

A Revision of the Surgeon Fish Genera *Zebrasoma* and *Paracanthurus*¹

JOHN E. RANDALL

THE SURGEON FISHES (Acanthuridae), like many of the families of tropical marine fishes, are in need of thorough taxonomic study on a world-wide basis. In the present paper, which is one of a series on the classification of the family (see Randall, 1955), the species of two of the genera, *Zebrasoma* and *Paracanthurus*, are considered. The question of whether *Zebrasoma flavescens* (Bennett) is or is not a dichromatic species is discussed in detail. Specimens of the three rare species of *Zebrasoma*, *Z. gemmatum* (Cuvier and Valenciennes), *Z. xanthurum* (Blyth), and *Z. rostratum* (Günther) were examined, and the validity of these species is confirmed. The postlarval *Zebrasoma* and early juvenile *Paracanthurus* are figured for the first time.

An attempt is made to give complete synonymies. Mere listings or records of species with insufficient data to permit identification are generally not included among the synonyms. When first citations are given without a locality, this information was not supplied by the author(s). A locality is listed with later citations of a species only when it appears that the author examined specimens from this locality. In the synonymies misidentifications are indicated by a period after the scientific name.

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In making dorsal and anal fin ray counts, the last two rays are counted as one only when they share the same basal element. All rudiments are included in the gill raker counts. In addition to the usual counts of gill rakers (herein designated anterior gill rakers), counts of the more ridge-like rakers along the inner surface of the first gill arch (posterior gill rakers) are given.

Most of the work on this paper was done at the United States National Museum, and the author is indebted to Leonard P. Schultz, Ernest A. Lachner, and Robert H. Kanazawa for their kind assistance. All of the *Zebrasoma* and *Paracanthurus* in the collections of the Academy of Natural Sciences of Philadelphia, Museum of Comparative Zoology at Harvard College, California Academy of Sciences, Stanford Natural History Museum, Bernice P. Bishop Museum, and University of Hawaii were examined.

ZEBRASOMA Swainson

Zebrasoma Swainson (1839: 256). (Type species by monotypy, *Acanthurus velifer* Bloch.)

Body compressed, ovate, depth contained 1.4 to 2.1 times in standard length (this and other proportional measurements based on specimens over 50 mm. in standard length); head length 2.9 to 3.7 in standard length; snout produced; caudal peduncle with a single folding spine on each side, fitting into a shallow depression; length of caudal spine 3 to 6 in head length; least depth of caudal

peduncle 2.7 to 3.6 in head length; mouth small, terminal; jaws equal; teeth close-set, compressed, denticulate, 10 to 20 in upper jaw, 12 to 22 in lower jaw; dorsal and anal fins elevated; dorsal fin with IV to V slender spines and 23 to 33 rays; anal fin with III spines and 19 to 26 rays; pectoral fin 2.7 to 3.3 in standard length; pectoral fin rays 14 to 17, the uppermost a short bony spicule, the next long and unbranched; pelvic fin with I spine and 5 rays, its length contained 3.5 to 4.5 in standard length; caudal fin truncate, with 16 principal rays; eye diameter (in specimens of 120 to 150 mm. in standard length) 3.5 to 4.5 in head length (except long-snouted specimens of *Z. rostratum*); interorbital slightly rounded, 2.9 to 3.4 in head length (also with the exception of *Z. rostratum*); gill openings restricted to sides; gill membranes attached to isthmus; anterior gill rakers 8 to 12; posterior gill rakers 9 to 13; scales very small, elevated, and with stout ctenii; 22 vertebrae; stomach elongate and thin-walled.

Zebrasoma is generally considered as an Indo-West-Pacific genus. Guichenot (1853: 122), however, recorded it (as *Acanthurus scopas* Cuvier and Valenciennes) from Cuba. He mentioned the very prominent snout, the great body depth, the small rough scales, and the patch of dense setae caudally on the body. The color was noted as gray-violet with brown spots; there were lines of white marks on the side and a white band in the humeral region. His choice of words in the brief description was very similar to that of Cuvier and Valenciennes (1835: 245). No meristic data were given, but there is little question that this author was describing a *Zebrasoma*. Günther (1861: 343) considered Guichenot's citing of *scopas* from Cuba as a "most remarkable fact." L. Bertin kindly checked for the specimen in the Paris Museum for me but could find no record of it. It seems possible that Guichenot's record is an error. To my knowledge there has been no further mention of *Zebrasoma* from the Atlantic.

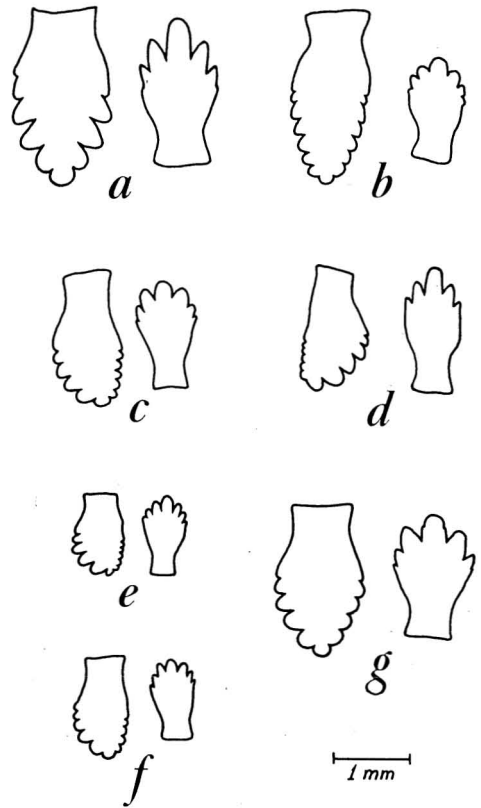


FIG. 1. Camera lucida drawings of upper and lower teeth of *Zebrasoma* and *Paracanthurus*. Teeth were taken from right side of jaws near center and drawn in inner or lingual view; the upper is to the left in each pair. *a*, *Z. veliferum*, 171 mm. specimen, Gilbert Islands; *b*, *Z. gemmatum*, 121 mm. specimen, Mauritius; *c*, *Z. xanthurum*, 181 mm. specimen, Red Sea; *d*, *Z. rostratum*, 140 mm. specimen, Tuamotu Archipelago; *e*, *Z. flavescens*, 100 mm. specimen, Johnston Island; *f*, *Z. scopas*, 108 mm. specimen, Philippine Islands; *g*, *P. hepatus*, 155 mm. specimen, Philippine Islands.

KEY TO THE SPECIES OF ZEBRASOMA

- 1a. Dorsal rays IV, 28 to 33; anal soft rays 22 to 26; longest dorsal ray 2.1 to 2.5 in standard length (in specimens over 50 mm. in length); body with alternate pale and dark, vertical bands. ***Zebrasoma veliferum***
- 1b. Dorsal fin rays IV or V, 23 to 28; anal soft rays 19 to 24; longest dorsal ray 2.8 to 3.7 in standard length (in specimens

- over 50 mm. in length); body without alternate pale and dark, vertical bands. . . 2
- 2a. Dorsal fin rays V (rarely IV), 23 to 26; anal soft rays 19 to 22; denticulations on lateral edge of upper teeth decidedly smaller than medial denticulations (Fig. 1c-f); body and dorsal and anal fins without spots (except longitudinal lines on *scopas* broken into fine spots anteriorly on the body) 3
- 2b. Dorsal fin rays (based on 2 specimens) IV, 28; anal soft rays 24; denticulations on both edges of teeth of equal size (Fig. 1b); body and dorsal and anal fins with numerous white (said to be blue in life) spots ***Zebrasoma gemmatum***
- 3a. Caudal fin abruptly pale (yellow in life) and in sharp contrast to dark body color; sheath of caudal spine black; profile of head from eye to upper lip only slightly concave ***Zebrasoma xanthurum***
- 3b. Caudal fin same color as body; sheath of caudal spine white; profile of head from eye to upper lip markedly concave (as snout is strongly produced) 4
- 4a. Body and fins not uniform black; lower teeth with 7 denticulations, the centermost only slightly larger than adjacent ones (Fig. 1c, f) 5
- 4b. Body and fins uniform black; lower teeth with 5 denticulations, the centermost about twice as large as adjacent ones (Fig. 1d) ***Zebrasoma rostratum***
- 5a. Body pale (yellow in life); dorsal soft rays 24 to 26 (usually 25); anal soft rays 19 to 22 (usually 20 or 21) ***Zebrasoma flavescens***
- 5b. Body brown with numerous pale longitudinal lines; dorsal soft rays 23 to 25 (usually 24); anal soft rays 19 to 21 (usually 19 or 20) . . ***Zebrasoma scopas***

Zebrasoma veliferum (Bloch)

Fig. 1a; Fig. 2; Fig. 3; Pl. 1

Acanthurus velifer Bloch (1797: 106, pl. 427,

fig. 1) (seas of East Indies); Lacépède (1802: 547); Rüppell (1828: 58, pl. 15, fig. 2) (Red Sea); Cuvier (1829: 224); Cuvier and Valenciennes (1835: 251) (Mauritius, East Indies, Red Sea); Günther (1861: 344) (Fiji Islands); Playfair in Playfair and Günther (1866: 57) (Zanzibar); Klunzinger (1871: 505) (Red Sea); Day (1876: 207) (seas of India); Sauvage (1891: 344) (Madagascar).

Acanthurus Velifer Bloch and Schneider (1801: xxxviii, 214).

Acanthurus (Harpurus) velifer Klunzinger (1884: 85).

Acanthurus Desjardinii Bennett (1835: 207) (Mauritius).

Acanthurus desjardinii Günther (1861: 344) (Mauritius); Playfair in Playfair and Günther (1866: 57) (Zanzibar).

Acanthurus Ruppellii Bennett (1835: 207) (Red Sea); Bleeker (1855: 451) (Kokos Island, Sumatra).

Acanthurus ruppellii Günther (1861: 345) (Red Sea).

Acanthurus Blochii Bennett (1835: 207) (India).

Zebrasoma velifer Swainson (1839: 256); Herre (1934: 63) (Philippine Islands).

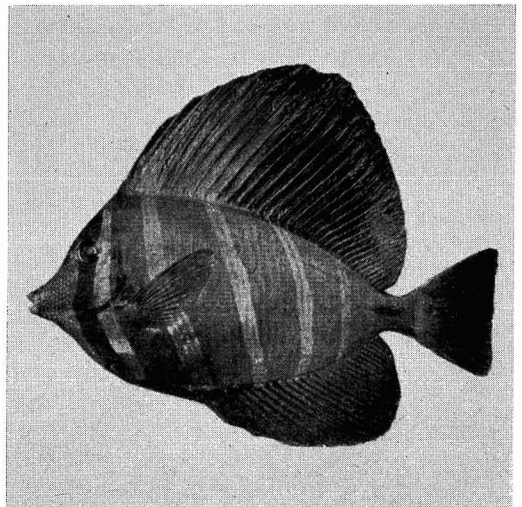


FIG. 2. *Zebrasoma veliferum* (Bloch), 183 mm., Gilbert Islands (reproduced from a 35 mm. Kodachrome transparency).

- Acanthurus suillus* Cuvier (1829: 224) (after Renard, 1718, vol. I, pl. 14, fig. 82); Cuvier and Valenciennes (1835: 254) (Mauritius); Günther (1861: 345).
- Acanthurus élégant* Liénard (1843: 69) (Mauritius) (reference from Sauvage, 1891: 344).
- Acanthurus hypsopleterus* Bleeker (1854: 327) (Larantuka, East Indies); Günther (1861: 344); Günther (1873: 117) (Samoa, Palau Islands and Misol, East Indies).
- Acanthurus maristarum* Thiollière in Montrouzier (1856: 458) (Island of Woodlark).
- Acanthurus* (*Harpurus*) *hypsopleterus* Steindachner (1901: 494, pl. 4, fig. 1) (Honolulu).
- Acanthurus kipas* Bleeker (1854: 327) (East Indies).
- Harpurus hypsopleterus* Bleeker (1863: 252) (Flores, East Indies).
- Harpurus Rüppelli* Bleeker (1863: 235) (Ternate, East Indies).
- Harpurus Desjardini* Bleeker and Pollen (1874: 96) (Mauritius).
- Acanthurus virgatus* Vaillant and Sauvage (1875: 283) (Hawaiian Islands).
- Acanthurus fasciatus* Bliss (1883: 53) (Mauritius).
- Zebrasoma hypsopleterum* Jenkins (1903: 479) (Honolulu); Ogilby (1916: 174, pl. 23) (Queensland, Australia).
- Zebrasoma veliferum* Jordan and Evermann (1905: 396, fig. 173) (Honolulu); Jordan and Seale (1906: 356) (Samoa); Kendall and Radcliffe (1912: 143) (Mangareva); Jordan and Jordan (1922: 66) (Honolulu); Herre (1927: 443, pl. 11, labelled *Zebrasoma viliferum*) (Philippine Islands); Fowler (1928: 275, pl. 32, fig. B); Fowler and Bean (1929: 255) (Philippine Islands and East Indies); Schmidt (1930: 104) (Riu Kiu Islands); Fowler (1931: 346) (Honolulu); Herre (1936: 249) (Solomon Islands); Hi-yama (1943: 95, pl. 21, fig. 58); Aoyagi (1943: 205, pl. 4, fig. 6, teeth only) (Riu Kiu Islands); Schultz (1943: 166) (Phoenix Islands and Samoa Islands); de Beaufort (1951: 167, fig. 28) (New Guinea and Ambon, East Indies); Schultz and Woods in Schultz, *et al.* (1953: 640) (Marshall Islands); Harry (1953: 152) (Raroia, Tuamotu Archipelago).
- Zebrasoma veliferum novae caledoniae* Borodin (1932: 88) (New Caledonia).
- Hepatus coccinatus* von Bonde (1934: 449, fig. 3) (Zanzibar).
- Zebrasoma velifera* Marshall (1950: 195) (Cocos-Keeling Islands).

Dorsal rays IV, 28 to 33 (in Oceania usually 31 or 32); anal rays III, 22 to 26 (in Oceania usually 24 or 25); pectoral rays 15 to 17 (usually 16); anterior gill rakers 8 to 11 and posterior gill rakers 9 or 10 (12 specimens from nine localities over the range of the species); the number of teeth increase slowly with age: a 25 mm. specimen from the Gilbert Islands had 10 upper and 12 lower teeth; 51, 80, and 94 mm. specimens had 12 upper and 14 lower teeth; 128, 154, and 168 mm. specimens had 14 upper and 16 lower teeth; 233 and 245 mm. specimens had 16 upper and 18 lower teeth.

Dorsal fin very elevated, longest soft dorsal ray 2.1 to 2.5 in standard length; fourth dorsal spine 2.5 to 2.8 in standard length; body depth 1.8 to 2 in standard length (1.4 in 25 mm. specimen); no patch of stiff bristles on side of body anterior to caudal spine. The posterior end of the caudal spine is not as broadly joined to the body in *veliferum* as in other species of *Zebrasoma*.

Color (in alcohol) brown with alternate, near-vertical, dark and light (pale yellow in life) bands; the first dark band passes through the eye and angles backward to the origin of the pelvic fins; the first pale band runs from the nape across the opercle just behind the eye to the pelvic region; the remaining four or five pale bands on the body are about one-third to one-fourth as broad as the intermediate brown areas, and each is bisected by a narrow dark line; within the intermediate brown areas alternate lines of dark and light are perceptible, the dark lines tending to

TABLE 1
FIN RAY COUNTS OF SPECIMENS OF SPECIES OF *Zebrasoma* FROM VARIOUS LOCALITIES

SPECIES AND LOCALITY	DORSAL SPINES		DORSAL SOFT RAYS											ANAL SOFT RAYS						PECTORAL RAYS					
	IV	V	23	24	25	26	27	28	29	30	31	32	33	19	20	21	22	23	24	25	26	14	15	16	17
<i>veliferum</i>																									
Hawaiian Is.	11									3	4	4							3	7	1		1	9	1
Phoenix Is.	3										1	2								2	1			3	
Samoa Is.	3											3								2	1			3	
Marshall Is.	6											3							2	4			1	5	
Gilbert Is.	10											4	4	2					4	5	1		3	7	
Society Is.	4							1				2	1						1	3				4	
Mangareva	1											1								1				1	
Philippine Is.	24									5	8	11						2	5	17			9	15	
East Indies	3										1	2								2	1			3	
Mauritius	8						1	6	1								1	6	1					8	
Zanzibar	1							1										1						1	
Egypt, Red Sea	7							2	3	1	1						2	4	1				1	5	1
<i>gemmatum</i>																									
Mauritius	2							2												2				1	1
<i>xanthurum</i>																									
Egypt, Red Sea		7		6	1									4	3									7	
<i>rostratum</i>																									
Tuamotu Arch.	1	10	1	7	3									1	10									11	
Society Is.		2		2											2									2	
<i>flavescens</i>																									
Hawaiian Is.	2	56	1	13	32	12								2	19	34	3					1	54	3	
Johnston I.		5		2	3										2	3							4	1	
Wake I.		3			3										1	2							2	1	
N. Marshall Is.		1				1										1							1		
Marcus I.		1			1											1							1		
Mariana Is.		6		1	2	3										5	1						4	2	
<i>scopas</i>																									
N. Marshall Is.	1	7		6	2										7	1								8	
Gilbert Is.		3	1	2										1	2									3	
Samoa Is.		21	1	14	6									4	15	2						2	18	1	
Society Is.		14	1	8	5									2	11	1						3	10	1	
Riu Kiu Is.		1	1											1									1		
Philippine Is.	1	41	9	28	5									10	32							7	33	2	
East Indies		13	2	9	2									2	11							1	12		
Mauritius		4		3	1										4								4		

break into spots antero-ventrally on the body; head and chest with small pale spots; dorsal and anal fins dark with curved pale lines which may be broken into spots; caudal fin dark with faint pale spots; caudal spine in a blackish area.

The low dorsal and anal fin ray counts (Table 1) of the Red Sea, Zanzibar, and Mauritius specimens and slightly different color (the very narrow vertical pale lines on the body are more conspicuous) suggest that the form in the Indian Ocean and Red Sea might be regarded as a different subspecies from that in the East Indies and Oceania. Many more specimens from various parts of the Indian Ocean are needed to establish the nature of subspecific differentiation in this species.

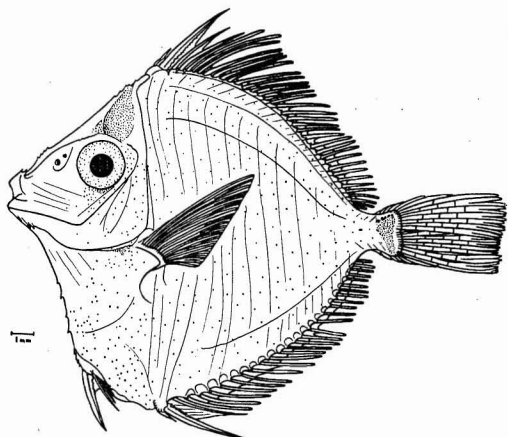


FIG. 3. Postlarval *Zebrasoma veliferum*, 18 mm., Hawaiian Islands. Drawn with the aid of a camera lucida by H. Randall.

The 18 mm. postlarval specimen of *Z. veliferum* (Fig. 3) was collected by Joseph E. King of the Pacific Oceanic Fishery Investigations on Dec. 26, 1951 offshore from Kaneohe, Oahu. It was taken in an oblique haul from the surface to about 200 meters with a 6 foot trawl.

The juvenile specimen (Pl. 1) was taken with rotenone by the author from a channel of 3 to 5 foot depth at Onotoa Atoll, Gilbert Islands. The area was sandy with occasional heads of *Heliopora*.

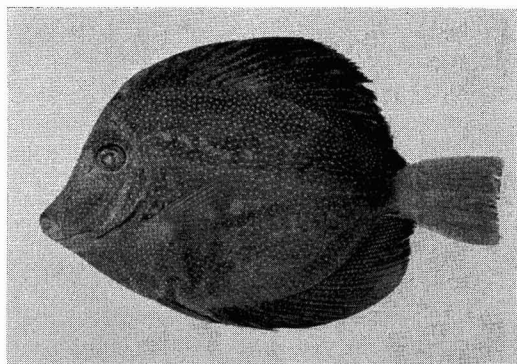


FIG. 4. *Zebrasoma gemmatum* (Cuvier and Valenciennes), 121 mm., Mauritius.

The largest specimen seen by me was 275 mm. in standard length. De Beaufort (1951: 169) recorded total length to 395 mm., which would be about 315 mm. in standard length.

Although widespread in the tropical Indian and West Pacific Oceans, this species is not as abundant as many of the other surgeon fishes. Schultz and Woods (1953: 641) state that a large school was observed entering shallow water in the Marshall Islands; the individuals of the school were swimming at times with their dorsal fins out of water like a sail. I have occasionally observed *Z. veliferum* underwater in the Hawaiian Islands and in the Gilbert Islands, but only as solitary individuals. I have never seen the dorsal fin elevated.

Zebrasoma gemmatum
(Cuvier and Valenciennes)

Fig. 1*b*; Fig. 4

Acanthurus gemmatus Cuvier and Valenciennes (1835: 255) (Mauritius); Günther (1861: 343); Sauvage (1891: 343) (Madagascar?).

Harpurus gemmatus Bleeker and Pollen (1874: 96) (Mauritius).

Zebrasoma gemmatum Fowler and Bean (1929: 258).

Dorsal rays IV, 28; anal rays III, 24; pectoral rays 16 or 17; anterior gill rakers 12 and posterior gill rakers 11; 121 mm. specimen

with 15 upper and 17 lower teeth; 179 mm. specimen with 18 upper and 20 lower teeth.

Longest soft dorsal ray 3 to 3.1 in standard length; fourth dorsal spine 4.5 to 5.9 in standard length; body depth 1.7 to 1.9 in standard length; no patch of setae on side of body anterior to caudal spine. All counts and measurements are based on two specimens.

Color (in alcohol) brown with numerous white spots on head, body, dorsal and anal fins, base of pectoral fin, and very faintly on caudal fin (these spots tend to be round on fins, head, and dorsal part of body, but elongate elsewhere on the body); caudal fin pale.

Cuvier and Valenciennes (1835: 256) stated that the caudal fin was yellow. Sauvage (1891: 344) (after Liénard) described the spots on this fish as blue.

Z. gemmatum is known only from the island of Mauritius and possibly Madagascar.

Zebrasoma xanthurum (Blyth)

Fig. 1c; Fig. 5

Acanthurus xanthurus Blyth in Kelaart (1852: appendix p. 50) (Ceylon); Günther (1861: 343); Playfair in Playfair and Günther (1866: 57, pl. 8, fig. 4) (Aden); Klunzinger (1871: 504) (Red Sea); Day (1876: 207).

Acanthurus (Harpurus) xanthurus Klunzinger (1884: 85).

Zebrasoma xanthurum Fowler and Bean (1929: 262).

Dorsal rays V, 24 or 25; anal rays III, 19 or 20; pectoral rays 15; gill rakers (from one specimen): anterior 11, posterior 13; upper teeth 18 to 20; lower teeth 22.

Longest soft dorsal ray 3.4 to 3.7 in standard length; fifth dorsal spine 3.9 to 4.1 in standard length; body depth 1.7 to 1.85 in standard length; an oval, velvety patch on side of body anterior to caudal spine. All measurement and meristic data except gill raker counts based on seven specimens, 120 to 181 mm. from the Red Sea.

Color (in alcohol) dark gray to black with small spots on head, nape, and chest (these

spots pale on two of the specimens and dark on the others); entire caudal fin abruptly yellowish white just posterior to caudal spine; dorsal, anal, and pelvic fins dark gray; pectoral fin with basal two-thirds dark gray, outer one-third pale.

Blyth (in Kelaart, 1882: appendix p. 50) described the color in life from a 7.5 inch specimen as ". . . wholly black with bright golden-yellow tail, and a tinge of the same upon the pectorals."

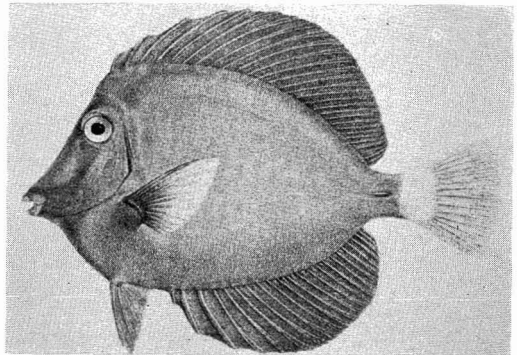


FIG. 5. *Zebrasoma xanthurum* (Blyth), (after Playfair, 1866).

This species is difficult to separate from *Z. scopas* and *Z. flavescens* on any basis other than color. The snout is slightly less produced in *Z. xanthurum* and, for a comparable size, the velvet like area on the side much less developed. It seems likely that *Z. xanthurum* attains a larger size. Four of the seven specimens from the Red Sea range from 145 to 181 mm. in standard length. The largest *Z. scopas* I have seen is 149 mm. in standard length (from the Society Islands). Of over 100 adult specimens in the United States National Museum from the Philippines and East Indies, the largest is 145 mm. and only nine exceed 115 mm. The largest of many *Z. flavescens* examined by me is a Hawaiian specimen 149 mm. in length.

Zebrasoma xanthurum is thus far reported only from Ceylon, the Gulf of Aden, and the Red Sea.

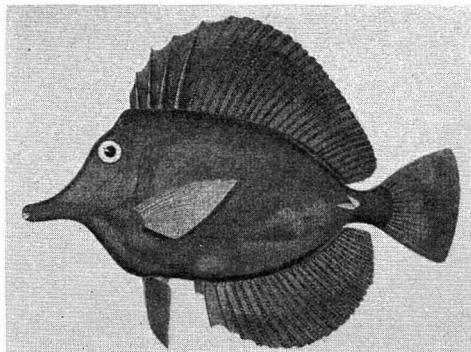


FIG. 6. *Zebrasoma rostratum* (Günther), (after Günther, 1873).

***Zebrasoma rostratum* (Günther)**

Fig. 1*d*; Fig. 6

Acanthurus rostratus Günther (1873: 117, pl. 66, fig. B) (Society Islands).

Zebrasoma rostratum Fowler (1928: 275); Harry (1953: 152) (Raroia, Tuamotu Archipelago).

Zebrasoma (Laephibichthys) rostratum Fowler and Bean (1929: 262).

Laephibichthys rostratus Fowler (1938: 127) (Apataki, Tuamotu Archipelago); Fowler (1952: 25, fig.).

Dorsal rays V (rarely IV), 23 to 25; anal rays III, 19 or 20; pectoral rays 15; anterior gill rakers 10 and posterior gill rakers 9 or 10 (from 2 specimens, Society Islands); 84 and 121 mm. specimens had 16 upper and lower teeth; a 166 mm. specimen had 16 upper and 18 lower teeth, and a 170 mm. specimen 18 upper and lower teeth.

Longest soft dorsal ray 3 to 3.7 in standard length; fifth dorsal spine 3.7 to 4 in standard length; body depth about 2 in standard length; patch of setae in front of the caudal spine may or may not be present (two of seven specimens which could be sexed had well-developed setae and were males; the others lacked this bristle area and were females; thus it is possible that this is a sexual character in this species).

The long snout was believed to be the most characteristic feature; however, examination of a series of 10 specimens in the Stanford Natural History Museum, collected by R. R. Harry from Raroia Atoll in the Tuamotus, revealed considerable variability in snout length. The ratio of snout length (measured from tip of upper teeth to nearest edge of eye) to standard length (tip of snout to base of caudal fin) ranged from about 3 to 5. This variability is not associated with growth nor does it appear to be related to sex.

I did not observe the dorsal spines to be noticeably stouter than those of other species of *Zebrasoma*, although Garrett's drawing (in Günther, 1873, reproduced herein as Fig. 6) shows them to be.

Color (in alcohol) entirely black except membranes of pectoral fin which are clear, the caudal spine which is hyaline with a white sheath, and in some specimens a faint pale longitudinal band in the posterior half of the dorsal and anal fins. Harry (1953: 152) gives the life color as solid black with white caudal spine.

Günther described *Acanthurus rostratus* from Garrett's notes and his painting of a 7.5 inch specimen. It has been presumed that the specimen is not in existence; however, I found two collected by Garrett, both 7.5 inches in total length, at the Museum of Comparative Zoology. It seems likely that one of these was the basis for the figure and therefore should be considered as the type.

Fowler (1938: 128) thought that the velvety patch in front of the caudal spine was removed by the publishers of "Fische der Südsee" from the painting. In this he is probably in error, for both of the Garrett specimens are females and lack this setous area.

Zebrasoma rostratum is known only from the Society Islands and two islands in the Tuamotus. Harry collected his specimens from lagoon shore reefs at Raroia and observed the species also on lagoon coral heads.

Zebrasoma flavescens (Bennett)

Fig. 1e; Fig. 7

Acanthurus flavescens Bennett (1828: 41) (Oahu); Günther (1873: 116, pl. 76, fig. B) (Hawaiian Islands); Steindachner (1901: 493) (Honolulu).

Zabrasoma agaña Seale (1901: 110) (Guam).

Zebrasoma flavescens Bryan and Herre (1903: 134) (Marcus Island); Jordan and Evermann (1905: 397, pl. 59) (Oahu); Jordan and Seale (1906: 355); Jordan and Jordan (1922: 66) (Hawaii); Fowler and Ball (1925: 19) (Johnston Island); Fowler (1928: 274, pl. 32, fig. A) (Hawaiian Islands, Johnston Island, Marcus Island); Aoyagi (in part) (1943: 203) (Riu Kiu Islands); Schultz and Woods in Schultz *et al.* (in part) (1953: 641) (Bikini Atoll, Marshall Islands).

Scopas flavescens Jenkins (1903: 480) (Honolulu and Puako Bay, Hawaii).

Dorsal rays V (rarely IV), 23 to 26 (usually 24 or 25); anal rays III, 19 to 22 (usually 20 or 21); pectoral rays 14 to 16 (usually 15); anterior gill rakers 8 to 12 and posterior gill rakers 11 or 12 (based on a total of 12 specimens from the Hawaiian Islands, Johnston Island, Wake Island, Bikini Atoll, Marcus Island, and Guam); a 25 mm. transforming specimen from Saipan had 12 upper and 14 lower teeth; a 77 mm. specimen collected by Schultz, Hiatt, and Brock at Bikini (U.S.N.M. No. 140586) had 15 upper teeth and 18 lower teeth; a 149 mm. specimen from Hawaii had 18 upper and 22 lower teeth.

The following proportional measurements were made on 15 specimens from 75 to 149 mm. in standard length: length of longest dorsal ray 2.8 to 3.8 in standard length; length of fifth dorsal spine 2.95 to 4.0 in standard length; body depth 1.4 to 1.75 (2.4 in 26 mm. juvenile specimen); a well-developed dense patch of setae posteriorly on the side of the body, progressively more prominent in larger specimens.

Color (in alcohol) uniform yellowish white, in life bright chrome yellow. Upper edge of

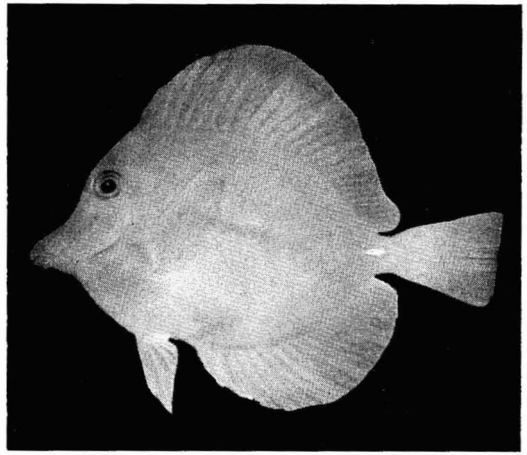


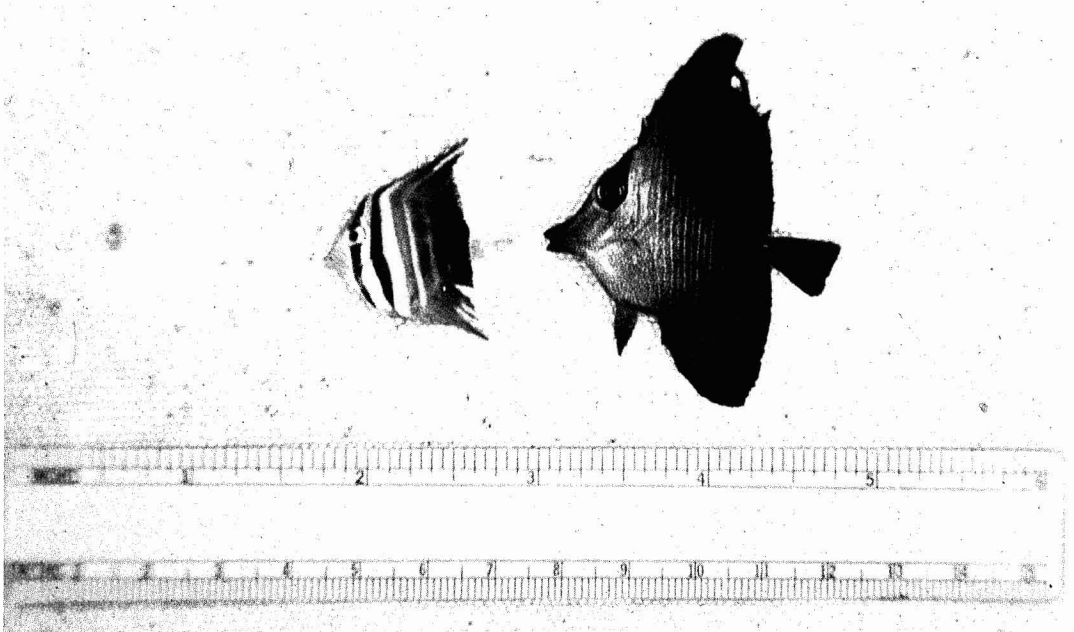
FIG. 7. *Zebrasoma flavescens* (Bennett), 120 mm., Hawaiian Islands (reproduced from a 35 mm. Kodachrome transparency).

pectoral fin with a very narrow dark margin; sheath of caudal spine white. Preserved specimens often show a long, faint whitish pale band running backward and slightly downward from just behind the upper end of the gill opening.

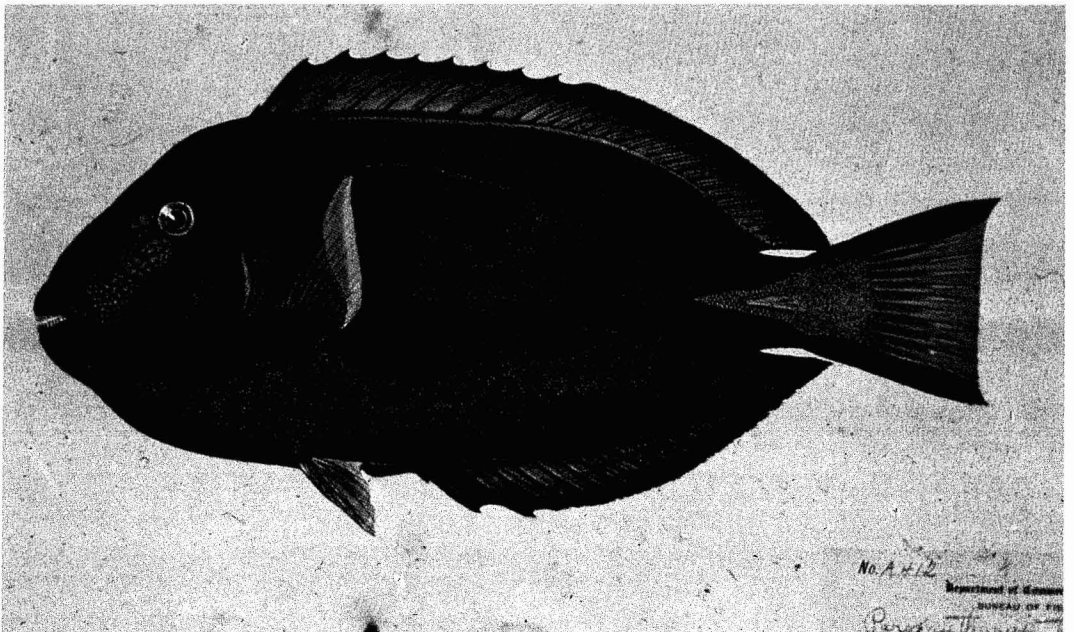
Two of three yellow specimens of *Z. flavescens* (U.S.N.M. No. 140567) collected by L. P. Schultz from Johnston Island are a light dusky color over the back and head and there is a slight concentration of brownish pigment anteriorly in the dorsal fin. The yellow Bikini specimen shows this same diffuse marking in the fin. Still, this is but a slight departure from the usual pure yellow color.

This brightly-colored species is abundant in the Hawaiian Islands. Brock (1954: 302) calls attention to the interesting fact that it is much more common on leeward sides of islands than windward. His figure 1 shows the relative abundance of this fish (as *Zebbrasoma*) in nine different localities around the islands of Hawaii and Oahu.

Jordan and Evermann (1905: 398) believed *Acanthurus virgatus* Vaillant and Sauvage to be the young of *Z. flavescens* and placed it in the synonymy of the latter. *A. virgatus* had vertical dark bars on the body and was probably a juvenile *Zebrasoma veliferum*. Juvenile



Young of *Zebrasoma veliferum* (left) and *Z. scopas*, Gilbert Islands (from a Kodachrome by the author).



Paracanthurus hepatus, 204 mm., Philippine Islands (from an unpublished painting in the files of the U. S. Natl. Mus.).

Z. flavescens display no dark markings of any kind. A 21.5 mm. transforming specimen taken at a depth of 40 feet off Waikiki, Oahu, on June 3, 1952 was bright yellow in color like adults.

Except for one sight record in the Tuamotus (Harry, 1953), *Z. flavescens* appears to be confined to the northern part of the tropical Pacific. I have seen specimens only from the Hawaiian Islands, Johnston Island, Wake Island, Marcus Island, northern Marshall Islands, and the Marianas (including the type of *Z. agaña* Seale from Guam, kindly loaned by E. H. Bryan of the Bishop Museum, and two small bright yellow specimens collected by Eugenie Clark at Saipan). See section on *Z. scopas* for further discussion of *Z. flavescens*.

Zebrasoma scopas (Cuvier)

Fig. 1f; Pl. 1

Acanthurus scopas Cuvier (1829: 224) (after Renard, 1718, vol. 1, pl. 40, fig. 210) (Neira, Province of Banda); Cuvier and Valenciennes (1835: 245, pl. 290) (New Guinea); Bleeker (1851: 348) (Solor, East Indies); Thiollière in Montrouzier (1856: 459) (Island of Woodlark).

Acanthurus rhombeus von Kittlitz (1834: 194, pl. 13, fig. 6) (Ulea Island = Woleai Atoll, Caroline Islands); Günther (1861: 342) (Aneityum, New Hebrides and Ceram, East Indies); Playfair in Playfair and Günther (1866: 57) (Zanzibar).

Acanthurus altivelis Cuvier and Valenciennes (1835: 249) (Indian Ocean and Mauritius).

Harpurus scopas Swainson (1839: 256).

Acanthurus goramensis Bleeker (1858: 208) (Goram, East Indies); Günther (1861: 343); Jatzow and Lenz (1898: 514, pl. 36, fig. 11) (Zanzibar).

Harpurus rhombeus Bleeker (1863: 271) (Timor, East Indies).

Acanthurus flavescens. Günther (1873: 116, pl. 76, fig. A) (Tahiti); Sauvage (1891: 342) (Madagascar).

Zebrasoma rhombeum Jordan and Seale (1906:

355) (Samoa); Jordan and Seale (1907: 34) (Panay, Philippine Islands); Jordan and Richardson (1908: 270) (Cagayancillo, Philippine Islands); Fowler (1928: 275) (Indo-Pacific, but not Hawaiian Islands, Johnston Island, or Marcus Island).

Zebrasoma flavescens. Jordan and Fowler (1902: 555) (Okinawa); Herre (1927: 441) (Philippine Islands); Fowler and Bean (1929: 258) (Philippine Islands and East Indies); Schmidt (1930: 103) (Riu Kiu Islands); Giltay (1933: 86) (East Indies); Herre (1934: 63) (Philippine Islands); Herre (1936: 248) (Society Islands, New Hebrides, Solomon Islands); Poll (1942: 11, fig. 3) (Tahiti); Aoyagi (in part) (1943: 203, pl. 8, fig. 3) (Riu Kiu Islands); Schultz (1943: 167) (Samoa Islands); de Beaufort (1951: 170) (Java); Schultz and Woods in Schultz *et al.* (in part) (1953: 641, pl. 66, fig. B) (Marshall Islands); Harry (1953: 152) (Raroia, Tuamotu Archipelago).

Zebrasoma rostratum. Jordan and Seale (1906: 356) (Samoa).

Zebrasoma supra-alba Fowler (1946: 198, fig. 70) (Riu Kiu Islands).

Dorsal rays V (rarely IV), 23 to 25 (usually 24); anal rays III, 19 to 21 (usually 19 or 20); pectoral rays 14 to 16 (usually 15); anterior gill rakers 9 to 12 and posterior gill rakers 10 to 13 (based on a total of 12 specimens from the Marshall Islands, Samoa, Society Islands, Philippine Islands, and East Indies); a 30 mm. specimen from the Gilbert Islands had 12 upper and 14 lower teeth; a 74 mm. specimen from the Philippines had 14 upper and 16 lower teeth; a 145 mm. specimen from the Philippines had 18 upper and 22 lower teeth.

The following proportional measurements were made on 15 specimens from 52 to 145 mm. in standard length: length of longest dorsal ray 2.7 to 3.6 in standard length; length of fifth dorsal spine 2.9 to 3.9 in standard length; body depth 1.5 to 1.7 in standard length (2.2 in a 30 mm. juvenile); oval-

shaped brush-like patch of setae on sides, very prominent in larger specimens where it extends nearly half way to the base of the pectoral fin from the caudal spine (this velvet-like region first becomes apparent in specimens of 65 to 70 mm. in standard length).

Color (in alcohol) brown with numerous, thin, light gray, irregular, horizontal lines on the body which are broken into discrete spots anteriorly and on head; on small specimens (about 45 to 65 mm. in length) the lines are entirely broken up on the body. Specimens smaller than 45 mm. have narrow vertical pale lines on the body between which spots are aligned vertically. In most specimens, regardless of length, a dusky white band of about the diameter of a pupil of eye in width extends posteriorly from a point just behind the upper edge of the gill opening over half the distance to the caudal spine. Sheath of caudal spine white; median fins brown; pectoral fin membranes hyaline, rays light brown; upper edge of unbranched pectoral ray with a narrow black line.

Color (in life) dark brown, yellowish brown anteriorly, with numerous, narrow, wavy, light blue longitudinal lines on the body, breaking up to small blue dots on nape, chest, and head (no linear pattern being evident on the latter); all fins except pectorals dark brown; pectorals clear with dusky orange rays and a narrow black upper margin. This color note was obtained from an 88 mm. specimen collected by me from a recess in a stand of dead staghorn coral in the lagoon of Onotoa Atoll, Gilbert Islands.

Although colors of olive or dark green and black have been given for the species, the majority of the records of the basic life color are brown. The other colors may represent variability which is possible in individual specimens. Other acanthurids are known for the ability to alter their hues (Townsend, 1929). *Ctenochaetus striatus* (Quoy and Gaimard), also a brown, blue-lined species, may appear almost black or distinctly olivaceous when alive.

The young of *Z. scopas* and *Z. veliferum* are compared in the upper figure of Plate 1. The photograph is of fresh specimens captured at Onotoa Atoll.

Schultz and Woods (1953: 642) reported that this species was found in or close to deep water in the Marshall Islands. I observed adults in about 8 feet of water in the Onotoa lagoon and on the lee reef of Butaritari Atoll in the Gilbert Islands; however, they were seen infrequently.

The largest specimen in the museum material which I have examined measured 149 mm. in standard length.

Varied opinions as to the relationship of *Z. scopas* and *flavescens* have been expressed in the literature.

Günther (1873: 117) united *Acanthurus rhombeus* (= *Z. scopas*) with *flavescens*, regarding the yellow form in Hawaii as probably a case of albinism. Jordan and Seale (1906: 355) (1907: 34) stated that the two are probably the same species, though they retained both names. Herre (1927: 443), Fowler and Bean (1929: 260), Aoyagi (1943: 204), Schultz and Woods (1953: 152), and others have asserted their belief that these are color forms of a single species. Jordan and Fowler (1902: 556) wrote, "Probably the typical *flavescens* is found in deep water, the variety *rhombeum* living near shore." Certainly this does not seem to be true, for neither form appears restricted to any particular depth on the reef. I have observed *Z. flavescens* in Hawaii in from about 3 to 90 feet of water. *Z. scopas* (as here defined) is known from Zanzibar to southern and western Oceania. In spite of extensive collecting and underwater observation in the Hawaiian Islands, Johnston Island, and Wake Island by W. A. Gosline, V. E. Brock, myself, and others, no specimens of *Z. scopas* (the so called brown phase of *Z. flavescens*) have been seen, although the bright yellow *Z. flavescens* is abundant. The few museum specimens from Marcus Island and Guam are pale, presumably yellow in life, and hence *Z. flavescens*.

I have examined 167 specimens from the Philippines, East Indies, Gilbert Islands, Samoa Islands, Society Islands, and Mauritius, and all were brown. Jordan and Seale (1906: 356) had 50 specimens from Samoa and saw none yellow in color. Fowler (1928: 274) recorded *Z. flavescens* from the Hawaiian Islands, Johnston Island, Samoa, Marcus Island, and Raiatea and described the species from preserved specimens as fuscous-black with fine grayish lines. Of his specimens only those from Samoa and Raiatea were of this color; the rest were pale yellowish.

Only from Bikini Atoll in the northern Marshall Islands have I seen both yellow and brown specimens from the same area. Of 14 specimens only one was yellow. Aoyagi (1943: 204) reported both yellow and brown and intermediate forms from the Riu Kiu Islands, however, he mentioned that there was some geographical separation. R. R. Harry (1953: 152) stated that he observed one yellow specimen underwater at Raroia Atoll in the Tuamotus but took only the dark form. Upon discussing this sight record with Harry, I learned that he was unaware of the solid bright yellow color of the young of *Acanthurus olivaceus* Bloch and Schneider. He then stated that he could not be certain that the specimen he saw was *Z. flavescens* and not *A. olivaceus*.

My efforts to distinguish the yellow *Z. flavescens* and the brown *Z. scopas* on other grounds than color met with the usual failure except for fin ray counts (Table 1) which provide a partial separation, the counts of *Z. flavescens* being higher. One might say that this meristic difference is due to the colder water of the northern part of Oceania to which the yellow "phase" seems to be restricted. However, the water of the Mariana Islands is as warm as the warmest areas of the Pacific (more specimens are needed from this region however, to be certain that the fin ray counts are really higher), and the fin ray counts of *Z. scopas* from the Society Islands, which are about as far south as the Hawaiian Islands

are north and have sea surface temperatures which are almost as cool as Hawaii (Hydrographic Office, 1944), show no increase (Table 1). Also *Z. veliferum* does not exhibit any obvious increase in ray counts in the Hawaiian Islands.

In view of the available data, I do not believe that *Z. flavescens* and *Z. scopas* can be considered as color varieties of one polymorphic species. If they were color varieties, at least an occasional brown specimen should have turned up in areas like the Hawaiian Islands, or yellow ones from the southern or western tropical Pacific or Indian Oceans. More important, one would not expect the fin ray counts of both phases to be different. Two other possibilities exist: the brown and yellow forms are full species or they are subspecies. My data are not yet sufficient to decide with assurance which is the case. At the present time I favor considering the two as species, although I may be placing too much emphasis on the single yellow specimen from Bikini with higher fin ray counts than brown specimens from the same atoll. This one yellow specimen might have been carried there as a larva from a *Z. flavescens* area such as Wake Island. If this were true, the case for subspecies would be strengthened.

The claim made by Aoyagi that yellow, brown, and intermediate forms occur in the Riu Kius is difficult to assess and should be checked. The intermediate forms were described as yellowish brown with minute spots. This is normal coloration for subadult and juvenile *Z. scopas*; thus this author might not have observed true intermediate forms at all. If the "geographical separation" which he mentioned is north-south within this island chain and true intermediate forms were found in a region of contact of the yellow and brown, the best explanation would be in terms of subspecies.

I examined the type of *Zebrasoma supra-alba* Fowler from the Riu Kiu Islands at the Academy of Natural Sciences of Philadelphia. The unique feature of the anterior part of the

dorsal fin being white appears to be caused by damage to the specimen. The fin membranes of the first four spines are completely torn off. A white area does appear posterior to the fourth spine to about the middle of the fin, but this seems to be due to a stripping off of the pigmented epidermis. The fin ray counts of this specimen are given in Table 1 for the Riu Kiu Islands under the heading *scopas*.

PARACANTHURUS Bleeker

Paracanthurus Bleeker (1863: 252). (Type species, *Acanthurus hepatus* (Linnaeus) Bloch and Schneider = *Teuthis hepatus* Linnaeus as restricted by Cuvier and Valenciennes.) The characteristics of the genus are those of the single known species.

Paracanthurus hepatus (Linnaeus)

Fig. 1g; Fig. 8; Pl. 3

Teuthis hepatus Linnaeus (in part) (1766: 507) (after Seba, 1734, and Valentijn, 1724) (sea of the Indies).

Acanthurus hepatus Bloch and Schneider (in part) (1802: 11); Cuvier and Valenciennes (1835: 183, pl. 288) (Mauritius and New Guinea); Bleeker (1854: 325) (Flores, East Indies); Günther (1861: 341) (Ambon, East Indies); Günther (1873: 115, pl. 75) (Gilbert Islands); Day (1876: 206) (seas of India).

Acanthurus theuthis Lacépède (1802: 547, 549).

Acanthurus Theuthis Shaw (1802: 377).

Acanthurus triangulus Cuvier and Valenciennes (1835: 189) (after Vlaming); Günther (1861: 341).

Paracanthurus hepatus Bleeker (1863: 252) (Ceram, East Indies); de Beaufort (1951: 131, fig. 25) (Pulu Weh and Banda, East Indies).

Colocopus lambdurus Gill (1885: 279); Jordan and Seale (1906: 355).

Acanthurus teuthis Weber (1913: 318) (Banda, East Indies).

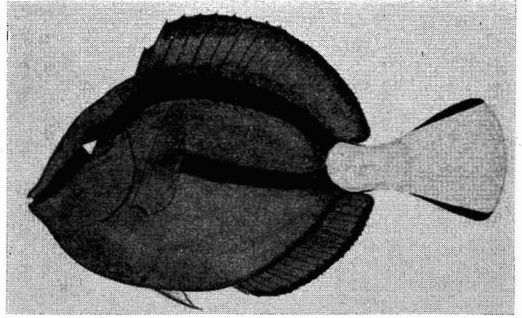


FIG. 8. *Paracanthurus hepatus* (Linnaeus), 30 mm., Schouten Islands, East Indies (photograph of an unpublished painting by Frederick M. Bayer).

Paracanthurus lambdurus Fowler (1926: 140); Herre (1927: 435, pl. 13, fig. 3) (Philippine Islands); Herre (1934: 63).

Paracanthurus theuthis Fowler (1928: 273); Fowler and Bean (1929: 205, fig. 10) (Philippine Islands and East Indies); Fowler (1931: 344) (Palau Islands); Aoyagi (1943: 202, pl. 8, fig. 1, pl. 4, fig. 8) (Riu Kiu Islands); Smith (1949: 239, pl. 33, no. 607) (Mozambique).

The following is based on the one catalogued adult specimen in the United States National Museum (No. 146636, 204 mm., Philippine Islands): body compressed, elliptical, the depth contained 2.3 in standard length; head length contained 3.75 in standard length; a broad groove on each side of caudal peduncle with a single movable spine, sharp anteriorly, broadly joined to body posteriorly; length of caudal spine 4 in head length; least depth of caudal peduncle 2.4 in head length; mouth very small, terminal; jaws equal; teeth small, close-set, denticulated, 14 in upper jaw and 17 in lower jaw (a 140 mm. specimen from the Gilbert Islands and now in the Bishop Museum, Honolulu, had 12 upper and 14 lower teeth); all spines of fins stout; dorsal and anal fins not elevated, longest dorsal ray 8.2 in standard length; dorsal fin rays IX (the first very short), 19 or 20; anal fin rays III (the first very short), 18 or

19 (based on four specimens from the Philippines, one from the Gilbert Islands, and two from Mauritius); pectoral fin rays 16; pelvic fin rays I, 3 (the first soft ray closely applied to the spine); length of pectoral fin 4.3 in standard length; length of pelvic fin 7.5 in standard length; caudal fin with 16 principal rays, truncate with upper and lower lobes slightly projecting; length of caudal fin 5.6 in standard length; eye small, 6 in head length; interorbital highly arched, 3.4 in head length; gill openings well-restricted to sides; gill membranes confluent and very broadly attached to isthmus; scales of body thick, each with many short ctenii on upper surface (ctenii on scales in a small area just anterior to caudal spine about three times as long as elsewhere on body); scales on head, especially anteriorly, enlarged to tuberculated plates; 22 vertebrae; stomach oval with moderately thick walls.

Color (in alcohol) light grayish brown (blue in life) with a broad black area on back, enclosing an oval light gray-brown region at the tip of the pectoral, and extending forward dorsally to eye; a long light yellowish brown triangle (bright yellow in life) with apex anterior to caudal spine and base formed by truncate posterior margin of caudal fin; upper and lower lobes of caudal fin black, this color confluent with the black area of the back; pectoral fin dark gray on first two principal rays and basal two-thirds of remaining rays; dorsal and anal fins with basal half yellowish gray and distal half dark gray; pelvics yellowish gray.

Fowler and Bean (1929: 206, fig. 10) show variation of color markings of this species with age.

Smaller than any of the specimens figured by Fowler and Bean is one, 30 mm. in standard length, collected in shallow water at Biak, Schouten Islands, in April, 1945, by Frederick M. Bayer. His unpublished painting is reproduced as Figure 8. The specimen had a bright blue body, yellow tail, and black markings as shown.

Acanthurus triangulus Cuvier and Valenciennes was described from an old drawing by Vlaming. It appears to be *Paracanthurus hepatus* with the black and yellow colors reversed.

P. hepatus is known from East Africa to the Philippines and the Riu Kiu Islands. It does not appear to range throughout the tropical Pacific, the only record from this vast area being that of Günther (1873) from the Gilbert Islands.

Three different species of surgeon fishes of five prelinnaean authors were cited by Linnaeus (1766: 507) under the specific name *hepatus*. Cuvier and Valenciennes (1835: 183) were the first to realize this confusion and used the name for the East Indian species of Seba (1734: 104, pl. 33, fig. 3) which is easily recognized as *Paracanthurus* (see de Beaufort, 1951: 133, for further discussion). The Atlantic species of *Acanthurus* usually called *hepatus* must therefore be given another specific designation. *Acanthurus chirurgus* (Bloch) is the first available name.

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