REDESCRIPTION OF LARVAE OF THE PIGFISH, *ORTHOPRISTIS CHRYSOPTERA* LINNAEUS (PISCES, HAEMULIDAE)

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ABSTRACT

A size series of larval pigfish, *Orthopristic chrysoptera*, was assembled from specimens collected from the lower Cape Fear River Estuary, North Carolina, and from the gulf coast of Texas. Larvae are rather heavily pigmented, principally along the ventral midline. Specimens up to about 9 mm SL have 13 to 19 ventral melanophores along the tail with those between the 19th and 22d myomeres typically larger. A dorsal melanophore usually is present above the largest ventral melanophore. At about 9 mm SL midlateral pigmentation begins near the peduncle and internal pigment appears posteriorly above and below the vertrbral column. By about 15 mm SL a distinct pattern of dorsal, lateral, and ventral longitudinal stripes is present. Pigfish larvae may be separated from similar cooccurring species by various combinations of pigment pattern, very small preopercular spines, and myomere and fin ray counts.

Larval development of the pigfish, *Orthopristis chrysoptera*, was described by Hildebrand and Cable (1930) based on reared yolk-sac stage larvae and older field specimens collected near Beaufort, N.C. They described yolk-sac stage larvae as having a barred pattern, with dorsal and ventral melanophores on the trunk at the level of the anus and at midtail, but stated that preserved larvae between about 3 and 15 mm were unpigmented. Scotton et al. (1973) illustrated a 12.3 mm larva with series of melanophores along the ventral and lateral midlines of the tail, and a few dorsally on the head. Johnson (1978) summarized these earlier descriptions, but added no new information.

Pigfish larvae collected from the lower Cape Fear River Estuary, N.C., differed from Hildebrand and Cable's (1930) description in that they maintained the barred pattern well past the yolk-sac stage, and had considerable pigment along the ventral midlines of the gut and tail throughout the larval period. Pigfish larvae from the northern Gulf of Mexico were examined subsequently and found to be pigmented in these same areas.

Since larval pigment of pigfish is heavier and more persistent than previously described, larval development (emphasizing pigment) is redescribed here, based principally on specimens from the Cape Fear River Estuary. Specimens larger than 9.2 mm are from the northern Gulf of Mexico, since larvae of this size were not taken in the Cape Fear River Estuary.

MATERIALS AND METHODS

Larvae were collected from the lower Cape Fear River Estuary in May and June 1977 with 0.5 mm mesh nets of approximately 0.6 m^2 mouth area, towed at ca. 0.5 m/s (Copeland et al 1979[2]). Samples were fixed immediately in the field in unbuffered 5-10% Formalin,[3] and the pigfish larvae subsequently removed were stored in 2.5% seawater-Formalin.

Larvae were examined under a dissecting microscope equipped with an ocular micrometer. Counts and measurements (made to the nearest 0.04 mm and reported to the nearest 0.1 mm) were made on the left side. The following dimensions were recorded: Total length, standard length, head length, snout length, eye diameter, preanal length, and depth at pectoral fin insertion. These measurements are defined by Saksena and Richards (1975). Lengths given in the text refer to standard length unless otherwise specified. Drawings were made with the aid of a camera lucida. All specimens were lightly stained with alizarin to aid in drawing and in counting fin rays and preopercular spines. Two larvae (11.8 and 13.2 mm) were cleared and stained following the method of Hollister (1934).

Descriptions are based on 19 Cape Fear and 4 Gulf of Mexico specimens; 26 additional postflexion Gulf of Mexico specimens were briefly examined for

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[2]Copeland, B. J., R. G. Hodson, and R. J. Monroe, 1979. Larvae and postlarvae in the Cape Fear Estuary, N. C., during operation of the Brunswick Steam Electric Plant 1974-1978. Report 79-3 to Carolina Power and Light Co., Raleigh, N.C.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

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pigmentation and found to conform with the description given here.

DESCRIPTION OF LARVAE

Pigmentation

The pigfish larva in the late yolk-sac stage (2.5 d; 3 mm) illustrated by Hildebrand and Cable (1930, fig. 27) is shown with large dorsal and ventral melanophores at myomeres 18-19, and a smaller pair at myomeres 9-10. Just after the yolk-sac stage, larvae from the Cape Fear River Estuary retain dorsal melanophores at myomeres 9-10 and between myomeres 18 and 21. The anterior dorsal melanophore rarely persists beyond 4 mm, while the posterior one (sometimes two) usually remains throughout the larval period (present in 13 of the 19 Cape Fear specimens; Figs. 1 and 2). This posterior dorsal melanophore(s) lies at the terminus of the dorsal fin in older larvae. About concurrently with completion of the dorsal fin (ca. 10.9 mm) additional melanophores develop posteriorly, forming a pigment patch just behind the fin. More patches are sub-

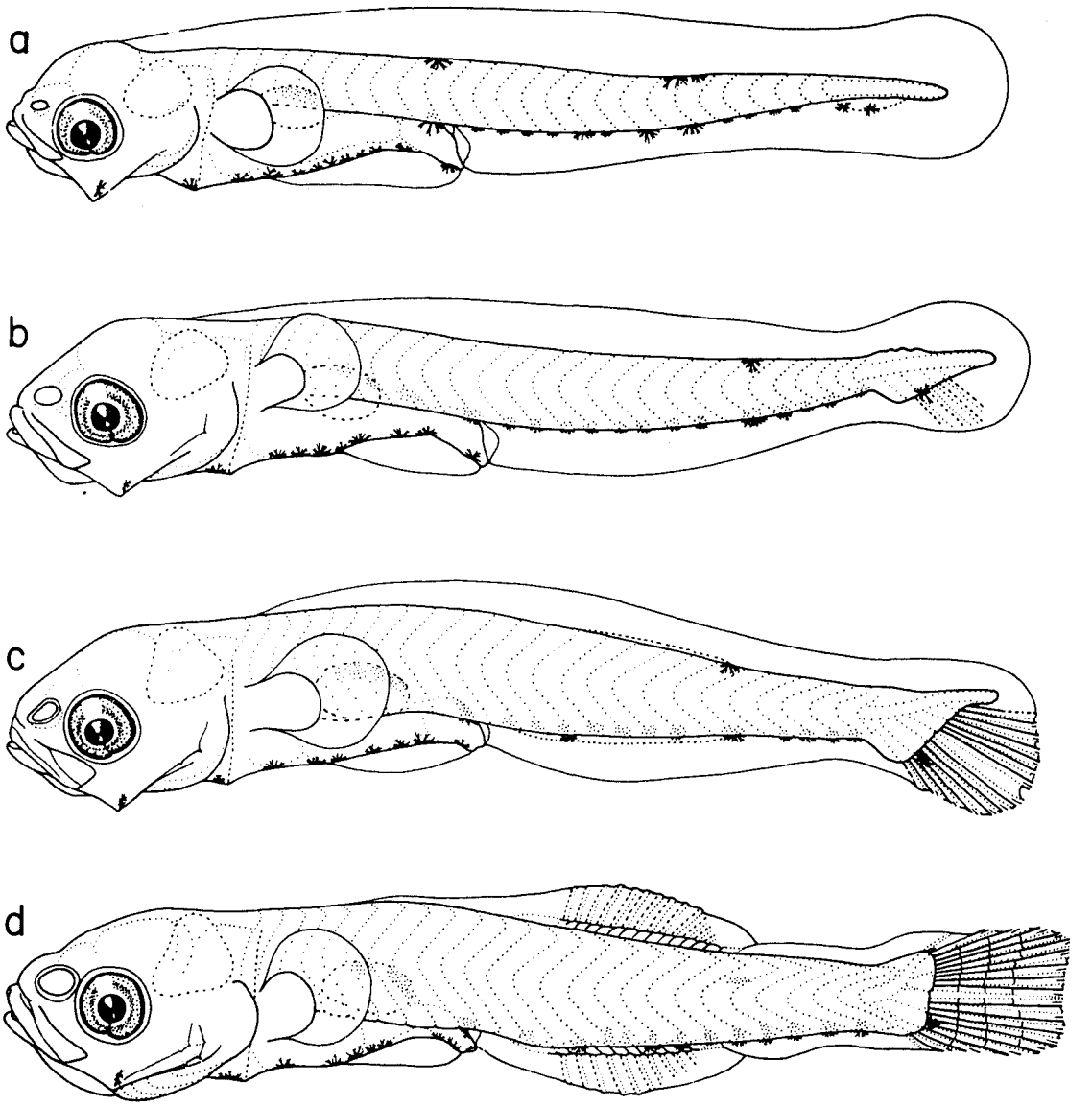


FIGURE 1.—*Orthopristis chrysoptera*; a. 4.2 mm; b. 5.6 mm; c. 6.4 mm; d. 7.3 mm. All specimens are from North Carolina.

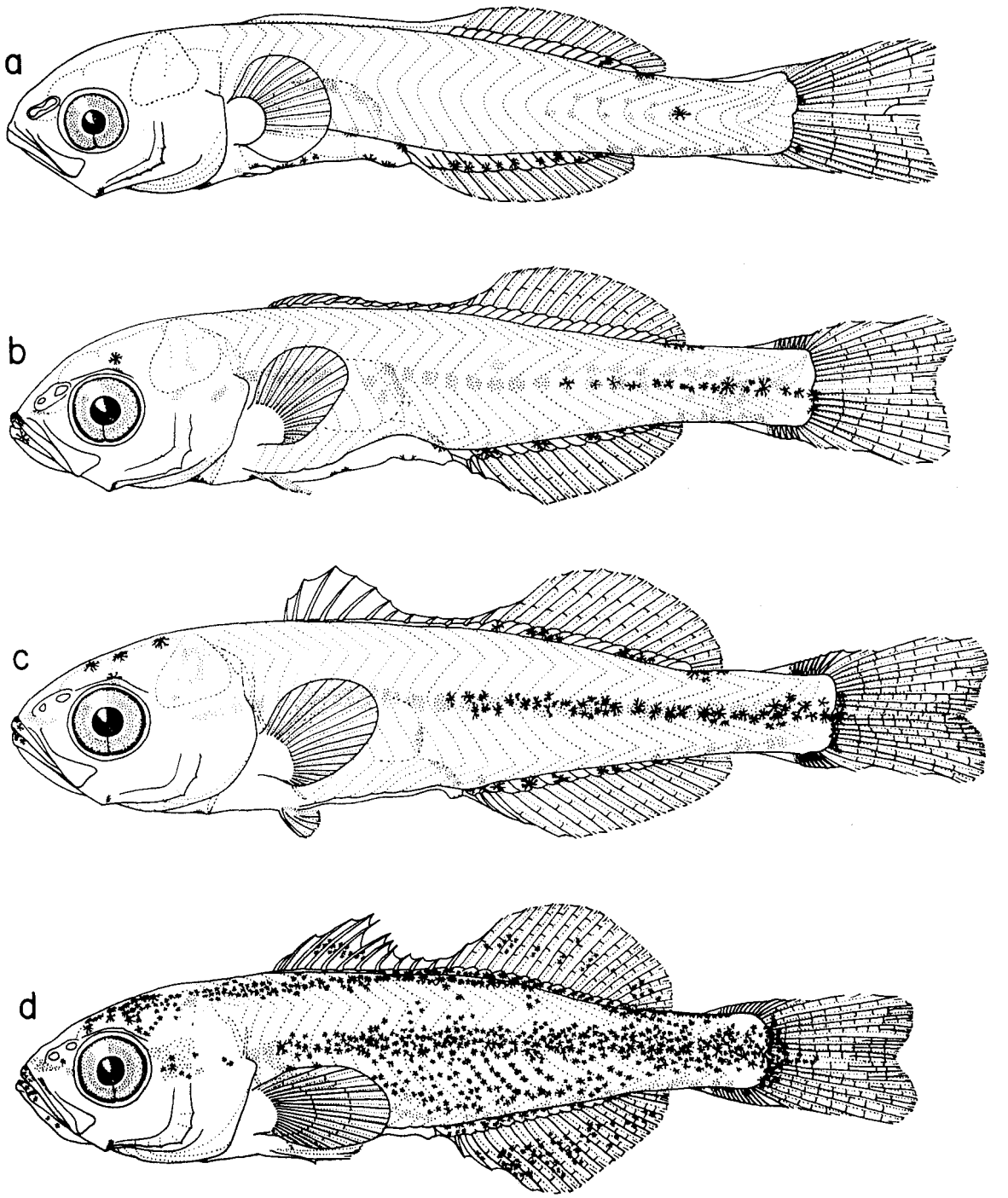


FIGURE 2.—*Orthopristis chrysoptera*; a. 9.2 mm; b. 1.1 mm; c. 12.7 mm; d. 15.8 mm. Specimen "a" is from North Carolina; specimens "b" through "d" are from the gulf coast of Texas.

sequently added from posterior to anterior along the dorsal fin ray bases (Fig. 2c) so that by the end of the larval period (ca. 16 mm) a continuous pigment line lies along each side of the dorsal midline. Melanophores develop on the membrane between the dorsal fin rays at this time (Fig. 2d).

Ventral tail pigment through most of the larval period consists of 12 to 17 melanophores arrayed along the length of the tail. Those at myomeres 17 to 21 (usually at 19 to 21) are distinctly larger, usually dendritic (Fig. 3), and correspond to the posterior ventral melanophore illustrated by Hildebrand and Cable (1930) in a 3 mm specimen. Larvae smaller than 5.7 mm typically have two or three enlarged ventral melanophores, while larger specimens have none to two. These lie at the posterior end of the anal fin in larger specimens. Melanophores behind the developing anal fin base (except the last melanophore) extend internally during notochord flexion. Those between the anus and myomere 19 or 20 extend internally early in larval development, but tend to move downward onto the developing anal fin ray bases during late flexion. They usually are located entirely along the sides of the anal fin ray bases in postflexion larvae (Figs. 2, 3). The last ventral melanophore is associated with the developing caudal complex and becomes located along the lower hypurals during notochord flexion. Melanophores proliferate along the distal hypural edge in postflexion larvae, forming a bar. Near the end of the larval period melanophores extend from the bar along the central caudal rays. At this time, melanophores also develop on the membranes between the dorsal and anal fin rays (Fig. 2d).

Lateral pigment is first evident in postflexion larvae (ca. 7.3 mm) as an internal melanophore above the notochord at myomere 20 or 21. Melanophores are added, first ventrally and then laterally, along the vertebrae both caudad and cephalad. The cephalad extension proceeds more rapidly. Hildebrand and Cable (1930, fig. 33) apparently illustrated this internal pigmentation in an 11 mm specimen, but did not mention it in the text. External pigment develops posteriorly along the lateral midline soon after the beginning of the cephalad extension of the vertebral melanophores (Fig. 2a). This external pigment proliferates both cephalad and caudad (more rapidly cephalad), but always lags behind the vertebral pigment (Fig. 2b). When the lateral pigment band reaches the level of the anus, it begins to widen as well (Fig. 2c), forming a broad lateral stripe from the opercular margin onto the central caudal fin rays by the

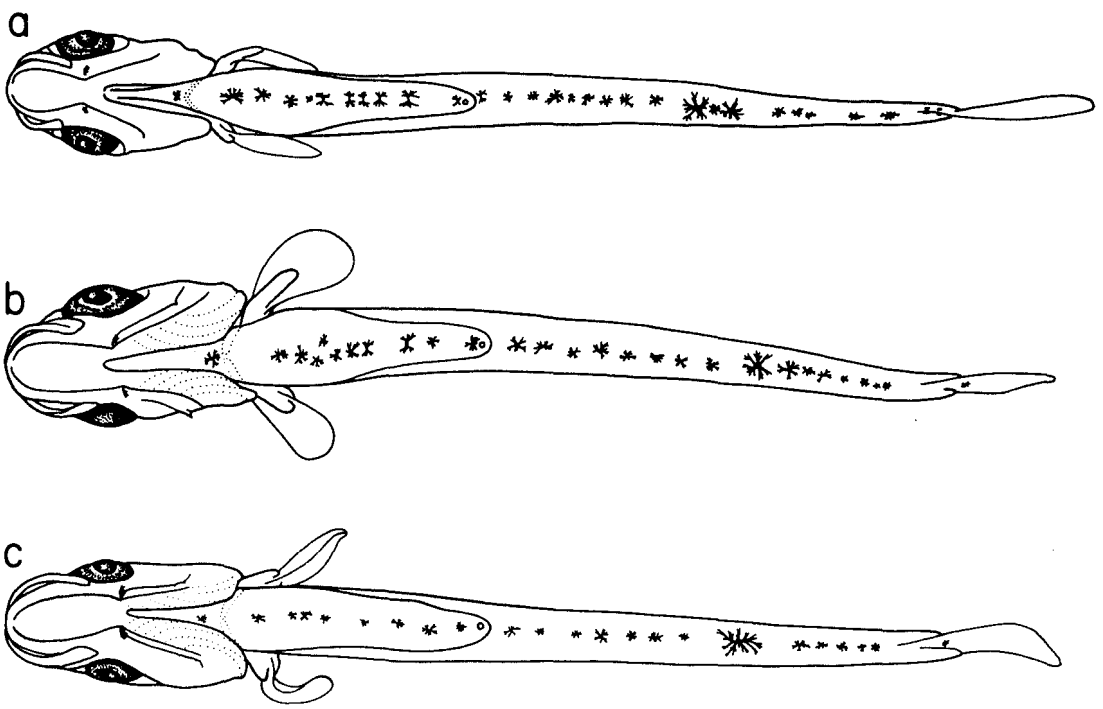


FIGURE 3.—Ventral view of *Orthopristis chrysoptera*; a. 4.2 mm; b. 5.6 mm; c. 6.4 mm; d. 7.3 mm; e. 9.2 mm;

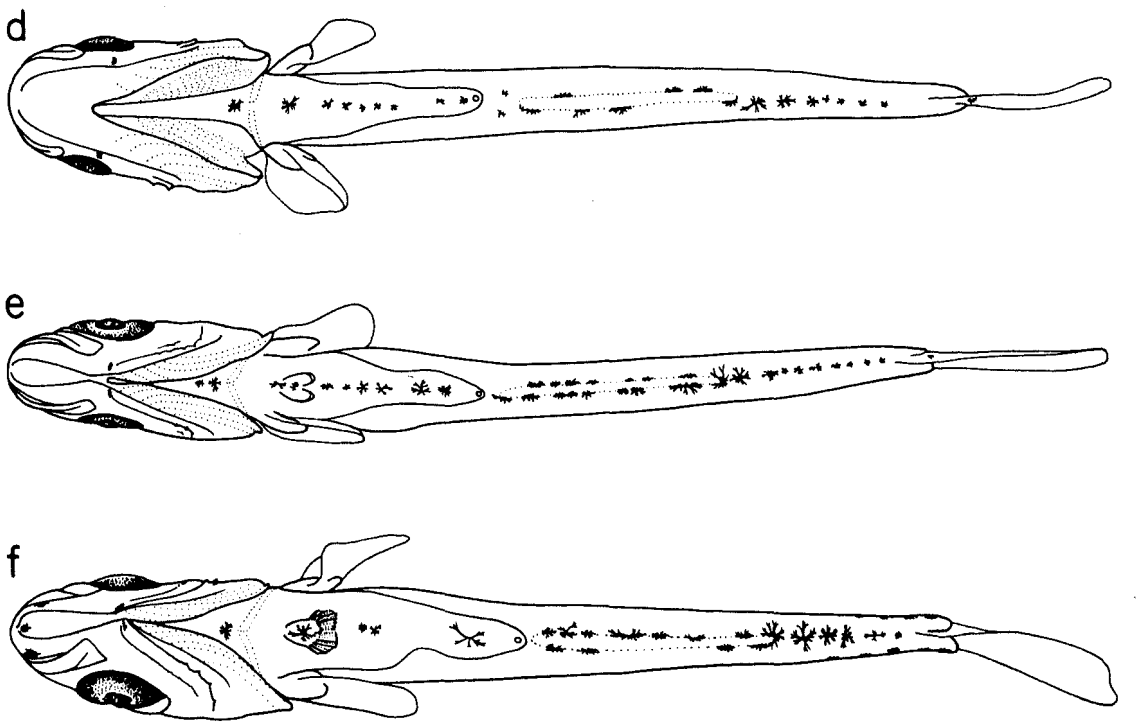
end of the larval period (Fig. 2d). Myoseptal melanophores develop late in the larval stage, particularly on the lower half of the body between about the level of midgut and the peduncle.

The gut and isthmus are moderately pigmented along their ventral midlines through notochord flexion: 6 to 11 melanophores are arrayed between the cleithral symphysis and the anus (Fig. 3). This number decreases in postflexion larvae, but at least one melanophore remains between the pelvic fin bases together with two or three between the pelvic bases and anus. One or two midline melanophores precede the cleithral symphysis throughout larval development.

Dorsal visceral pigment through most of the larval period consists of a single large melanophore over the hindgut where it turns down at the 9th or 10th myomere, and several melanophores over the posterior dorsal surface of the swim bladder. Occasionally a second melanophore lies over the hindgut between these areas. Swim bladder pigment extends forward to cover the entire dorsal surface during late postflexion. At this same time pigment proliferates over the hindgut and anterior to the swim bladder to form a band continuous with the vertebral pigment.

Pigfish larvae retain a melanophore at the angle of the lower jaw throughout the larval period. A melanophore may sometimes occur under the hindbrain before notochord flexion but this typically is absent until after notochord flexion. Pigment proliferates rapidly under the hindbrain in postflexion larvae, forming a continuous line with the vertebral and dorsal gut pigment. Pigment develops on the roof of the mouth during late postflexion, completing an internal stripe extending the length of the body. Near the end of the larval period pigment develops around the posterior midbrain and anterior hindbrain. Pigment may appear along the upper lip at ca. 9 mm, but is not consistently present until ca. 11 mm. Pigment develops along the lower lip at ca. 11 mm. External melanophores appear at the nostril and behind the eye at the end of the larval period, completing a nearly continuous external midlateral stripe extending along the entire length of the fish (Fig. 2d).

Dorsal head pigment first develops above the midbrain in postflexion larvae (Fig. 2b) at ca. 11 mm. This pigment proliferates rapidly to form longitudinal head stripes which become continuous with the dorsal trunk stripes by the end of the larval period (Fig. 2d). Pigfish larvae at this stage, although more heavily pigmented, display nearly the same pattern described by Hildebrand and Cable (1930).



f. 11.1 mm. Specimens "a" through "e" are from North Carolina; specimen "f" is from the gulf coast of Texas.

Morphology

Measurements of the 23 larvae examined are summarized in Table 1. All body parts measured increase relative to standard length with increasing larval length. However, these changes are small. The greatest changes are in body depth and preanal length relative to standard length, from means of 0.15 and 0.47, respectively, for preflexion-stage larvae to means of 0.21 and 0.52, respectively, for postflexion-stage larvae. Despite these small changes in proportions, the relationships of body parts with standard length are adequately described by straight lines (Table 2). These pigfish larvae are slightly more robust than those described by Hildebrand and Cable (1930).

The sequence of fin ray differentiation is as follows: Principal caudal, second dorsal and anal, pectoral, first dorsal, pelvic, and secondary caudal. Differentiation of the first anal fin ray into the third anal fin spine is delayed until after the larval stage. The following description of fin development refers to discernible, but not necessarily ossified, structures.

Fin development generally is as described by Hildebrand and Cable (1930). The caudal anlage is developing in the smallest specimen examined (3.8 mm). Notochord flexion begins between 4.8 and 5.5 mm and is complete by ca. 7 mm. Principal caudal fin rays begin developing during notochord flexion, with the full complement of 9 + 8 attained just after flexion (Table 3). Secondary caudal rays begin to develop after ca. 9.2 mm but before 10.9 mm, with the full complement of 13 + 12 present at the end of the larval period (ca. 16 mm).

Anal and dorsal fin anlagen develop simultaneously during late flexion (between ca. 5.8 and 6.2 mm). The dorsal fin base initially extends between myomeres 14 and 19 but elongates to between myomeres 4-5 and 20-21. Differentiation of second dorsal fin ray supports begins at 6.4 to 7.0 mm followed by the rays at 7.2 to 9.0 mm. Dorsal spines develop between 9.0 and 10.9 mm. The full dorsal fin complement of 12 spines and 15 to 17 soft rays is acquired by 10.9 mm. The anal fin base initially lies between myomeres 11-12 and 19, and ultimately extends caudad to myomere 20-21. Anal fin ray support differentiation begins almost simultaneously with the second dorsal fin ray supports. Anal fin rays are first discernible between 7.2 and 9.0 mm. All anal fin elements are present by ca. 10.9 mm but the third anal spine does not ossify from the first ray until well into the juvenile stage (at ca. 31 mm).

Pelvic fin buds appear near the end of notochord flexion, and pelvic fin rays begin differentiating at ca. 10.9 mm. The full complement of elements (I,5) is present by ca. 11.1 mm (Table 3).

Upper pectoral fin rays first differentiate in postflexion larvae at ca. 9.0 mm. The full complement of 19 rays is present at the end of the larval period.

The first preopercular spine appears at the angle in preflexion larvae (ca. 4.8 mm). A second spine is added on the lower preopercular margin during flexion (ca. 6.2 mm) and a third on the upper margin just after flexion (ca. 7.3 mm). Fourth and fifth spines subsequently appear along the lower and upper margins, respectively. A second, more anterior, row of one to three very small preopercular spines may develop during notochord flexion. All of these spines are short: The longest is no more than 10% of the eye diameter.

All gill rakers are present by ca. 13.2 mm (5 upper + 1 + 11 lower).

TABLE 1.—Summary of measurements (in mm) of larval *Orthopristis chrysoptera*. Specimens between dashed lines are undergoing notochord flexion.

Total length	Standard length	Preanal length	Head length	Snout length	Eye diameter	Depth
—	3.8	1.8	0.7	0.2	0.2	0.6
4.2	4.0	1.9	0.9	0.2	0.3	0.6
4.4	4.2	2.0	0.8	0.2	0.3	0.6
4.9	4.8	2.3	1.1	0.3	0.3	0.7
5.0	4.8	2.3	1.2	0.4	0.4	0.7
—	5.5	2.6	1.2	0.3	0.4	0.8
—	5.5	2.6	1.2	0.3	0.4	0.8
5.8	5.6	2.6	1.3	0.3	0.4	0.8
—	5.7	2.6	1.3	0.3	0.4	0.8
—	5.7	2.7	1.4	0.4	0.4	0.9
6.0	5.8	2.7	1.7	0.4	0.4	0.8
—	6.2	3.2	1.5	0.4	0.4	1.0
7.1	6.4	3.2	1.6	0.4	0.4	1.0
—	6.4	3.2	1.6	0.4	0.5	1.1
8.1	7.0	3.6	1.9	0.5	0.5	1.2
8.4	7.2	3.7	1.6	0.6	0.6	1.4
8.4	7.3	3.7	2.0	0.5	0.5	1.3
—	8.8	4.6	2.6	0.7	0.8	1.8
10.5	9.2	4.6	2.6	0.6	0.7	1.7
[1]12.8	10.9	6.1	3.0	0.8	1.0	2.2
[1]12.7	11.1	6.0	3.2	0.8	1.0	2.4
[1]15.1	12.7	7.0	3.8	1.0	1.2	2.9
[1]18.5	15.8	8.7	4.8	1.3	1.5	3.8

[1]Specimens from Texas.

TABLE 2.—Summary of regressions of measurements of body parts (y) on standard length (x) of larval *Orthopristis chrysoptera*.

y	n	r	Regression equation
Preanal length	23	0.998	$y = -0.573 + 0.590x$
Head length	23	0.995	$y = -0.575 + 0.343x$
Snout length	23	0.986	$y = -0.152 + 0.091x$
Eye diameter	23	0.993	$y = -0.184 + 0.103x$
Depth at pectoral fin origin	23	0.993	$y = -0.636 + 0.272x$

TABLE 3.—Summary of counts from larval *Orthopristis chrysoptera*. Specimens between dashed lines are undergoing notochord flexion. The presence of a fin anlage is denoted by "A".

Standard length (mm)	Myomeres		Caudal fin rays			Dorsal fin		Anal fin rays	Pectoral fin rays	Pelvic fin rays
	Precaudal	Caudal	Dorsal secondary	Primary	Ventral secondary	Spines	Rays			
3.8	9	17		A						
4.0	10	16		A						
4.2	9	18		A						
4.8	9	17		A						
4.8	9	17		4						
5.5	10	16		A						
5.5	10	16		A						
5.6	10	16		A						
5.7	10	16		A						
5.7	9	17		4						
5.8	10	16		10						
6.2	10	16		12			A	A		
6.4	10	16		12			A	A		
6.4	10	16		14			A	A		Bud
7.0	9	16		16			A	A		Bud
7.2	10	17		17			14	12		Bud
7.3	10	16		17			A	A		
8.8	10	16		17			A	A		Bud
9.2	10	16		17			14	13	10	Bud
[1]10.9	11	15	8	17	7	XII	16	11,14	17	I,4
[1]11.1	12	14	8	17	7	XII	16	11,14	17	I,5
[1]12.7	12	14	9	17	8	XII	15	11,14	19	I,5
[1]15.8	12	14	13	17	12	XII	17	11,15	19	I,5

[1]Specimens from Texas.

IDENTIFICATION

Larvae of haemulids resemble those of several other families, most notably gerreids, lutjanids, sparids, and some sciaenids. Gerreids, lutjanids, and sparids can be separated from haemulids by myomere count: 24 versus the 26 or 27 of haemulids. Sciaenids have 24 to 29 vertebrae (most species have 25) but are deeper bodied and often have a shorter gut than the described haemulid larvae. Sciaenids frequently have heavier preopercular armature as well (Johnson 1978). Counts of dorsal soft fin rays allow easy separation of older specimens: Most sciaenids have 19 or more while the western Atlantic haemulids have 18 or fewer (Miller and Jorgenson 1973).

Postflexion specimens of *Orthopristis chrysoptera* are easily separated from other haemulids with which they may occur by using anal fin ray counts. No other species has more than 11 soft rays (Table 4). Separation of smaller specimens may be much more difficult, since larvae of most of the western Atlantic haemulids are undescribed.

Larval *Haemulon plumieri*, described by Saksena

TABLE 4.—Fin ray and vertebral counts of haemulid species which may occur with *Orthopristis chrysoptera* along the Atlantic and gulf coasts of the United States.

Species	Dorsal fin rays	Anal fin rays	Pectoral fin rays	Vertebrae	Source[1]
Anisotremus virginicus	XII, 16-17	III,10-11	17-18	10+16-17	1,2
A. surinamensis	XI-XII,16-18	III,9	18-19	10+16	1,2
Conodon nobilis	XII,13	III,7		10+16	1
Haemulon album	XII,16-17	III,5-8	18-19	10+16	1,3
H. aurolineatum	XIII,14-16	III,7-9	16-18	10+16	1,3
H. chrysargyreum	XII,12-14	III,9-10	15-17	10+16	1,3
H. flavolineatum	XII,14-15	III,7-9	16-17	10+16	1,3
H. macrostomum	XII,15-17	III,8-9	17-18		3
H. melanurum	XII,15-17	III,7-9	16-18	10+16	1,3
H. parrai	XII,16-19	III,8-9	16-17		3
H. plumieri	XII,15-17	III,8-9	16-17	10+16	1,3
H. sciurus	XII,15-17	III,8-9	15-17		3
H. striatum	XIII,12-15	III,7-9	17-19	10+16-17	1,3
Orthopristis chrysoptera	XII-XIII,15-16	III,12-13	19	10-16	1,4,5
Pomadasys crocro	XIII,11-12	III,7			4

[1] 1 Miller and Jorgenson (1973).
2 Hoese and Moore (1977).
3 Courtenay (1961).
4 Walls (1975).
5 This study.

and Richards (1975), closely resemble *O. chrysoptera*. *Haemulon plumieri* larvae between the end of yolk-sac absorption and late flexion lack the dorsal trunk pigment typically present in *O. chrysoptera*, and apparently lack the enlarged midventral trunk melanophore(s) at all sizes (Saksena and Richards 1975). Both species develop preopercular spines at about the same size, but *H. plumieri* acquires more, with those in the posterior series larger than the corresponding spines of *O. chrysoptera*.

Larvae of other species of *Haemulon* have not been described. Assuming that they resemble *H. plumieri*, the combination of slightly different trunk pigment and somewhat longer preopercular spines may allow separation of smaller specimens. Larvae of the Atlantic species of *Conodon* and *Pomadasys* have not been described. A juvenile (17.3 mm) *Conodon nobilis* illustrated by Heemstra (1974) has rather long preopercular spines, suggesting that this character may be useful in separating the larvae. Likewise, if larval *Pomadasys* from the Atlantic resemble larval *Pomadasys* from the Indo-Pacific, then they also may be distinguished from *O. chrysoptera* by having more, and longer, preopercular spines (Nellen 1973; Leis[4]).

De Sylva (1970) illustrated a 16.5 mm specimen of *Anisotremus virginicus* which was deeper bodied and much more lightly pigmented than *O. chrysoptera* of the same size. *Anisotremus virginicus* is being described from reared larvae by Potthoff et al.[5] The similarity between *A. virginicus* and *A. davidsonii* from the eastern Pacific (Watson and Walker[6]) indicates that *Anisotremus* can be separated from *O. chrysoptera* by being deeper bodied (mean depth 25% of SL for *A. davidsonii* vs. mean depth 17% of SL for *O. chrysoptera*) and by having more and longer preopercular spines than *O. chrysoptera*.

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