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Notes on the Labrid Fish *Stethojulis maculata* from Japan

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When Randall and Kay (1974) prepared their key to the species of the Indo-Pacific labrid fish genus *Stethojulis* Günther, they had not examined any specimens of *S. maculata* Schmidt (1930). At that time the species was known only from the holotype, 131 mm in total length, from Amami-Ohshima, Ryukyu Islands. It was distinguished in the key by its barred color pattern, which is unknown for any other species of the genus, and low gill-raker count of 19. The sex of the holotype was not given by Schmidt, but the large size is suggestive of the terminal male form. Since all other species of *Stethojulis* are strongly dichromatic, the existence of a primary color form for *S. maculata* seemed probable. The principal objective of the present paper is to describe this color form.

For a week beginning May 17, 1975 the second author visited the Tatsuo Tanaka Memorial Biological Station (TMBS) on Miyake-jima, Izu Islands, at the invitation of the Director, Jack T. Moyer. One of the purposes of the visit was to collect *S. maculata* which had been sighted at the island by the first author, a resident of the station. Not until May 23 was a single large male observed in 4~5 m over a rocky bottom off Sabigahama on the island. It was speared by the second author, photographed (Fig. 1, top), and deposited in the Bernice P. Bishop Museum, Honolulu (BPBM 19015, 140 mm SL). A second smaller *Stethojulis* was seen in the immediate vicinity at the same time which the authors suspected was the primary phase of *S. maculata*. From the distended abdomen it seemed to be a ripe female. It was brownish on the back, finely flecked with pale, whitish ventrally with rows of small dark spots, and had a yellow horizontal streak from behind the upper lip to the end of the operculum and yellowish median fins. In spite of much effort, this fish was not collected. During subsequent months the first author collected this form (and other terminal males) at Miyake-jima and demonstrated without question that it is the primary phase of *S. maculata*.

Masuda et al. (1975, pl. on p. 107, fig. H) illustrated in color the terminal male of *S. maculata*. They reported on specimens from Tanabe Bay, Wakayama Prefecture, from Kerama Island, Okinawa, and the specimen mentioned above from Miyake-jima. They noted that the species was common at Kerama Island.

Araga kindly sent on loan two terminal male specimens he collected from a rocky reef near the Seto Marine Biological Laboratory of Kyoto University at Shirahama, Wakayama Prefecture (SMBL 72105, 104.5 mm SL; SMBL 72106, 113 mm SL) and a color slide of the smaller of these two fish. These were useful in the preparation of the description of the species, along with 15 specimens from Miyake-jima, 32.5 to 140 mm SL.

Description: Dorsal rays IX,11 (one of 17 specimens with 12); anal rays III,11 (one of 17 specimens with 12); pectoral rays 13 (including upper rudimentary ray); lateral-line scales 26 (plus one beyond hypural); gill rakers 19 to 23 (modally 21; the single count of 19 from Schmidt).

Body moderately elongate, the depth 3.1 to 3.7 in SL (body relatively deeper in larger individuals) and somewhat compressed, the width 1.7 to 2.2 in depth; head length 2.7 to 3.1 in SL (head relatively shorter in larger individuals); snout 2.7 to 3.1 in head; diameter of orbit 5 to 8 in head; least depth of caudal peduncle 2.5 to 2.8 in head; length of ninth dorsal spine 3.3 to 4.3 in head; length of longest dorsal soft ray 2.8 to 3.4 in head; base of dorsal fin 1.7 to 1.9 in SL; third anal spine 4.3 to 5.8 in head; longest anal soft ray 2.9 to 3.4 in head; anal fin base 3.1 to 3.6 in SL (dorsal and anal fins relatively shorter in larger individuals); caudal fin rounded, 1.5 to 1.7 in head; pectoral fins 1.6 to 2.0 in head, the base about 15° from the horizontal in large individuals; pelvic fins short, 2.4 to 2.8 in head.

Dentition and squamation typical of the genus.

Color of terminal males in alcohol: brown with five or six black bars on side of body, the upper ends broader and usually cojoined in region of lateral line (first bar above pectoral base and partially obscured by pectoral fin, the last beneath about middle of soft portion of dorsal fin); a white spot as large or larger than

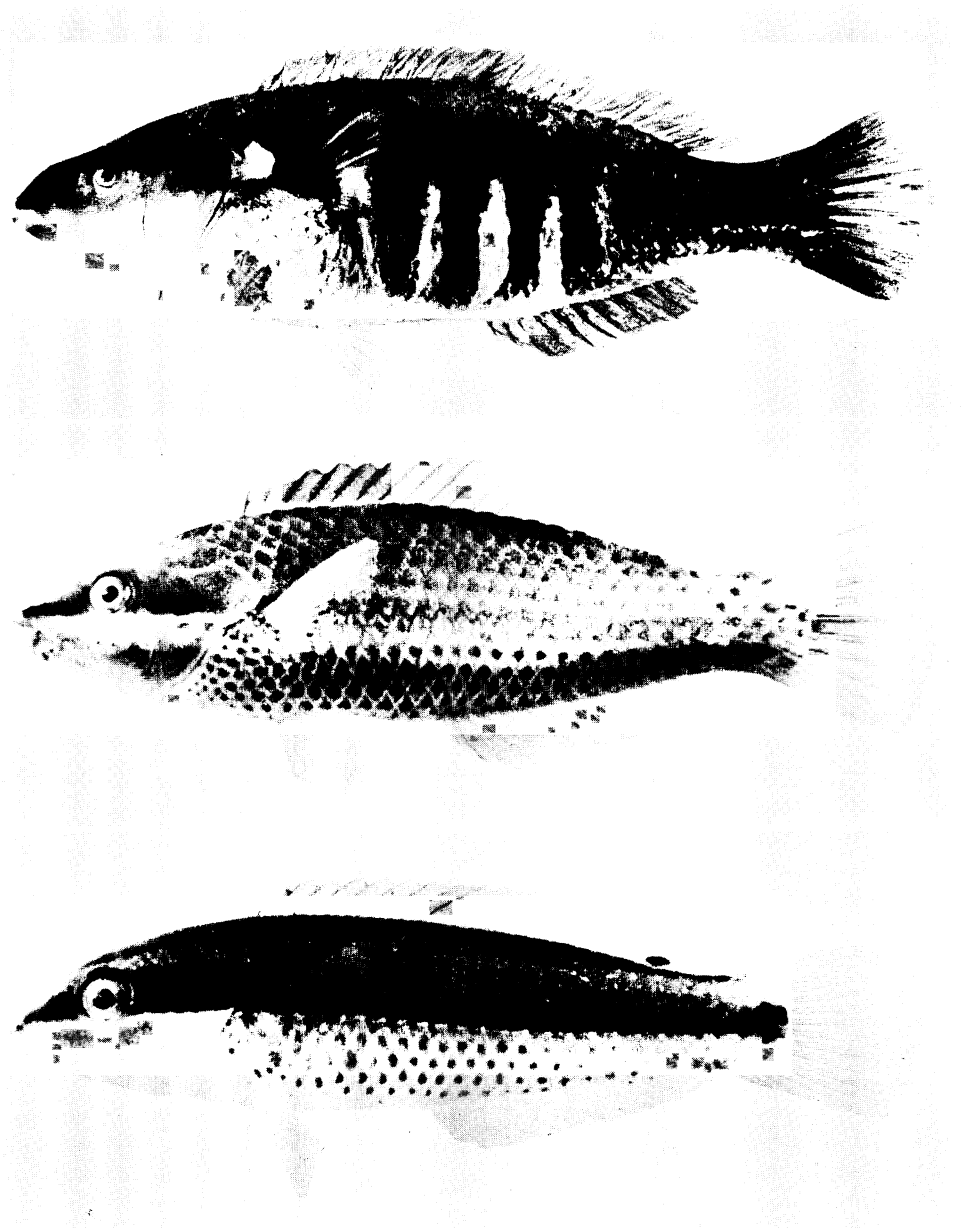

Fig. 1. *Stethojulis maculata* taken from Miyake-jima, Japan. From top: 140 mm SL, male, BPBM 19015, photo by J. Randall; 67 mm SL, primary-phase male, BPBM 19913, by J. Shepard; 32.5 mm SL, juvenile, BPBM 19911, by J. Shepard.

eye between upper end of gill opening and pectoral base (tip of opercular flap which overlaps spot also pale); median fins brown; paired fins pale.

Color of terminal males in life: olivaceous on back, pale greenish ventrally, with black bars on mid-side of body; a bright yellow spot posterior to upper end of gill opening; a horizontal solid or broken blue line (may alter to pink or magenta after death) from behind upper lip to upper pectoral base; a second blue line running anteriorly from upper part of eye (it

may continue as a broken line at same level behind eye); a diagonal blue line may be present above and behind eye; an indistinct irregular horizontal blue line posteriorly on lower third of body; a broken blue line or series of blue dots along base of dorsal fin; scales may be edged with blue in pale interspaces between dark bars on side of body; median fins greenish, the anal lighter than dorsal or caudal; paired fins whitish.

Color of primary phase (Fig. 1, center) in alcohol: brown on about upper half of body, whitish ventrally, with rows of small dark spots (each at base of a scale); fins pale (though dorsal may be gray with fine pale spotting).

Color of primary phase in life: grayish brown on back, very finely dotted with bluish white, these dots tending to form lines, the most conspicuous of which are mid-laterally on body; ventral part of body light lavender-grey, the edges of the scales narrowly white, with a blackish spot on each scale (may be faint over abdomen); head above lower edge of eye brown, finely dotted with bluish white, the lower part light lavender-grey with a pinkish cast; a narrow horizontal band of yellow running from corner of mouth where it is broadest to upper pectoral base; a small red area between gill opening and upper pectoral base; edges of lips white, shading to rosy near corner of mouth; median fins dull yellow (anal and soft portion of dorsal most conspicuously so), the dorsal and caudal base finely flecked with bluish white; paired fins pale.

Juveniles (Fig. 1, bottom) are similar to the primary phase but have a mid-lateral blackish stripe which ends in a black spot on the caudal base. A 32.5 mm specimen (BPBM 19911) has a black spot at the rear base of the dorsal fin; this is not present on a 36.5 mm juvenile (TMBS 750708).

Ecology: *S. maculata* is most often found in areas of large algae-covered boulders exposed to moderate surge. Our adult specimens have been taken in the depth range of 3～12 m. Two juveniles (32.5 and 36.5 mm SL) were collected in a large sand-bottomed tide pool at a depth of 2 m.

Terminal phase *S. maculata* were usually found alone or in the company of a single

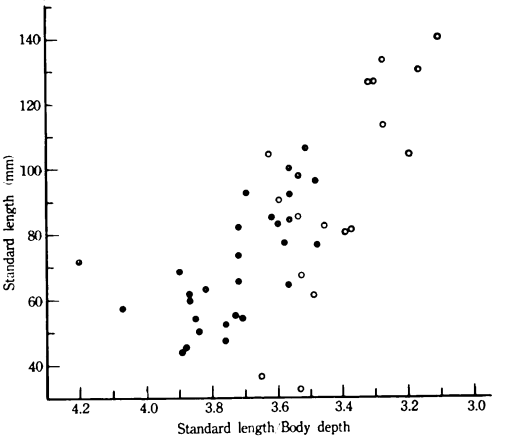

Fig. 2. Comparison of relative body depths of *Stethojulis maculata* (circles, n=17) and *S. interrupta terina* (dots, n=29). Mean body depth for *i. terina* 3.73, for *maculata* 3.40.

primary-phase fish. Members of the species were not observed in groups of their own kind (*S. interrupta terina* Jordan and Snyder and *S. bandanensis* (Bleeker) are frequently encountered at Miyake-jima feeding and swimming in groups of moderate size). Single primary-phase individuals were often seen in association with small numbers of *S. interrupta terina* and young goatfish (*Parupeneus* spp.).

Members of this species of all sizes were observed to feed by picking at algae-covered rock surfaces in a manner common to other species of the genus. Probably they feed mainly on small mollusks, polychaetes, and crustaceans as noted by Randall and Kay (1974) for *S. balteata* (Quoy and Gaimard) in Hawaii.

In an aquarium this fish buries in sand at night, as is characteristic of most of the smaller Labridae. It was also noted to hide beneath the sand when frightened. This behavior was not observed when the fish were pursued in the sea. Like other *Stethojulis* this species cannot ordinarily be approached closely by a diver. It is a strong swimmer even when propelled solely by its pectoral fins and can easily keep ahead of a pursuing human.

Many of the labrid fishes which occur at Miyake-jima appear as juveniles only during the summer months, grow well into the fall, but do not survive the winter. The sea temperature at Miyake-jima can drop as low as 13°C in winter.

Fig. 3. *Stethojulis maculata*, TMBS 751127, 80.5 mm SL, photographed (from top to bottom) on first, sixth, and 14th days following initial treatment with testosterone.

S. maculata, however, is a year-around resident at the island.

S. maculata is endemic to Japan, occuring from central Honshu to Okinawa. It is the largest species of the genus.

Several lines of evidence have served to link the primary color form with the terminal male phase. The six specimens of the terminal phase we have examined, which measure 91 to 140 mm SL, are all males. We have observed no small individuals in this color form. The primary phase may be either male or female (most of our specimens are female). We could find no meristic or morphological differences (other than what might be size-related, such as a relatively small eye in larger individuals) between the

two forms. The primary phase described herein was the only *Stethojulis* seen in close association with terminal *S. maculata*. We did not, however, witness any intensive courtship or spawning. Nor did we observe in nature any individuals changing from the primary to the terminal phase. The species is not common at Miyake-jima, thus limiting the opportunity for observations of the interaction of the two color forms and the chances of seeing an individual during that short period of its life span when it is changing its sex and color pattern. It was decided, therefore, to attempt to bring about this color change by injecting the primary phase with testosterone.

Hormone treatment: Three fish in the primary phase (TMBS 750830, 61 mm SL; TMBS 751127, 80.5 mm SL; TMBS 750720, 104 mm SL) were treated with "Enarmon", a commercial preparation of testosterone propionate suspended in sesame oil (25 mg/ml). The fish were injected intraperitoneally with .01 ml per gram of body weight. This treatment was repeated after eight days. The aquarium was maintained at 26°C. The smallest fish died within two hours of the initial injection, apparently as a result of the treatment. The remaining pair showed no adverse reaction during the course of the observation period.

After two days the dark spots on the ventral side of the body had begun to fade. By the fourth day the characteristic yellow band below the eye was turning blue and the blue line anterior to the eye had appeared. The basal half of the anal fin was clear with a blue tinge, and the barred pattern of the terminal color phase was faintly visible. On the fifth day, traces of the blue lines behind the eye and on the body could be seen. At the end of the first week these lines were completely developed. The median fins had entirely lost the yellow coloration, and the scattered pale dots on the dorsal portion of the head and body had largely disappeared. By the ninth day the yellowish orange spot above the pectoral base was fully developed, and the lower head and body had gained a light greenish blue cast. During the following three days the bars on the side continued to darken and lengthen, extending well onto the ventral half of the body by the thirteenth day. Fig. 3 dcpicts the color of TMBS 751127 during the first, sixth, and fourteenth days of the treatment.

At the end of two weeks the fish were noticeably weakened and emaciated as a result of their confinement, and were sacrificed. At this time, the basic pattern of the terminal color phase was complete, although not as pronounced as that exhibited by individuals in nature. In our fish the black bars were relatively light and ill-defined. The body and fins were dusky, only approaching the darkness of *S. maculata* which have undergone a natural transformation of color pattern.

Remarks: The primary phase of *S. maculata* and *S. interrupta terina* are similar in appearance. Both are brownish above, the paler lower side marked with series of dark spots following the scale rows. Each has a reddish area adjacent to the upper pectoral base. Of the two, *S. maculata* is unique, however, in displaying the yellow band below the eye, cross-hatched pattern on the lower side, and distinctly yellow soft dorsal and anal fins. As shown in Fig. 2, *S. maculata* is also deeper-bodied.

Kishimoto (1974) reported on the transformation of primary-phase individuals of *S. interrupta* (Bleeker) to the terminal color pattern, based on his observations of fish collected in southern Japan and kept in aquaria at the Marine Science Museum of Tokai University. He referred *S. terina* to the synonymy of *S. interrupta*, considering the *terina* form to be one stage in progressive color pattern changes displayed by *interrupta*. No reference was made, however, to the problem of geographical color differences. Randall and Kay (1974) distinguished *S. terina* from *S. interrupta* on the basis of color differences and slight but broadly overlapping differences in gill-raker counts. Additional material of *S. interrupta* collected by Randall in the Solomon Islands included specimens in the primary phase with the pale-edged dark longitudinal line beneath the pectoral fin that was thought to be restricted to the primary phase of *S. terina*. Smith (1949) illustrated a similar dark line on the primary form of *S. interrupta* from southern Africa (his *S. phekadopleura*, pl. 57, fig. 804, is *S. interrupta*). The broad blackish longitudinal band on the

Table 1. Comparison of gill-raker counts of *Stethojulis maculata* and two subspecies of *S. interrupta*.

	19	20	21	22	23	24
S. maculata	1	2	10	4	1	
S. interrupta interrupta		4	8	15	8	2
S. interrupta terina	2	6	15	15	4	

caudal peduncle just above the mid-lateral line of the terminal phase is still known only from the *terina* form. Additional gill-raker counts continue to show a separation of nearly one raker on the average (Table 1). We now think that *S. terina* might best be regarded as a subspecies of *S. interrupta*. More specimens are needed, however, particularly from such areas as the Philippines, to determine if the subspecific designation should be retained for these geographical variants.

Acknowledgments

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After the above was written, Shepard was informed by Drs. Arai (National Science Museum) and Ida (Kitasato University) of the occurrence of *S. maculata* in the Bonin (Ogasawara) Islands. Specimens have recently been taken by them at that locality. We are grateful to them for allowing us to include this noteworthy range extension.

日本産スミツキベラについて

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カミナリベラ属の日本固有種スミツキベラ，*Stethojulis maculata* Schmidt は，原記載以来 1974 年まで報告がなかった．著者らは主として三宅島産の標本をもとに，その形態を再記載し，これまで不明であった本種の幼魚および primary phase の色彩・斑紋を明らかにした．飼育魚に雄性ホルモンを与えた結果，斑紋変化の過程を追跡できた．また，幼形の斑紋が本種に似ている *S. terina* やカミナリベラ *S. interrupta* との関係を論じた．

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