

Stethojulis axillaris, a Junior Synonym of the Hawaiian Labrid Fish *Stethojulis balteata*, with a Key to the Species of the Genus¹

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IN THE RECENT LITERATURE two species of the labrid fish genus *Stethojulis* are recognized from the Hawaiian Islands, *S. axillaris* (Quoy & Gaimard) and *S. albovittata* (Bonnaterre) (Gosline and Brock 1960). Both have been recorded from many localities of the tropical Indo-Pacific (de Beaufort 1940).

Since the senior author published a paper in which he showed that *Stethojulis strigiventer* (Bennett) and *S. renardi* (Bleeker) are sexually dichromatic color phases of a single species (Randall 1955), a suspicion has arisen that other similar pairs remain to be elucidated within the genus, including the two nominal species from the Hawaiian Islands.

The principal objective of the present paper is to demonstrate that there is a single endemic Hawaiian species of *Stethojulis* for which the name *S. balteata* (Quoy & Gaimard) must be applied. *S. axillaris* is a junior synonym due to page priority of *balteata*. *S. albovittata* is a related Indian Ocean species.

In order to be certain that the Hawaiian form is distinct, it was necessary to study the other species of the genus. In the process five other sexually dichromatic pairs, for which two or more scientific names are presently applied, have been linked. The evidence for the pairing of these species, however, is less comprehensive than that presented below for the Hawaiian pair. At this time these will only be listed until more definitive studies can be made. The five additional pairs are as follows (valid name of each pair given first):

bandanensis (Bleeker) and *rubromacula* Scott
trilineata (Bloch & Schneider) and *pbekado-
pleura* (Bleeker)
interrupta (Bleeker) and *kalosoma* (Bleeker)

terina Jordan & Snyder and *trossula* Jordan & Snyder
albovittata (Bonnaterre) and *axillaris* (Quoy & Gaimard)

As would be expected, the primary color phase of the species of *Stethojulis* is drab compared to the terminal phase. Although data are limited, the latter phase seems to be only male, and no small individuals in this phase have been found. Thus it seems likely that sex reversal is taking place in this genus as in so many other labrid and scarid fishes. All species in this phase have colorful narrow bands on the head and on the body, which are bright blue in life (though Bleeker has illustrated these bands as red on *trilineata* and *interrupta* in volume 1 of his *Atlas Ichthyologique*). Judging from the data on a few species, the primary phase may be either male or female.

In the first pair of the above list, *bandanensis* is the primary phase. Most authors have used the name *axillaris* for this form. The terminal phase has often been labelled *casturi* (Bleeker); however, as pointed out by Schultz in Schultz and collaborators (1960), *casturi* is a junior synonym of *trilineata* (Bloch & Schneider). Schultz described the terminal male form as *S. linearis*, but he was unaware that Scott (1959) had named it *rubromacula* the previous year.

For the second and third pairs the terminal phase was described earliest. In the fourth the primary phase, *terina*, has page priority. The latter is closely related to *interrupta*. *S. albovittata* is the terminal phase of the fifth pair. The primary phase of this species has generally been called *axillaris*; however, as indicated above, this name is a synonym of *balteata*.

Three species, *balteata*, *bandanensis*, and *albovittata*, form an allopatric complex in which the primary phase is similar. This color form has one to four (usually two) small black spots mid-laterally on the caudal peduncle and caudal base.

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TABLE 1
PECTORAL-RAY AND GILL-RAKER COUNTS OF SPECIES OF *Stethojulis*

SPECIES	NUMBER OF PECTORAL RAYS				NUMBER OF GILL RAKERS											
	12	13	14	15	19	20	21	22	23	24	25	26	27	28	29	30
<i>balteata</i>			26	2								1	6	17	4	
<i>bandanensis</i>			25	2									2	8	11	6
<i>albovittata</i>			21	4							1	3	7	10	3	1
<i>strigiventer</i>				1	23						1	8	9	5	1	
<i>trilineata</i>	1	27									1	3	15	9		
<i>interrupta</i>	4	22				3	8	11	4							
<i>terina</i>		27			2	3	10	9	3							
<i>maculata</i>		1			1											

It is not surprising, therefore, that the name *axillaris* has often been used for this phase for all three species.

Stethojulis bandanensis is wide ranging in the tropical Pacific. It is known from the Indo-Malayan region and throughout Oceania except Hawaii and Easter Island. It is the only species of the genus to have crossed the Eastern Pacific Barrier (specimens from Clipperton and Cocos Islands kindly sent on loan from the University of California at Los Angeles by John E. Bleck). *S. albovittata* is confined to the Red Sea and Indian Ocean, though more material is needed to determine its range within the Indian Ocean. *S. balteata* is known only from the Hawaiian chain and nearby Johnston Island.

It appears that there are eight species of *Stethojulis*, as distinguished in the key below. Pectoral-ray and gill-raker counts were valuable in differentiating some of the species and in linking the sexually dichromatic pairs (Table 1). Pectoral-ray counts include the uppermost rudimentary ray. As it was sometimes difficult to decide which raker was at the angle of the first gill arch, only the total count of gill rakers was recorded. Rudiments are included in this count.

No material of *Stethojulis maculata* was examined. This species was described from a single specimen 131 mm in total length from Kominato, Amami-Oshima Island, Ryukyu Islands by Schmidt (1930).

KEY TO THE SPECIES OF *Stethojulis*

- 1a. Pectoral rays 14 or 15; primary phase with a small dark brown spot middorsally at front of snout 2
- 1b. Pectoral rays 13 (rarely 12); no dark brown spot middorsally at front of snout 5
- 2a. Pectoral rays 14 (rarely 15); gill rakers 25 to 30 (usually 27 to 29); body not slender, the depth 2.75 to 3.5 in standard length; primary phase without whitish stripes ventrally on body; primary phase with one to four (usually two) small dark brown spots midlaterally on caudal peduncle, the last at caudal base; terminal phase lacking a dark spot on caudal base and on opercular flap 3
- 2b. Pectoral rays 15 (rarely 14); gill rakers 24 to 28 (usually 25 to 27); body moderately elongate, the depth 3.3 to 3.85 in standard length; primary phase with five narrow whitish stripes on ventral half of body; primary and terminal phases with a very small dark spot on caudal fin at level of upper edge of last lateral-line scale; terminal phase with an oblong black spot, partially rimmed in pale blue, on upper part of opercular flap (Indo-Pacific, except Hawaii) *strigiventer*
- 3a. Primary phase with a bright yellow area above and adjacent to pectoral base; terminal phase with a broad orange stripe, edged in blue, passing from beneath pectoral fin to lower caudal base (Hawaiian Islands) *balteata*

- 3b. Primary phase with a bright red area above and adjacent to pectoral base; terminal phase without a broad orange stripe on side of body4
- 4a. Terminal phase with a red area above and adjacent to pectoral base; terminal phase with two parallel blue lines on side of body, one from gill opening along upper edge of red area to a vertical approximately at anus, and the other from pectoral axil to caudal fin (western Pacific, Oceania except Hawaii, and Clipperton and Cocos in eastern Pacific)*bandanensis*
- 4b. Terminal phase without a red area above pectoral base; terminal phase with two parallel blue lines, one from above pectoral base and one from lower pectoral axil, both passing to caudal base (Indian Ocean)*albovittata*
- 5a. Body moderately elongate, the depth 3.45 to 4.4 in standard length; gill rakers 19 to 23; color not as in 5b (except small dark spots ventrally on body of primary phase of *interrupta* and *terina*)6
- 5b. Body not elongate, the depth 2.7 to 3.2 in standard length; gill rakers 25 to 28; primary phase with pale dots on upper two-thirds of body (only dorsally on caudal peduncle), horizontal rows of dark spots on lower third, and a dark spot at midbase of caudal fin; side of body of terminal phase with three narrow pale stripes that are blue in life, the one from upper end of gill opening and the one skirting lower pectoral base passing to caudal fin, the middle stripe ending beneath pectoral fin (Indo-Malayan region and a few localities in Oceania)*trilineata*
- 6a. No large blackish spots on side of body; gill rakers 19 to 23 (usually 21 or 22)7
- 6b. A series of four large vertically elongate blackish spots on side of body from beneath pectoral fin to above first three anal rays; gill rakers 19 (Ryukyu Islands)*maculata*
- 7a. Primary phase without a pale-edged black line beneath pectoral fin; terminal phase without a broad blackish zone on side of caudal peduncle (Indo-Malayan region)*interrupta*
- 7b. Primary phase with a slightly diagonal pale-edged irregular black line beginning posterior to opercular flap, passing beneath pectoral fin, and disappearing on midside of body above origin of anal fin; terminal phase with a poorly defined broad blackish zone on side of caudal peduncle and basal part of caudal fin (Japan)*terina*

Stethojulis balteata

Diagnosis

Plate 1, Fig. 1

Dorsal rays IX, 11; anal rays III, 11; pectoral rays 14 (rarely 15); lateral-line scales 25 (plus two beyond hypural); gill rakers 26 to 29 (modally 28); body not slender, the depth 2.75 to 3.1 in standard length.

Julis balteatus Quoy & Gaimard, 1824. Voyage... l'Uranie...Zool., p. 267, p. 56, fig. 1 (type locality, Maui, Hawaiian Islands).

Julis axillaris Quoy & Gaimard, 1824. Voyage...l'Uranie...Zool., p. 272 (type locality, Hawaiian Islands).

Stethojulis axillaris Jordan & Evermann, 1905. Bull. U.S. Fish. Comm., vol. 23, p. 283 (fig. 121 is *S. bandanensis*, copied from Günther).

Stethojulis albovittata Jordan & Evermann, 1905. Bull. U.S. Fish. Comm. vol. 23, p. 284, pl. 26.

Hinalea axillaris Jordan & Jordan, 1922. Mem. Carnegie Mus., vol. 10, no. 1, p. 69.

Hinalea balteata Jordan & Jordan, 1922. Mem. Carnegie Mus., vol. 10, no. 1, p. 69.

Color in alcohol of primary phase brown, the dorsal half darker (finely dotted with pale blue in life), with one to three (usually two) small dark brown spots midlaterally on caudal peduncle, the most posterior spot at caudal base; a small dark brown spot middorsally at front of snout; a pale area (yellow in life) above pectoral base; lips pale; a faint diffuse pale (yellowish in life) band from corner of mouth to region adjacent to and below eye; fins brownish (the dorsal with tiny pale blue dots in life); pectoral base dark brown.

Terminal male phase dark brown on back,



FIG. 1. Juvenile of *Stethojulis balteata*, 20 mm standard length, Johnston Island, BPBM 12013.

lighter brown ventrally, the two areas separated by a broad pale band (orange in life), bordered with dark-edged whitish (blue in life) lines, which passes from axil of pectoral fin to lower caudal fin base; head with four narrow whitish (blue in life) bands, one from upper edge of eye across nape to origin of dorsal fin and thence along base of fin, the second from snout, through eye, along upper edge of operculum and extending onto first four scales of body just below lateral line, the third from snout, touching lower edge of eye, crossing opercular flap and joining blue upper margin of orange body stripe, and the fourth a curved segment on lower head from beneath corner of mouth arching across lower preopercle to margin of operculum, then dorsally along edge of gill opening to upper pectoral base; all fins pale (the dorsal and caudal light orange in life, the remaining fins whitish), the edge of dorsal and upper and lower edges of caudal fin dark; pectoral base pale (orange in life).

The 20-mm juvenile (Fig. 1) from Johnston Island was light yellowish brown in life, the head below lower edge of eye pale yellowish, above brownish orange with fine irregular blue lines; two black spots, one above the other, in

an orange zone at end of caudal peduncle; dorsal fin orange, the outer third of soft portion clear; anal fin yellow, the outer third clear; a black spot with a blue center, rimmed in yellow, posteriorly in dorsal and anal fins; a white spot at pectoral base; remaining fins pale.

The black spot posteriorly in the dorsal and anal fins persists to a size of about 50 to 55 mm standard length; however a 69-mm specimen still has a vestige of the dorsal fin spot.

Remarks

Jordan and Evermann (1905) employed the name *albovittata* for the terminal male phase of the Hawaiian *Stethojulis*, and most authors have done the same. *S. albovittata* was described by Bonnatere (1788) (after Koelreuter), but no type locality was given. Judging from the known range of this species, it must have been from a site in the Indian Ocean.

Jordan and Jordan (1922) pointed out that the type locality of *albovittata* could not have been Hawaii because no collections of fishes had been made there in Koelreuter's time (1770). They adopted Quoy's and Gaimard's name of *balteata* for the terminal phase of the species in

Hawaii and retained the name *axillaris* for the primary phase. Subsequent authors, however, have continued to use the name *albovittata* for the terminal form of the Hawaiian species.

Jordan and Jordan erected the genus *Hinalea* for the nominal species *balteata* and *axillaris*, but there is no justification for this. The subgenus *Rhytejulis* was established by Fowler and Bean (1928) for *albovittata*, *renardi*, and *trilineata*, but this is also untenable, particularly since primary and terminal phases of the same species are placed in different subgenera.

The holotype and one paratype of *Julis axillaris* (MNHN 9025) and the four syntypes of *Julis balteatus* (MNHN 8997) were examined at the Muséum National d'Histoire Naturelle in Paris. We select the largest of the syntypes, 93 mm standard length, as the lectotype.

Several lines of evidence have demonstrated beyond any question that *axillaris* and *balteata* are color phases of a single species. First, the counts of pectoral rays and gill rakers are the same for both forms. Second, we have not seen any small individuals of the terminal color phase. We have examined 49 specimens of this color form which range from 77 to 114 mm standard length (the largest was collected at Laysan in the Leeward Hawaiian Islands). We were able to determine the sex of 37 of these, and all are males. Both sexes may be found among the specimens of *axillaris*, which ranged to 96 mm standard length, but there seems to be a preponderance of females. We did not use histological techniques to determine the sex, only direct examination of gonads under dissecting microscope. For this reason the percentage of males and females was not ascertained (small ovaries are more readily identified than small testes; thus more of the smaller fish would be among those classified as females). We have observed the terminal males in courtship with *axillaris* females; however, actual spawning was not seen.

Our most convincing evidence for conspecificity of these two forms resulted from injecting testosterone into the *axillaris* phase and noting a progressive color change which approached the terminal *balteata* pattern. Four fish in the *axillaris* phase (1.08 to 5.74 g) were injected intraperitoneally with testosterone in sesame oil (1/100 cc/g body weight). Four

other fish (0.84 to 3.66 g) which served as controls were injected with the oil alone. After 1 day the fish injected with testosterone showed a noticeable color change beginning with a general darkening. After 2 days the dark spots on the caudal peduncle were either very light or absent, and the yellow spot above the pectoral fin was lost or nearly so. Within 3 to 4 days the *axillaris* pattern was gone and the characteristic blue lines of the *balteata* form were beginning to develop. The blue lines on the head were completely formed by the 6th or 7th day, and the two parallel blue lines on the body by the 8th or 9th day. The areas between these two lines is deep orange in the terminal phase of *balteata*. Our specimens never attained this color band—at best only slightly yellowish. Our experiment was repeated by Hiroshi Kato, then of the University of Hawaii, and some of his fish developed a distinctly yellow zone between the two blue lines. Evidently a single injection of testosterone is insufficient to cause a transformation of the *axillaris* phase to the definitive color form of *balteata* with the orange band. The fish in our experiment died of fungus infection; those that survived longest began to show a regression of the *balteata* color pattern (fading of blue lines, etc.).

Stethojulis balteata is one of the more common of Hawaiian reef fishes. It lives in relatively shallow water (our deepest locality was 22 meters), both in protected areas and on exposed outer reefs. It is especially abundant where there is considerable sand as well as coral and rock. Well-developed beds of algae are also to its liking. As pointed out by Gosline and Brock (1960), juveniles smaller than 60 mm SL are often light green, a color having obvious adaptive value in a habitat with much green algae, such as inshore beds of *Ulva*. Like most other wrasses, this species buries itself in sand at night.

The stomach contents of 11 adult specimens from Oahu 70 to 110 mm in standard length were examined. These fish had fed on a great variety of small invertebrates along with sand and detritus (Table 2). The small size of the prey animals was most striking. Unlike many of the Labridae, *Stethojulis* is not inclined to render the larger invertebrates into pieces. Also surprising was the complete absence of

TABLE 2

STOMACH CONTENT ANALYSES OF 11 SPECIMENS
OF *Stethojulis balteata*

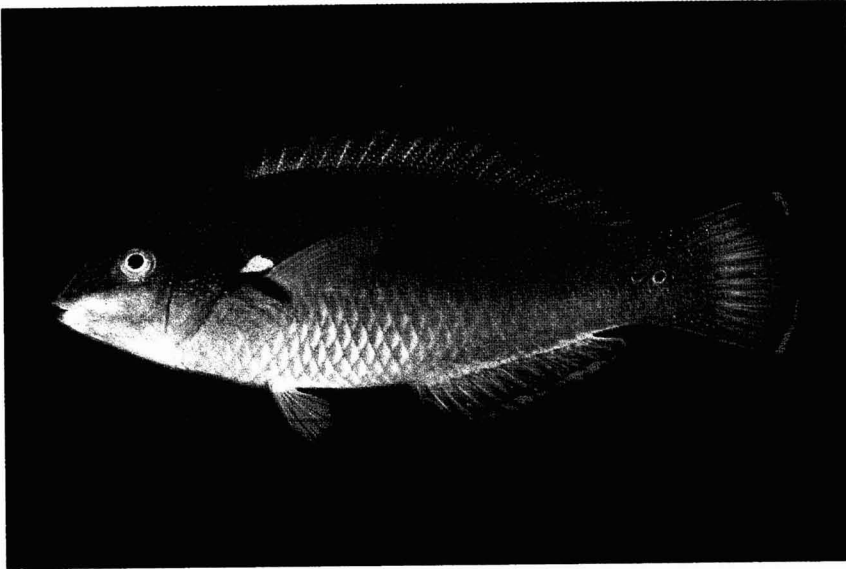
FOOD ORGANISMS	PERCENTAGE OF VOLUME OF STOMACH CONTENTS
Pelecypods	22.9
Polychaetes	19.2
Sipunculids	10.5
Gastropods	6.9
Ostracods	4.6
Amphipods	4.2
Crabs	2.9
Foraminifera	2.9
Shrimps	2.7
Copepods	2.4
Chitons	1.8
Unidentified Worms	1.5
Unidentified Crustaceans	1.3
Hermit Crabs	0.7
Isopods	0.4
Fish	0.4
Unidentified Animal Material, Sand, and Detritus	14.7

echinoderms. If more material were examined, however, one might expect at least some ophiuroids to be included among the food organisms.

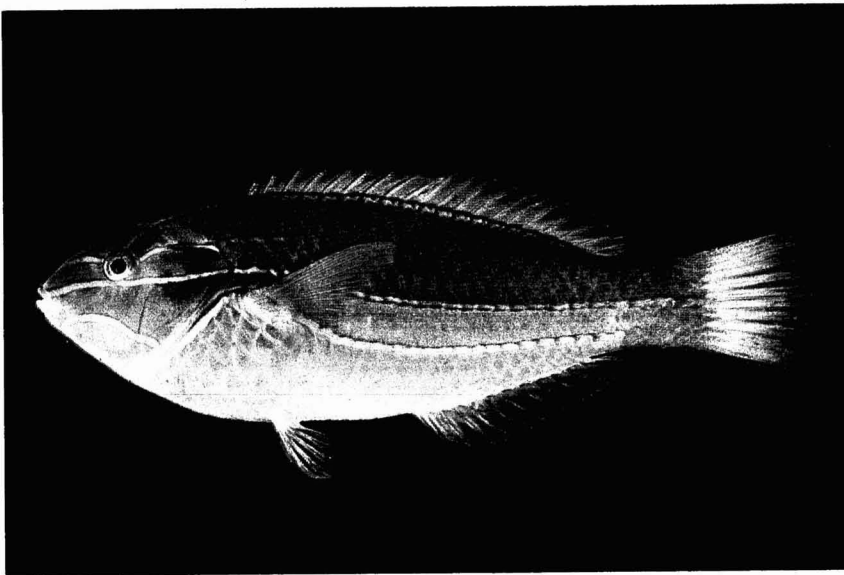
Two of the above fish, 80 and 83 mm standard length, were fully ripe females. The transparent ova were 0.5 mm in diameter. These fish were collected on 2 November 1971 (the time of full moon) off Waikiki in 8 meters.

LITERATURE CITED

- BEAUFORT, L. F. DE. 1940. The fishes of the Indo-Australian Archipelago. VIII. Percomorphi (continued) Cirrhitidae, Labri-formes, Pomacentriformes. E. J. Brill, Leiden. 508 pp.
- BONNATERRE, J. P. 1788. Tableau encyclopédique et méthodique des trois règnes de la nature. . . Ichthyologie. Paris. 215 pp.
- FOWLER, H. W., and B. A. BEAN. 1928. Contributions to the biology of the Philippine Archipelago and adjacent regions. Bull. U.S. Nat. Mus. 100, vol. 7. viii + 525 pp.
- GOSLINE, W. A., and V. E. BROCK. 1960. Handbook of Hawaiian fishes. University of Hawaii Press, Honolulu. 372 pp.
- JORDAN, D. S., and B. W. EVERMANN. 1905. The aquatic resources of the Hawaiian Islands. I. The shore fishes. Bull. U.S. Fish. Comm. for 1903, vol. 23. xxviii + 574 pp.
- JORDAN, D. S., and E. K. JORDAN. 1922. A list of the fishes of Hawaii, with notes and descriptions of new species. Mem. Carnegie Mus. 10(1): 1-92.
- RANDALL, J. E. 1955. *Stethojulis renardi*, the adult male of the labrid fish *Stethojulis strigiventer*. Copeia, no. 3: 237.
- SCHMIDT, P. J. 1930. Fishes of the Riu-Kiu Islands. Trans. Pacif. Comm. Leningr. 1: 19-156.
- SCOTT, T. D. 1959. Notes on Western Australian fishes, no. 1. Trans. roy. Soc. S. Aust. 82: 73-91.
- SCHULTZ, L. P., AND COLLABORATORS: W. M. CHAPMAN, E. A. LACHNER, AND L. P. WOODS. 1960. Fishes of the Marshall and Marianas Islands. Vol. 2. Families from Mullidae through Stromateidae. Bull. U.S. Nat. Mus. 202. ix + 438 pp.



Stethojulis balteata, "axillaris" phase, 80 mm standard length, Oahu, BPBM 7377.



Stethojulis balteata, terminal male phase, 99 mm standard length, Oahu, BPBM 7320.