DESCRIPTION OF LARVAL AND EARLY JUVENILE VERMILION SNAPPER, *RHOMBOPLITES AURORUBENS*[1]

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ABSTRACT

Larval and early juvenile development of vermilion snapper, *Rhomboplites aurorubens*, family Lutjanidae, is described and illustrated. Identification and description are based upon morphology, pigmentation, and meristics of 27 larval and 11 early juvenile specimens ranging from 4.0 to 14.2 mm standard length. All specimens were collected 65 km east of Sapelo Island, Ga., lat. 31°30'N, long. 80°30'W on 10 August 1972.

Larval and early juvenile vermilion snapper, *Rhomboplites aurorubens* (Cuvier), family Lutjanidae, are described from 27 larval and 11 small juvenile specimens collected at a station located approximately 65 km east of Sapelo Island, Ga., lat. 31°30'N, long. 80°30'W on 10 August 1972 (depth 22 m, surface temperature 26.7°C).

The genus *Rhomboplites* is monotypic and occurs only in the western Atlantic, from North Carolina and Bermuda to Rio de Janeiro, Brazil, including the Gulf of Mexico (Jordan and Evermann 1898; Hildebrand and Schroeder 1928; Hildebrand 1941; Anderson 1967; Böhlke and Chaplin 1968). Walker (1950) and Munro et al. (1973) reported *R. aurorubens* with mature ovaries during the cooler months, but Munro et al. (1973) suggested that some lutjanids may spawn throughout the year. I was unable to find any descriptions of lutjanid larvae. Small juveniles of the genera *Lutjanus* (Starck 1971; Heemstra 1974; Fahay 1975) and *Symphysanodon* (Fourmanoir 1973) have been illustrated.

METHODS

All specimens were collected by personnel aboard the U.S. National Marine Fisheries Service RV *Delaware II*. Ichthyoplankton was collected with a 60-cm diameter, 0.505-mm mesh, bongo net towed obliquely at 1.1 km/h (0.6 knot) from 20 m to the surface.

The specimens were stored in 3–5% buffered Formalin[3] after being removed from the sample (fixed in 10% buffered Formalin). Specimens were lightly stained with alizarin to facilitate measuring and counting body parts. One specimen (10.8 mm) was cleared and stained using the technique of Taylor (1967).

Illustrations were prepared using a camera lucida. Measurements were taken on the left side with an ocular micrometer. Measurements include:

Standard length (SL)—distance from tip of snout to posterior tip of notochord (before hypural formation) and tip of snout to posterior margin of hypurals (after hypural formation posterior to notochord tip).

Head length—distance (horizontal) from tip of snout to cleithrum.

Snout to anus—distance from tip of snout to posterior margin of anal opening.

Body depth—vertical distance between dorsal and ventral surfaces, to the ventral tip of the cleithrum.

Eye diameter—maximum diameter of eye.

Spine and fin ray lengths—distance from point of entry of spine or ray into flesh to distal tip.

IDENTIFICATION

Identification of the series was based on counts of small juvenile specimens which had 24 myomeres; 7 branchiostegal rays; XII, 11 dorsal fin

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spines and rays; III, 8 anal fin spines and rays; 17–18 pectoral fin rays; I, 5 pelvic fin spine and rays; 9+8 principal caudal fin rays. Taxa listed by Bailey et al. (1970) were checked for the counts listed above. Only *R. aurorubens* was found to have the above counts (Jordan and Evermann 1898; Hildebrand and Schroeder 1928; Anderson 1967; Böhlke and Chaplin 1968; Miller and Jorgenson 1973) among fishes inhabiting western North Atlantic waters less than 200 m deep. Larvae were linked to the juvenile specimens by similarities of morphology and pigmentation.

Future identifications of small larvae based upon this paper should be made with care since larvae of other lutjanids have not been described.

DESCRIPTION OF LARVAE AND JUVENILES

Only large larval and small juvenile stages are described since egg, yolk-sac, and small post yolk-sac stages were not available. Larvae are defined as all forms between yolk-sac absorption and differentiation of the adult complements of spines and soft rays in the fins. Transformation from larva to juvenile is gradually completed between 8.3 and 10.9 mm.

Pigmentation

Head pigmentation increases through the larval period (Figures 1, 2) with the smallest larva (4.0 mm) showing least pigmentation (Figure 1A). Head pigmentation includes a large stellate melanophore centered over the posterior portion of the midbrain and another on the ventral surface anterior to the tips of the cleithra (Figures 1, 2). The large dorsal melanophore is present on all larval and juvenile specimens except one which has a melanophore over each hemisphere of the midbrain on either side of the point where the central melanophore would be expected. A small area of internal pigmentation is also present ventral to the juncture of the midbrain and hindbrain. As the larvae increase in size, smaller stellate melanophores develop on each hemisphere of the midbrain anterior to the large central melanophore.

By 4.8 mm, a melanophore appears posterior to the dorsal tip of the opercle and 2 or 3 melanophores appear on the body beneath the opercle anterior to the cleithrum. Additional melanophores are added to the area of internal pigmentation ventral to the juncture of midbrain and hindbrain (Figure 1B).

There is a gradual increase of pigmentation over the forebrain and midbrain until melanophores form a cap of pigment over those structures (Figure 2B, C). From 15 to 20 melanophores per forebrain hemisphere and from 60 to 80 melanophores per midbrain hemisphere make up the cap in larger juvenile specimens (>10.0 mm). Three to five small melanophores appear at 9.0 mm scattered along the dorsal surface of the snout. On juveniles >10.0 mm, 8–12 small melanophores are scattered on the anterior portions of upper and lower lips.

Preanal body pigmentation includes dense peritoneal pigment which spreads ventrally in bands along the dorsolateral surface of the coelomic wall. The banding results from variations in size and spacing of discrete melanophores. Peritoneal pigmentation appears less distinct on largest juveniles due to an increase in overlying musculature. A pronounced melanophore occurs on the ventral surface anterior to the anus on all specimens <5.1 mm, and occasionally on those 5.1–6.3 mm, but is absent on individuals >6.3 mm.

A large stellate melanophore is present (on all specimens examined) internally on myomere 15, 16, or 17 above the posterior end of the anal fin near the ventral body margin (Figures 1A, B; 2A–C). Three to seven smaller melanophores develop anteroventrally to this spot along the bases of anal fin rays, appearing first on 4.7-mm larvae and occurring on all larger specimens (Figures 1C, 2). Posterior to the large internal melanophore, 1–4 melanophores occur on the ventral margin of specimens <7.0 mm. The number of melanophores present in this region is variable, tending to increase in number with body length, specimens >7.0 mm having 5–12.

A small melanophore appears on larvae 5.1–5.4 mm along the dorsal margin of myomere 21 or 22. Specimens >5.4 mm have 5–9 melanophores on the dorsal margin of the caudal peduncle (Figure 2B, C). At 4.9 mm, an internal melanophore appears dorsal to the point of notochord flexure and is present in all larger specimens examined (Figure 2A–C). An additional melanophore appeared anterior to this melanophore in two specimens, 8.7 and 10.5 mm long. Specimens with all principal caudal rays developed have 1–6 melanophores near the bases of the rays, usually on the lower 8 principal rays (Figure 2).

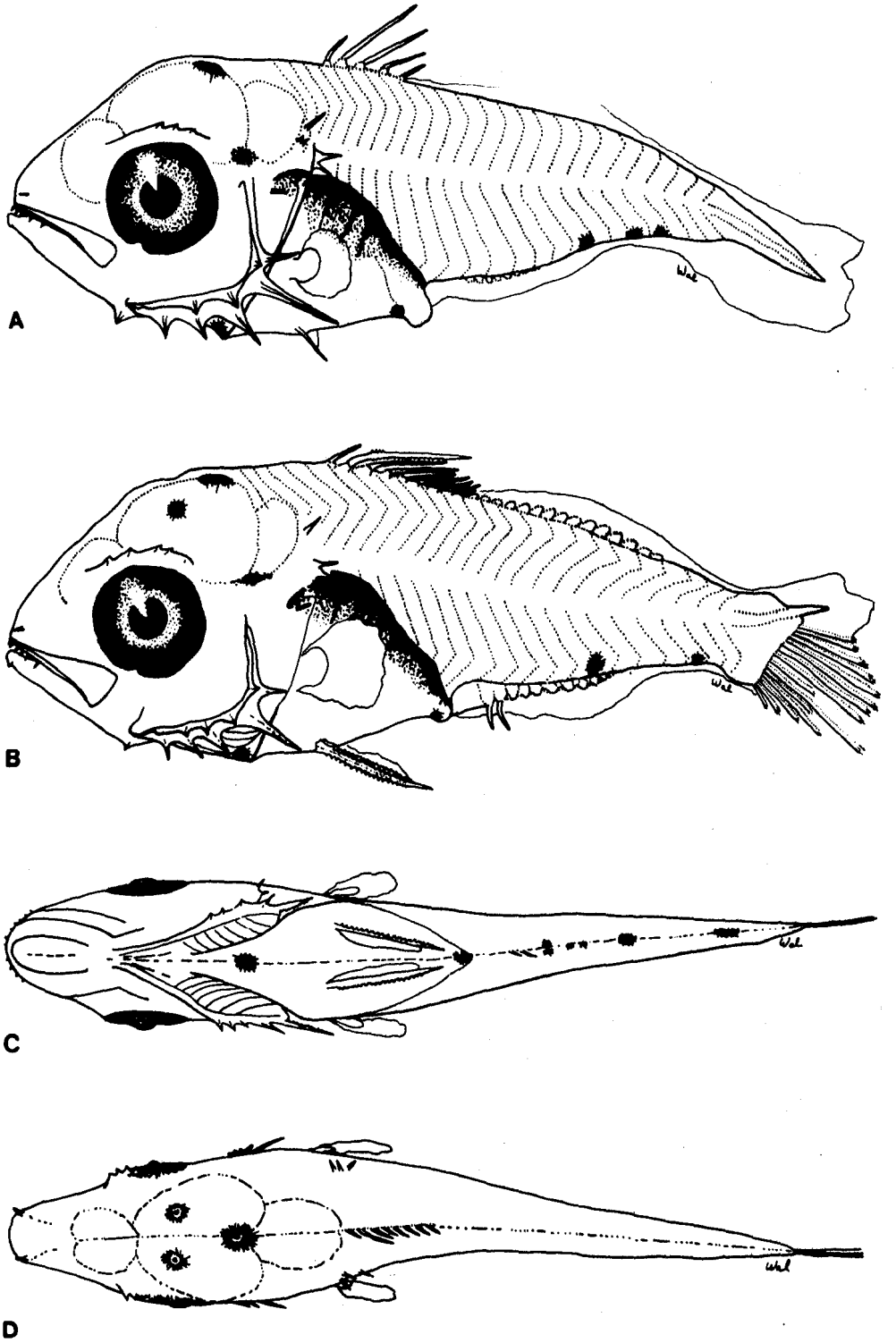

FIGURE 1.—Developmental stages of *Rhomboplites aurorubens:* A. 4.0-mm larva; B. 4.7-mm larva; C. 4.7-mm larva, ventral view; D. 4.7-mm larva, dorsal view.

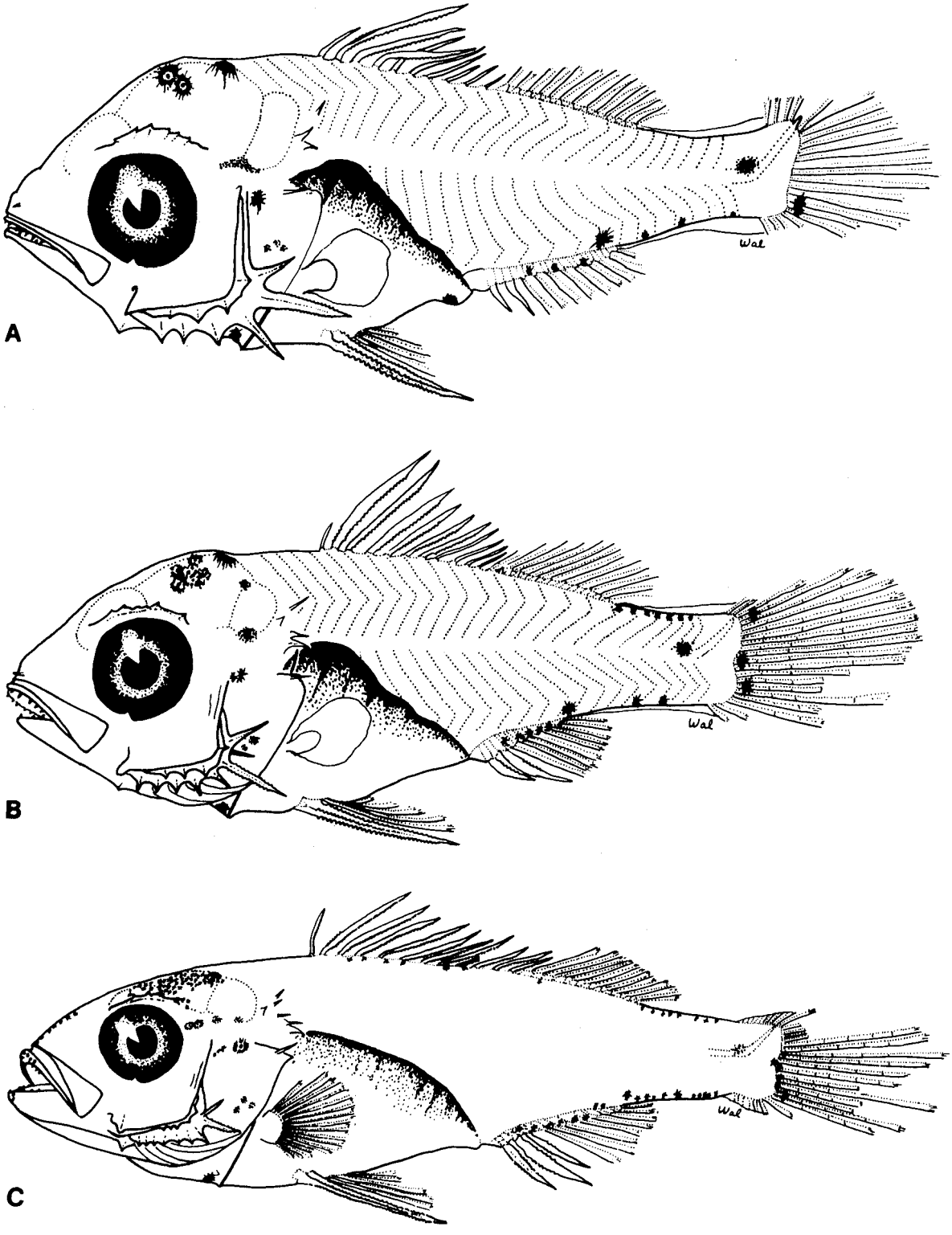

FIGURE 2.—Developmental stages of *Rhomboplites aurorubens:* A. 5.1-mm larva; B. 6.9-mm larva; C. 14.2-mm juvenile.

Fin Formation

Dorsal and pelvic fin formation begins by 4.0 mm (Figure 1A). Other fin development initiates in the following sequence: caudal, anal, and pectoral. The pelvic fins are first to complete development, while the dorsal fin is last.

Dorsal Fin

The anterior five dorsal spines are present on the smallest larva (4.0 mm) with an undifferentiated fin fold continuing to the caudal region (Figure 1A). The fin develops from anterior to posterior. At 4.8 mm, the adult number of dorsal fin elements appears with the posterior 1–3 spinous dorsal elements represented by soft rays.

Development of the dorsal fin occurs rapidly between 4.0 and 4.8 mm. After the adult number of fin-ray elements (23) appears, development towards the final adult dorsal fin complement (XII, 11) proceeds slowly as spines form from soft rays immediately posterior to the posteriormost spine. Dorsal spine development is similar to that described by Mansueti (1958) for anal spine development in *Roccus saxatilis*.

The dorsal fin is the last fin to attain the adult complement of spines and rays. Attainment of full dorsal fin complement between 8.3 and 10.9 mm marks the division between larval and juvenile stages.

The fourth dorsal spine is longest in adult *Rhomboplites aurorubens* (Jordan and Evermann 1898). The second dorsal spine is longest in all specimens of my series except the largest juvenile (14.2 mm) in which the third spine is longest (Figure 2C). The longest dorsal spine is longer than the longest dorsal soft ray throughout the series.

Dorsal spines are V-shaped in cross section, with the V open posteriorly. The two posterior edges are serrated nearly to the tip, which is sharp and oval in cross section. On larger spines the anterior edge is sometimes serrate for a short distance above the base (Figures 1B, 2B, C). Specimens between 4.8 and 9.0 mm have 29–40 serrations along each posterior edge of the second dorsal spine; larger specimens have 42–45 serrations.

Pelvic Fins

Pelvic fin spines and fin folds compose the pelvic fins of the 4.0-mm larva (Figure 1A). The pelvic fin attains the adult complement of I spine and 5 rays between 4.7 and 4.8 mm. The pelvic spine is long and serrate, extending slightly beyond the anus (24% SL) at its longest (about time of dorsal fin completion). Small specimens have spines which are V-shaped in cross section with serrations along all three edges. Specimens >4.5 mm have a double row of serrations along the leading edge of the spines creating an almost trapezoidal appearance in cross section (Figure 2).

Caudal Fin

The adult caudal fin has 17 principal and 19–21 procurrent rays (Miller and Jorgenson 1973). Principal rays are divided into two groups with 9 rays above and 8 rays below the midline of the body.

Notochord flexure occurs between 4.8 and 4.9 mm (Table 1). Flexure probably results in a slight decrease in standard length because the angle of the flexed notochord shortens the horizontal distance from snout tip to end of notochord. As a result of flexure and individual variation in rate of development, larvae of equal length may be at various stages of development (Table 1).

The caudal fin starts to form at the beginning of notochord flexure, about 4.7 mm. Fifteen or sixteen principal rays form simultaneously, slightly below and ventral to the posteroventral margin of the notochord. As the notochord flexes, these rays become elevated into the terminal position. The remaining rays are added dorsally and ventrally until the adult principal ray number is attained at about 4.8 mm (Figures 1B, 2A).

Anal Fin

The adult fin ray complement for vermilion snappers is III spines and 8 soft rays. Initial anal fin formation occurs at 4.7 mm. Embryonic fin rays (actinotrichia) are visible on 4.8-mm larvae. True soft rays (lepidotrichia) begin to form by 4.9 mm. The fin ray count remains II, 8 until about 5.4 mm and then becomes II, 9 (Table 1). The posteriormost ray forms last. The adult complement (III, 8) appears at about 8.3 mm as the anteriormost soft ray transforms into a spine. Each spine becomes serrate along its posterior edge, larger spines having a few serrations along the base of the anterior edge. The second anal spine is longest throughout the series studied, but in adults the third spine is longer.

TABLE 1.—Development of meristic characters of larval and small juvenile vermilion snapper, *Rhomboplites aurorubens*.

SL (mm)	Principal caudal fin rays		Dorsal fin		Anal fin		Pectoral fin rays	Pelvic fin		Notochord flexure
	Upper	Lower	Spines	Rays	Spines	Rays		Spines	Rays	
4.00			V					I		straight
4.13			VI					I		straight
4.67	8	7	VIII					I		straight
4.80	8	8	IX		II	8		I	5	flexed
4.80	9	8	XI	12	II	7		I	5	straight
4.80	9	8	X	13	II	8		I	5	flexed
4.87	9	8	X	13	II	8		I	5	flexed
4.93	9	8	X	13	II	8		I	5	flexed
4.93	9	8	X	13	II	8		I	5	straight
5.07	9	8	VIII	15	II	8		I	5	flexed
5.07	9	8	X	13	II	8		I	5	flexed
5.07	9	8	IX	14	II	8		I	5	flexed
5.07	9	8	IX	14	II	8		I	5	flexed
5.13	9	8	XI	12	II	8		I	5	flexed
5.27	9	8	X	13	II	8		I	5	flexed
5.40	9	8	X	13	II	9		I	5	flexed
5.46	9	8	XI	12	II	9		I	5	flexed
5.46	9	8	X	13	II	9		I	5	flexed
6.06	9	8	X	13	II	9		I	5	flexed
6.13	9	8	XI	12	II	9		I	5	flexed
6.26	9	8	XI	12	II	9		I	5	flexed
6.33	9	8	XI	12	II	9		I	5	flexed
6.40	9	8	XI	12	II	9		I	5	flexed
6.53	9	8	XI	12	II	9		I	5	flexed
6.53	9	8	XI	12	II	9		I	5	flexed
6.53	9	8	XI	12	II	9		I	5	flexed
6.93	9	8	XI	12	II	9	16	I	5	flexed
7.80	9	8	XI	—	II	9	16	I	5	flexed
8.26	9	8	XII	11	III	8	16	I	5	flexed
8.60	9	8	XI	12	III	8	17	I	5	flexed
8.66	9	8	XII	11	III	8	17	I	5	flexed
9.00	9	8	XI	12	III	8	17	I	5	flexed
10.00	9	8	XI	12	III	8	17	I	5	flexed
10.53	9	8	XII	11	III	8	17	I	5	flexed
10.80	9	8	XII	11	III	8	17	I	5	flexed
10.93	9	8	XI	12	III	8	18	I	5	flexed
11.20	9	8	XII	11	III	8	17	I	5	flexed
14.20	9	8	XII	11	III	8	17	I	5	flexed

Pectoral Fins

The pectoral fins are the last to begin development, embryonic rays becoming visible at about 4.9 mm. Ray formation proceeds from dorsal to ventral. True rays begin to form at about 6.9 mm, the adult complement, 17–18 rays, appearing by 8.6 mm.

Pectoral fin rays were frayed and broken on many specimens (including the specimen in Figure 2C). Longest pectoral fin rays without obvious damage were 11.9–15.0% SL, having no obvious within range correlation with standard length.

Head

All larvae have one small spine projecting from the posterodorsal portion of the operculum. This spine is very small and difficult to locate on small specimens (Figures 1, 2).

The preopercle is armed with two rows of spines. The smaller spines are located proximally along the margin of the preopercular crest, and the larger spines occur distally along the preopercular margin (Figures 1, 2). Both preopercular crest and preopercular margin have an upper (ascending) and lower (horizontal) margin which form approximately right angles.

Specimens <5.0 mm have 2 or 3 spines along the lower margin and 1 spine on the upper margin of the preopercular crest. Larger specimens have 3 or 4 spines along the lower and 1 or 2 spines along the upper margins (Figures 1, 2). Spines increase in size towards the angle of the preopercular crest.

Three spines are present along the lower margin of the preopercular margin on specimens <4.0 mm, 4 spines on specimens 4.0–5.4 mm, 5 spines on specimens 5.4–9.0 mm, and 6 or 7 spines on specimens >9.0 mm. These spines increase in size towards the angle of the margin, larger spines being serrated on juvenile specimens. A large, stout, and serrate spine occurs at the preopercular angle in all specimens. Length of the angle spine was 6.5% SL on the smallest larva (4.0 mm). All

other specimens <8.0 mm had angle spines which were 10.1–14.6% SL, averaging 12.6%. Specimens >8.0 mm had angle spines which were 7.0–13.1% SL, averaging 9.7%. The largest juvenile (14.2 mm) had the smallest spine within this group (7.0%). One spine occurred on the upper margin of the preopercular margin of all specimens examined, with a smaller spine occasionally occurring between it and the angle spine (Figure 2B).

The posttemporal has 1 or 2 sharp spines projecting posterodorsally; the supracleithrum, 2–5 similar spines; the number of spines increasing with growth (Figures 1, 2). The supraocular crest has 2–7 serrations which increase in number with growth. A sharp projection which appears to be the anterior tip of the lachrymal bone projects anteriorly and slightly ventrally from each side of the snout on all specimens.

The eye is nearly circular and has a ventral cleft (Figures 1, 2).

Conical teeth are present on premaxillary and dentary of all specimens; vomerine and palatine teeth, on 14.2-mm specimen.

TABLE 2.—Measurements of body parts for larval and juvenile vermilion snapper, *Rhomboplites aurorubens*, in millimeters.

SL	Head length	Snout to anus	Depth	Eye diameter
4.00	1.53	2.00	1.32	0.52
4.13	1.69	2.23	1.42	0.60
4.67	1.90	2.67	1.65	0.62
4.80	1.92	2.53	1.65	0.68
4.80	2.13	2.93	1.85	0.75
4.80	1.92	2.80	1.82	0.68
4.87	2.03	2.73	1.75	0.70
4.93	2.20	2.97	1.88	0.75
4.93	1.87	2.93	1.88	0.70
5.07	2.11	2.93	1.82	0.72
5.07	2.13	2.93	1.84	0.72
5.07	2.26	3.13	1.82	—
5.07	2.00	2.87	1.85	0.70
5.13	2.13	3.00	1.88	0.72
5.27	2.21	3.20	1.85	—
5.40	2.26	3.20	2.00	0.75
5.46	2.21	3.27	1.92	0.78
5.46	2.24	3.20	2.08	0.80
6.06	2.52	3.60	2.08	0.85
6.13	2.55	3.53	2.18	0.85
6.26	2.52	3.73	2.30	0.90
6.33	2.65	3.77	2.20	0.90
6.40	2.55	3.87	2.28	0.91
6.53	2.83	4.00	2.38	0.92
6.53	2.68	4.13	2.20	0.90
6.53	2.65	4.00	2.50	0.88
6.93	2.78	4.33	2.40	0.95
7.80	3.12	5.06	2.60	1.05
8.26	3.27	5.33	2.67	1.12
8.60	3.07	5.27	2.93	1.15
8.66	3.33	5.47	2.93	1.12
9.00	3.40	5.60	2.93	1.12
10.00	3.53	6.13	3.20	1.30
10.53	3.73	6.73	3.47	1.35
10.93	4.00	6.73	3.47	1.35
11.20	3.93	7.00	3.53	1.40
14.20	4.93	8.46	4.00	1.48

Body Growth

Measurements of body parts is presented in Table 2. The growth of various body parts as related to standard length is described by linear regression analysis using Bartlett's three-group method for Model II regression (Sokal and Rohlf 1969). Statistics for regressions of head length, depth of body, snout to anus distance, and eye diameter versus standard length are presented in Table 3. Correlation coefficients are greater than 0.97 for all relationships.

TABLE 3.—Statistics describing regressions of body measurements versus standard length for larval and small juvenile vermilion snapper, *Rhomboplites aurorubens*. The x variable is standard length in all cases.[1]

Variable y	Size range (mm)	$\bar{x}$	$\bar{y}$	N	b	a	$S_{y \cdot x}$	r
Head length	4.00–14.20	6.64	2.62	37	0.326	0.454	0.217	0.988
Body depth	4.00–14.20	6.64	2.28	37	0.285	0.388	0.198	0.986
Snout to anus	4.00–14.20	6.64	4.01	37	0.672	−0.450	0.185	0.995
Eye diameter	4.00–14.20	6.73	0.91	35	0.110	0.170	0.090	0.978

[1] $\bar{x}$ = mean value of x, $\bar{y}$ = mean value of y, N = number of specimens examined, b = rate of increase of y with respect to x, a = regression line intercept, $S_{y \cdot x}$ = standard deviation from the regression, r = correlation coefficient.

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