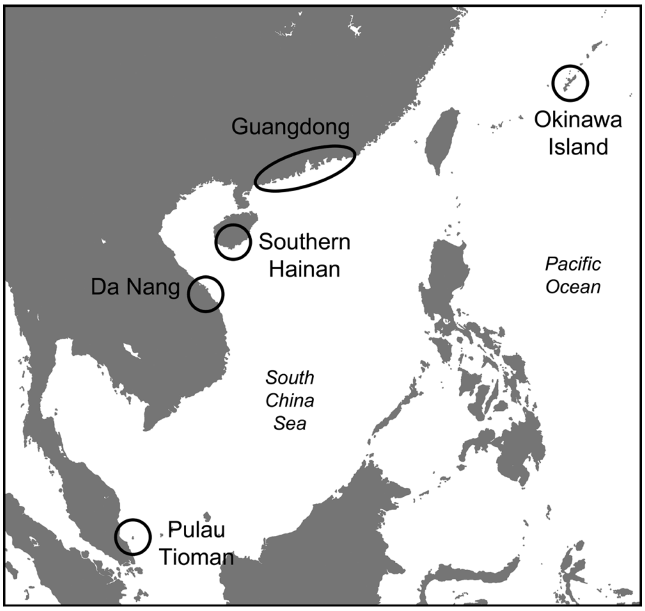


Fig. 8. Map of South China Sea showing localities where *Stiphodon multisquamus* has been recorded.

Okinawa Island in southern Japan (Maeda & Saeki, 2013), central Vietnam (present study), and Pulau Tioman (Chen & Tan, 2005) (Fig. 8).

*Stiphodon atropurpureus*, another species of *Stiphodon* known from the western South China Sea is also recorded from Pulau Tioman (Ng et al., 1999). The main habitat of *S. atropurpureus* is the Philippines (islands of Luzon, Leyte, Cebu, and Mindanao), and it is also distributed in Taiwan, southern Japan, and Guangdong (Watson & Kottelat, 1995; Watson & Chen, 1998; Nip, 2010; Maeda et al., 2012b). This species is strikingly similar to *S. semoni*, known from northeastern Australia, the Solomon Islands, Papua New Guinea, and Indonesia (islands of Yapen, New Guinea, Ambon, Ceram, Halmahera, Sulawesi, Flores, Bali, and Sumatra) (Maeda & Tan, 2013). Currently the known ranges of these two species do not overlap. More extensive biogeographical studies should further clarify this matter and enhance understanding of speciation and distribution dynamics of sicydiine gobies.

**Continental habitat of *Stiphodon*.** Usually sicydiine gobies are found in insular streams and are considered to have amphidromous life cycles (Watanabe et al., 2014). Adults spawn in freshwater streams. Newly hatched larvae migrate downstream to the sea where they develop as pelagic larvae, and then the larvae migrate to freshwater streams, where they grow further and reproduce. Unlike other amphidromous taxa, such as *Rhinogobius* or *Plecoglossus* (see Taniguchi & Ikeda, 2009; Kondo et al., 2013), no sicydiines are known to have land-locked populations. It has been demonstrated that *Sicyopterus japonicus* larvae cannot survive and develop in fresh water (Iida et al., 2010). Thus, migration is considered to be obligate for sicydiine gobies. Newly hatched sicydiine larvae are very small and undeveloped. Usually the mouth opens three to five days after hatching, and the yolk is exhausted four days after hatching (Manacop, 1953; Lindstrom & Brown, 1994; Bell & Brown, 1995; Yamasaki & Tachihara, 2006; Valade et al., 2009; Yamasaki et al., 2012). McDowall (2009) discussed the risk of starvation during the downstream migration of amphidromous gobies, and suggested that it partially explains why sicydiine gobies are so prevalent in short and often swiftly flowing streams on small islands, where downstream transport to the sea is likely rapid. However, suitable habitat may exist not only on islands, but also on continents, if suitable streams are available in mountainous areas near the sea.

*Sicydium* species are widely distributed in Mexico, Central America, and northern South America and their distributions are clearly related to the presence of coastal mountain ranges (Lyons, 2005). But there are few reports of sicydiine gobies from the other continents. For example, four species of *Stiphodon*, *Sicyopterus lagocephalus*, *Sicyopus discordipinnis*, and *Smilosicyopus* sp. have been found in Australia, but each has been recorded only occasionally, and only then in the restricted Wet Tropics region in northeast Queensland (Ebner et al., 2012). In the eastern Atlantic Ocean, three *Sicydium* species and *Parasicydium bandama* have been found on islands in the Gulf of Guinea, as well as in continental regions along the coast of the Gulf of Guinea, including Côte d'Ivoire, Cameroon, and the Republic of Congo (Harrison, 1993; Pezold et al., 2006), but their complete distributions are not known. In the western Indian Ocean, there are no records of the sicydiine gobies from the east coast of the African Continent, although they are known from the Comoro and Mascarene Islands and from Madagascar (Watson, 1995b; Keith et al., 2005, 2011). *Sicyopterus* species are known from southern India and Myanmar (Day, 1874, 1877; Biju et al., 1998). The only other record from the Eurasian Continent is from Guangdong, southern China, where four species of *Stiphodon* and *Sicyopus zosterophorus* were recorded, but all of these species are rare (Nip, 2010).

In the Indo-Pacific, multiple species (usually multiple genera) of sicydiine gobies are found in the same streams, and diadromous *Awaous*, *Eleotris*, *Kuhlia*, *Microphis*, and *Anguilla* species commonly cohabit these streams (Maciolek & Ford, 1987; Keith et al., 1999; Buden et al., 2001; Kido, 2008; Maeda & Tachihara, 2006; Keith et al., 2013: Maeda, 2013). For example, on Okinawa Island *S. multisquamus* is found together with multiple diadromous species, including nine other species of sicydiine gobies (Table 2). In Australia, distributions of sicydiine species are restricted to streams in a small part of Queensland where multiple species of sicydiines usually share habitats (Ebner et al., 2012). The fish faunas in these streams are more similar to those of distant Pacific islands than to those of nearby continental river systems (Ebner & Thuesen, 2010; Thuesen et al., 2011). Thus, the population of *S. multisquamus* in the tributaries of a large river system in central Vietnam is unique in three regards: 1) this species is very abundant; 2) no other sicydiines co-occur; and 3) the remainder of the fish fauna is mainly composed of continental non-diadromous fishes, which are believed to inhabit adjacent regions as well (Table 2). These characteristics seem to be similar to those of *Sicyopterus japonicus* on Taiwan and the Japanese main islands (Kyushu, Shikoku, and Honshu). These continental islands have relatively large river systems occupied by cyprinids and loaches, where *S. japonicus* often forms large, single-species aggregations (Kawanabe & Mizuno, 1989; Lin, 2007; Iida, pers. com.). *Stiphodon multisquamus* and *S. japonicus* may have some behavioural and morphological traits to coexist with non-diadromous freshwater fishes and to migrate between large river systems and the sea. A larger body size is probably one such trait. Most sicydiine species that inhabit continents belong to the genera *Sicyopterus* and *Sicydium*, and generally have a larger body than species of *Stiphodon*. It is interesting that *S. multisquamus* is the largest among the genus *Stiphodon*. To discuss the ecological significance of those characteristics, their life history should be studied, and the distributional status of less known continental sicydiines should be examined.

While *S. multisquamus* is abundant in the newly discovered localities in central Vietnam, it is rare in other part of the range, including Hainan Island, Guangdong, Pulau Tioman, and Okinawa Island (Wu, 1991; Chen & Tan, 2005; Nip, 2010; Maeda & Saeki, 2013). It is possible that central Vietnam represents the main range of this species, and the Vietnamese population might often provide the larvae to the peripheral regions. The presence of *S. multisquamus* on Pulau Tioman is noteworthy. This island is isolated from central Vietnam as well as southern China, and some regions between them, such as the Mekong Delta, seem unsuitable for sicydiine gobies. Genetic studies will be required to understand connectivity between these populations.

**Comparative material.** ***Stiphodon alcedo*:** NSMT-P 103600, holotype, 30.8 mm SL, Okinawa Island, Japan, 10 November 2008; BLIH 20110001, paratype, 29.7 mm SL, Okinawa Island, 27 October 2006; BLIH 20110002, paratype, 33.2 mm SL, Okinawa Island, 13 December 2006; BLIH 20110003, paratype, 47.9 mm SL, Iriomote Island, Japan, 20 October 2009; BLIH 20110004, paratype, 40.3 mm SL, Iriomote Island, 5 July 2010; NSMT-P 103601–103603, 3 paratypes, 27.9–32.5 mm SL, same data as holotype; NSMT-P 103604, paratype, 33.5 mm SL, Okinawa Island, 5 November 2006; NSMT-P 103605, paratype, 30.1 mm SL, Okinawa Island, 13 December 2006; NSMT-P 103606, paratype, 45.6 mm SL, Iriomote Island, 20 October 2009; NSMT-P 103607, 103608, 2 paratypes, 36.2 and 42.1 mm SL, Okinawa Island, 29 November 2009; NSMT-P 103609, paratype, 39.7 mm SL, Iriomote Island, 5 July 2010; URM-P 46066, paratype, 30.1 mm SL, Okinawa Island, 27 October 2006; URM-P 46067, paratype, 34.2 mm SL, Okinawa Island, 13 December 2006; URM-P 46068, 46069, 2 paratypes, 29.4 and 29.6 mm SL, Okinawa Island, 24 November 2008; URM-P 46070, 46071, 2 paratypes, 34.4 and 37.2 mm SL, Okinawa Island, 27 September 2009; URM-P 46072, paratype, 38.8 mm SL, Okinawa Island, 7 November 2009; URM-P 46073, paratype, 35.4 mm SL, Iriomote Island, 9 November 2009; URM-P

46074, paratype, 31.7 mm SL, Iriomote Island, 10 November 2009; URM-P 46075–46078, 4 paratypes, 26.0–44.9 mm SL, Okinawa Island, 3 September 2010; OMNH-P 15609, 51.9 mm SL, Iriomote Island, 13 August 1999. ***Stiphodon atratus*:** SMF 27242, holotype, 37.0 mm SL, Waigeo Island, Indonesia, April 1990; WAM P.27862-006, 2 paratypes, 26.6 and 31.7 mm SL, Papua, Indonesia, 15 November 1982. ***Stiphodon atropurpureus*:** ZRC 38392, neotype, 33.1 mm SL, Leyte, Philippines, 29 June 1993; URM-P 46058, 46059, 2 specimens, 33.6 and 42.2 mm SL, Okinawa Island, Japan, 13 December 2006; URM-P 45067–45070, 45075–45080, 10 specimens, 21.8–37.9 mm SL, Cebu, Philippines, 28 August 2007; URM-P 46060–46063, 4 specimens, 24.3–36.0 mm SL, Okinawa Island, 10 November 2008; URM-P 46064, 46065, 2 specimens, 30.2 and 36.0 mm SL, Okinawa Island, 29 November 2009; ZRC 46555, 47.0 mm SL, Pulau Tioman, Malaysia, 18 July 2001. ***Stiphodon carisa*:** MNHN 2006-1604, 2006-1605, 2006-1606, 2006-1607, 4 paratypes, 26.9–35.2 mm SL, Sumatra, Indonesia, 25 October 2005. ***Stiphodon elegans*:** URM-P 45016–45018, 45020–45027, 11 specimens, 27.2–40.2 mm SL, Moorea, French Polynesia, 7 December 2006. ***Stiphodon imperiorientis*:** NSMT-P 48063, holotype, 48.5 mm SL, Iriomote Island, 2 September 1986; BLIH 19810202, paratype, 43.0 mm SL, Iriomote Island, 10 July 1981; BLIH 19860400, paratype, 44.1 mm SL, same data as holotype; BLIH 19950002, 19950028, 2 paratypes, 37.9 and 43.5 mm SL, Iriomote Island, 4 November 1995; URM-P 3205, 3206, 2 paratypes, 41.8 and 47.5 mm SL, Iriomote Island, 4 June 1982; URM-P 4823–4825, 3 paratypes, 50.9–52.0 mm SL, Iriomote Island, 13 September 1982; OMNH-P 34657, 32.0 mm SL, Okinawa Island, 29 July 2008; OMNH-P 34937, 29.3 mm SL, Okinawa Island, 15 November 2008; OMNH-P 35471, 48.2 mm SL, Iriomote Island, 28 July 1997; OMNH-P 35472, 39.5 mm SL, Iriomote Island, 8 August 2000; URM-P 32169–32171, 3 specimens, 45.2–49.7 mm SL, Iriomote Island, 29–30 July 1994; URM-P 36457, 39.4 mm SL, Iriomote Island, 20 August 1996; URM-P 46079, 30.6 mm SL, Okinawa Island, 27 October 2006; URM-P 46957, 46958, 2 specimens, 30.8 and 31.2 mm SL, Okinawa Island, 23 December 2011; URM-P 46959–469662, 4 specimens, 40.4–47.1 mm SL, Iriomote Island, 16 August 2012. ***Stiphodon kalfatak*:** MNHN 2006-0805, holotype, 21.2 mm SL, Santo, Vanuatu, 22 July 2003; MNHN 2006-0806, 7 paratypes, 19.8–23.8 mm SL, same data as holotype. ***Stiphodon larson*:** WAM P.29602-013, 20 of 50 paratypes, 24.2–29.6 mm SL, Papua New Guinea, 10 October 1987. ***Stiphodon maculidorsalis*:** MZB 17213, holotype , 43.7 mm SL, Sumatra, Indonesia, September 2004; ZRC 51445, 4 paratypes, 25.4–32.5 mm SL, Sumatra, 18 March 2008; ZRC 51822, 4 paratypes, 37.2–47.0 mm SL, same data as holotype; ZRC 51836, 3 paratypes, 49.8–54.8 mm SL, Sumatra, 22 January 2009. ***Stiphodon martenstyni*:** SMF 27049, holotype, 34.5 mm SL, Sabaragamuwa Province, Sri Lanka, January 1981. ***Stiphodon niraikanaiensis*:** NSMT-P 114244, holotype, 27.1 mm SL, Okinawa Island, Japan, 14 November 2012; NSMT-P 114245, Paratype, 30.0 mm SL, Okinawa Island, 25 November 2012; URM-P 46084, paratype, 36.0 mm SL, Okinawa Island, 7 June 2013; URM-P 48227, 36.6 mm SL, Okinawa Island, 12 December 2013. ***Stiphodon ornatus*:** SMF 12493, 2 syntypes, 37.8 and 39.5 mm SL, Sumatra, Indonesia, 1973; SMF 12494, 4 specimens, 25.0–42.9 mm SL, Sumatra, 1973; SMF 17932, 30.6 mm SL, Sumatra, November 1971; ZRC 46620, 11 specimens, 44.9–51.8 mm SL, Sumatra, September 2001; ZRC 51821, 7 specimens, 38.8–52.5 mm SL, Sumatra, September 2004; ZRC 54113, 4 specimens, 34.9–38.8 mm SL, Sumatra, 21 July 1997. ***Stiphodon pelewensis*:** OMNH-P 34791, 34792, 35269, 35270, 4 specimens, 30.4–37.3 mm SL, Babelthuap Island, Palau, 17 August 2008. ***Stiphodon pulchellus*:** CAS-SU 26360, neotype, 50.5 mm SL; Negros, Philippines, 15 June 1931; CAS-SU 26359, 9 specimens, 45.5–59.9 mm SL, Culion, Philippines; 19 April 1931; CAS-SU 26362, 55.2 mm SL, Culion, 28 April 1931; CAS-SU 38618, 3 specimens, 37.7–50.6 mm SL, Busuanga, Philippines, 21 June 1940; CAS-SU 38622, 48.0 mm SL, Busuanga, 24 June 1940; CAS-SU 69760, 69898, 3 specimens, 34.6–57.5 mm SL, same data as neotype; CMK 9986, 6 specimens, 23.2–45.3 mm SL, Leyte, Philippines, 9 July 1993; NSMT-P 45093, 51.2 mm SL, Palawan, Philippines; 13 November 1988; ZRC 38396, 38397, 4 specimens, 24.7–53.5 mm SL, Leyte, 6 July 1993. ***Stiphodon semoni*:** ZMA 110.972, lectotype, 29.0 mm SL, Ambon, Indonesia, 1893; ZMA 121.252, 3 paralectotypes, 27.0–28.6 mm SL, same data as lectotype; ZMA 121.254, paralectotype, 30.1 mm SL, same data as lectotype; ZRC 54112, 12 specimens, 26.2–35.0 mm SL, Sumatra, 18 March 2008; ZRC 46979, 3 specimens, 23.5–23.8 mm SL, Sumatra, 4 Febuary 2002. ***Stiphodon weberi*:** ZMA 121.253, holotype, 35.8 mm SL, Ambon, Indonesia, 1893; WAM P.31038-002, 2 paratypes, 23.9 and 25.2 mm SL, Yapen, Indonesia, 10 July 1995.

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