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Early development of fat snook, *Centropomus parallelus* (Poey 1860) (Teleostei, Centropomidae) from Southeastern Brazil

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Abstract

Early development of fat snook, *Centropomus parallelus* (Poey 1860), is described based on embryos and larvae obtained from rearing experiments and from specimens caught in the field, in Cananéia, southeastern Brazil, during December 1999–January 2000. Larvae of common snook, *C. undecimalis*, were also collected to compare the pigmentation pattern and body shape. Eggs of *C. parallelus* were relatively small (0.65 to 0.70 mm in diameter), spherical, and usually with a single oil globule. Notochord length (NL) of newly hatched ranged between 1.1 mm to 1.4 mm. Notochord flexion began at 3.4 mm NL and was usually completed by 4.0 mm SL. Larval and early juvenile of both species were very similar with tenuous distinction, however, some morphological and pigmentation characters were used to distinguish their early stages. The main differences were as follow: trend of lower values of the ratio of body depth to body length (BD/BL) for *C. parallelus* larger than 10.0 mm SL; absence of the post-temporal spine in *C. undecimalis*; absence of pigmentation along the dorsal midline of *C. parallelus* larvae by 2.6–7.0 mm; and presence of a pair of dendritic melanophores posterior to the bases of pelvic fins in *C. parallelus* larger than 6.0.

Key words: *Centropomus parallelus*, Fish eggs, Fish larvae, Cananéia-Iguape estuarine system, southeastern Brazil

Introduction

Centropomid fishes are euryhaline and diadromous that inhabit coastal estuaries and freshwater rivers and lakes (Figueiredo & Menezes 1980, Nelson 2006). The family Centropomidae consists of one genus, *Centropomus*, with 12 species (Nelson 2006). The previously recognized subfamily Latinae was raised to family by Mooi and Gill (1995), based on an analysis of the association of epaxial musculature with dorsal fin pterygiophores. Later, this taxonomic level was confirmed by Otero (2004). Four centropomid species are described in Brazilian waters, *C. ensiferus* (Poey 1860), *C. parallelus* (Poey 1860), *C. pectinatus* (Poey 1860), and *C. undecimalis* (Bloch 1796) (Menezes and Figueiredo 2003). Two species, *C. parallelus* and *C. undecimalis*, are known to occur in the Cananéia-Iguape estuarine system, where they contribute to the local commercial and recreational fisheries (Mendonça & Katsuragawa 2001).

Many biological and ecological aspects concerning the juvenile and adult *C. parallelus* have been studied, *e.g.* diet and reproduction in Venezuela (Rojas 1972) and in Mexico (Chavez 1963); reproduction, growth and juvenile habitat in the Southeastern Brazil (Radasewsky 1976); physiologic studies involving effect of salinity and time of exposure on metabolism and growth (Rocha *et al.* 2005); nursery habitat and diet of juveniles in the estuaries of Puerto Rico (Aliaume *et al.* 1997).

Because aquaculture of centropomid species is important throughout their range, some rearing experiments of *C. parallelus* and *C. undecimalis* have been carried out (Cerqueira 2002, Álvarez-Lajonchère *et al*. 2004, Álvarez-Lajonchère & Tsuzuki 2009, Wittenrich *et al*. 2009, among others). However, information on development of early

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life stages for species of this family is scanty. Descriptions of the development for *C. undecimalis* is the exception (Jackson & Ockelmann-Lobello 2006), for which the ontogeny and osteological series was developed by Lau and Shafland (1982) and Pottoff and Tellok (1993). Studies of the embryonic and larval developmental stages of *C. parallelus* were previously conducted and briefly described by Álvarez-Lajonchère *et al*. (2002), and by Cerqueira and Tsuzuki (2009) but details of pigmentation and illustration of the larval developmental series is lacking. This study aims to describe the morphological development of larval and early juvenile *C. parallelus* based on specimens obtained during rearing experiments and from wild specimens collected at the Cananéia-Iguape estuarine system in southeastern Brazil.

Material and methods

A total of 71 eggs, 75 recently hatched larvae, and 235 older (from preflexion to flexion) larvae of *C. parallelus* were obtained during a rearing experiment conduced at the laboratory of Research and Development Center of the South Coast, Fishery Institute of the São Paulo State, in Cananéia, southeastern Brazil, during December 1999-January 2000. All specimens were fixed and preserved in 4% buffered formalin. In addition, some postflexion wild larvae were caught in rivers and tidal creeks located at the southernmost Cananéia-Iguape estuarine system (Fig. 1). Sampling of wild larvae was conducted using a type of small beach seine 3.0 m long, 1.5 m deep and with 0.5 mm mesh size (Itagaki *et al.* 2007), during February–April 2001. From the total of 2146 centropomid larvae and juvenile obtained in the field, a portion was fixed in 4% buffered formalin and the remainder in 10% alcohol buffered with ©Sigma 7-9 (Tris[hydroxymethyl]aminomethane) for otolith analysis. The analysis of eggs and larvae were conducted as quickly as some months after collection.

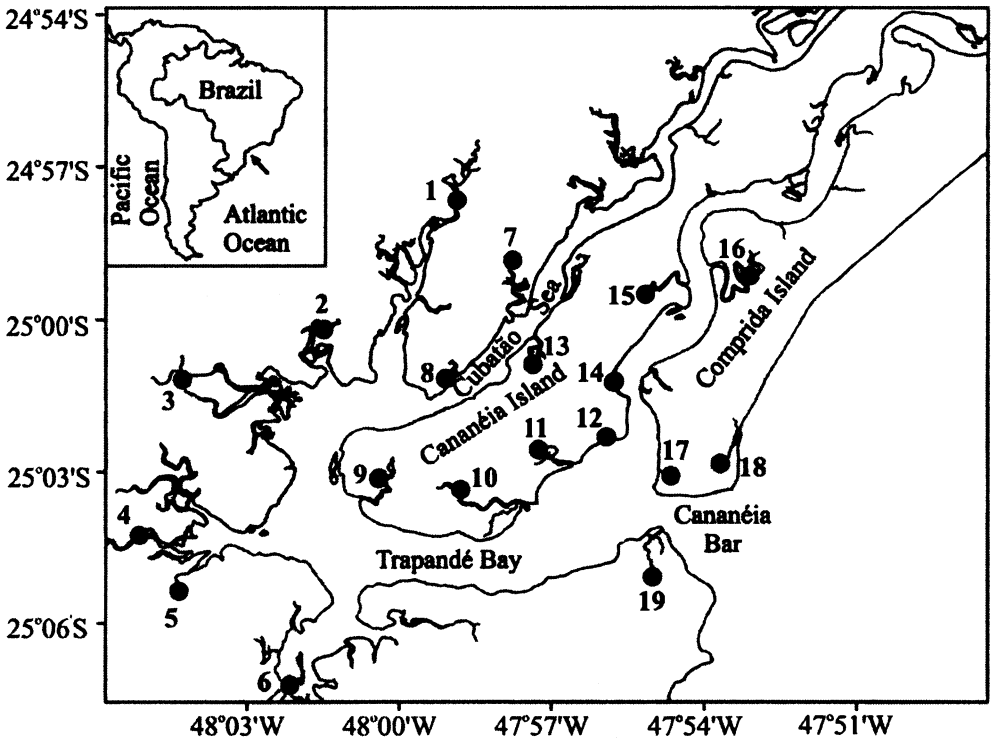

FIGURE 1. The study area in the Cananeia-Iguape System on the southeastern coast of Brazil. The black spots indicate the stations where *Centropomus parallelus* larvae were collected.

Wild-caught larvae were examined and identified as *C. undecimalis* following the descriptions of Lau and Shafland (1982) and Pottoff and Tellock (1993). The wild larvae and juveniles of *C. parallelus* were identified by the developmental series method (Leis & Trnski 1989). The larval body regions were defined according to Leis and Trnski (1989) as head (from the tip of snout to the posterior margin of opercle), trunk (body between head and anus), and tail (portion of body posterior to the anus). Larvae were examined under a stereoscopic microscope and

drawings of the continuous morphological series were made with a camera lucida attached to a stereoscopic microscope. Morphological measurements were made with a portable micrometer attached to a stereoscopic microscope. The following measurements were made according to the terminology and methodology described by Moser (1996): Body Length (BL) that was equated to Notochord Length (NL) for preflexion and flexion larvae, Standard Length (SL) for postflexion larvae and juveniles, and Body Depth (BD). Larvae were categorised as preflexion, flexion and posflexion stage, according to the stage or degree of notochord flexion (Ahlstrom *et al.* 1976). The juvenile stage was defined generally as pre-reproductive specimens morphologically similar to adults, with complete fin-ray complements and squamation (Moser 1996). Relationships of the ratios BD/BL to BL were made to compare the morphological development of *C. parallelus* with of *C. undecimalis*. A series of 23 specimens, with size range of 14.35–24.24 mm SL, was cleared and stained according to Dingerkus and Uhler (1977), in order to observe the anal fin spines ossification process.

Results

Morphology. The diameters of fertilized eggs of fat snook after 15 h of rearing in laboratory ranged from 0.65 to 0.70 mm (mean = 0.68 mm, sd = 0.02, n = 61) (Fig. 2A). The single large oil globule ranged in diameter 0.20 to 0.35 mm (mean = 0.26 mm, sd = 0.04, n = 28). Two oils globules were observed in a few eggs.

Eighteen hours after fertilization, the newly hatched larvae ranged from 1.1 to 1.4 mm NL (mean = 1.28 mm, sd = 0.08, n = 75) and possessed a large oval yolk sac bearing a single oil globule in its anterior-most portion (Fig. 2B). At this time the anlage of the finfold was observed around the trunk and the tail while some vertical segments, probably primordial post-anal myomeres, were also visible in the tail. Approximately one day after hatching a prominent finfold was present and the gut was observed as a thin tube.

At two days post hatching, NL ~ 2.2 mm, the mouth began to form and the yolk

sac was still visible. However, some specimens that measured 2.3 mm NL possessed a functional mouth and had a larger partitioned gut (Fig. 2C). Pigmented eyes and the beginning of the swim bladder were also observed by 2.3 mm NL. The caudal fin rays began to form and became visible as an anlage by 3.1 mm NL and all 17 principal rays were present by 5.0 mm (Table 1). Notochord flexion began by 3.4 mm NL and was complete by 4.0 mm SL (Fig. 2E, F). The fin rays of the second dorsal fin began to develop by 3.4 mm NL, although the number of elements varied until NL = 4.5 mm SL, and the first dorsal fin began to form after the second dorsal by 4.2 mm SL. But either the total complement of 8 spines in the first dorsal fin, or of 1 spine plus 10 rays in the second dorsal fin were observed in larvae by 5.0 mm SL (Table 1), reflecting the meristics of adult *C. parallelus*. The anal fin elements began to form by 3.35 mm NL, but the composition of 2 spines plus 7 rays were first present by 5.0 mm SL, and this count maintained until 10.8 mm SL (Table 1). The third anal spine began to differentiate later, as observed after clearing and staining some *C. parallelus* specimens ranging from 14.35 to 24.24 mm SL. By 14.35 mm SL this third element was 2.35 mm long and 57.45% ossified, increasing to 4.55 mm long and ossification rate of 97.80% by 24.24 mm SL. Unfortunately, due to a gap in the developmental series from 10.8 to 14.35 mm SL, it was not possible to observe the exact size when the differentiation begins. The pelvic and pectoral fins rays were the last to develop. Pelvic fins began development by 5.0 mm (Fig. 3A, B) and had the full complement of one spine and five soft rays by 7.4 mm SL (Table 1). The base of the pectoral fins and its membrane were present during the early stages, although its rays began to develop only by 5.0 mm SL. The rays of the pectoral fins varied between 10–16 rays in older specimens (Table 1). Scales began to development between 14.0–18.1 mm SL (Figs. 3;4).

The relative values of body depth (BD/BL) increased continuously until the postflexion stage, trending stabilization and followed by a slight decrease during the juvenile stage (Fig. 5). In preflexion larvae (2.1–3.3 mm NL) the body was elongate with BD = 18.9% BL (sd = 2.8; range 13.3–28.1% BL; n = 131). During the flexion stage (3.4–4.0 mm NL) the body became moderate with BD = 24.6% BL (sd = 2.2; range 19.4–29.0% BL; n = 64). The body depth continued to increase in postflexion larvae (4.1–17.8 mm SL) reaching BD = 29.0% BL (sd = 2.1; range 24.4 – 32.7% BL; n = 62). A slight decrease of body depth was observed in juveniles (>18.0 mm SL), with BD = 28.8% BL (sd = 0.9; range 26.7 –30.9% BL; n = 51). Unfortunately, in the present study there are no measurement data for preflexion and flexion *C. undecimalis*; however, analysis of some larger specimens revealed lower ratio values of body depth for this species if compared to *C. parallelus*. In postflexion *C. undecimalis* the average value was 25.8% BL (sd = 1.6), and in juveniles was 25.1% BL (sd = 1.4).

TABLE 1. Meristic data of larval and juvenile *Centropomus parallelus*. Roman and Arabic numerals show numbers of spines and soft rays, respectively. The + symbol means elements present but not counted. Rare counts in parentheses.

NL or SL (mm)	Principal Caudal Rays	First Dorsal	Second Dorsal	Anal Fin	Pelvic Fin	Pectoral Fin
3.1	1					
3.2	3					
3.3	10					
3.35	10–15		(+)	(+)		
3.6	11–16		9–10 (+)	5		
3.65	9–15		+ (5)	(+)		
3.7	15		10	6		
3.75	16		+	+		
3.8	17		10	7		
3.85	15–16		10	6–7		
3.9	13–16		10	5–7		
3.95	16		9–10	6–7		
4.0	16		10	7		
4.1	17		10	I+7		
4.15	17		10	7		
4.25	16	+	10	I+6		
4.3	17	I–II	10–1+10	7–1+7		
4.5	16		9	I+7		
5.0	17	VIII	I+10	II+7		
6.7	17	VIII	I+10	II+7	I+4	14
6.85	17	VIII	I+10	II+6	I+5	14
7.0	17	VIII	I+10	II+7	I+3	14
7.1	17	VIII	I+10	II+7	I+4	10
7.35	17	VIII	I+10	II+7	I+5	13
7.5	17	VIII	I+10	II+7	I+5	14–15
7.75	17	VIII	I+10	II+7	I+5	13
8.25	17	VIII	I+10	II+7	I+5	15
8.3	17	VIII	I+10	II+7	I+5	15
8.5	17	VIII	I+10	II+7	I+5	16
9.35	17	VIII	I+10	II+7	I+5	16
10.8	17	VIII	I+10	II+7	I+5	14

Head spination was scanty in larval fat snook—few spines developed either on the posttemporal or on the anterior or posterior preopercle. However, two spines became visible on the anterior preopercular margin by 4.7 mm SL (Fig. 2F) and three spines were detected on the posterior preopercular margin at 6.5 mm SL (Fig. 3A). The posttemporal spines became visible by 14.2 mm SL (Fig. 4C) and were arranged vertically in a series of 2-5 small spines.

Pigmentation. No pigment was visible in newly-hatched larvae (Fig. 2B); however, at one day post hatching, a single melanophore was observed on the posterior region of the hindbrain and three bands of pigment, consisting of dendritic extensions of melanophores were detected. The first band was formed by a single internal melanophore over the gas bladder; the second band consisted of two melanophores on the dorso-ventral margin of the trunk in the hindgut region. The third band was formed by two melanophores along the dorso-ventral and dorsal midline margin halfway along the tail, between the 15th and 18th myomeres.

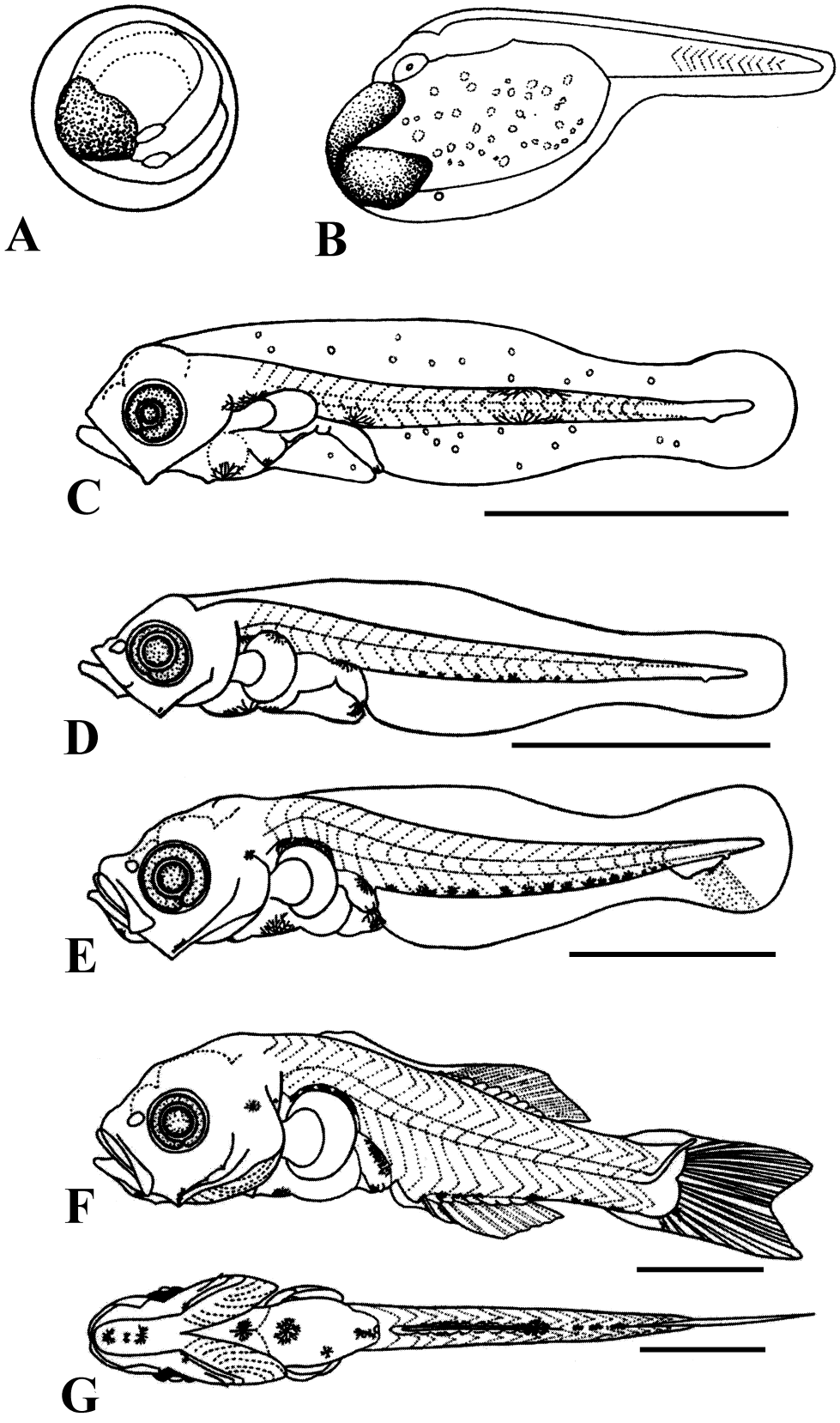

FIGURE 2. Early development of *Centropomus parallelus* reared in the laboratory: A, egg stage, 0.7 mm diameter; B, newly hatched larvae, 1.3 mm NL, C, 2.3 mm NL, 3 days old, preflexion; D, 2.6 mm NL, 8 days old, preflexion; E, 3.4 mm NL, 24 days old, early flexion; F, 4.7 mm SL (5.7 mm TL), 35 days old, early postflexion; G, ventral view of F; Bar = 1 mm.

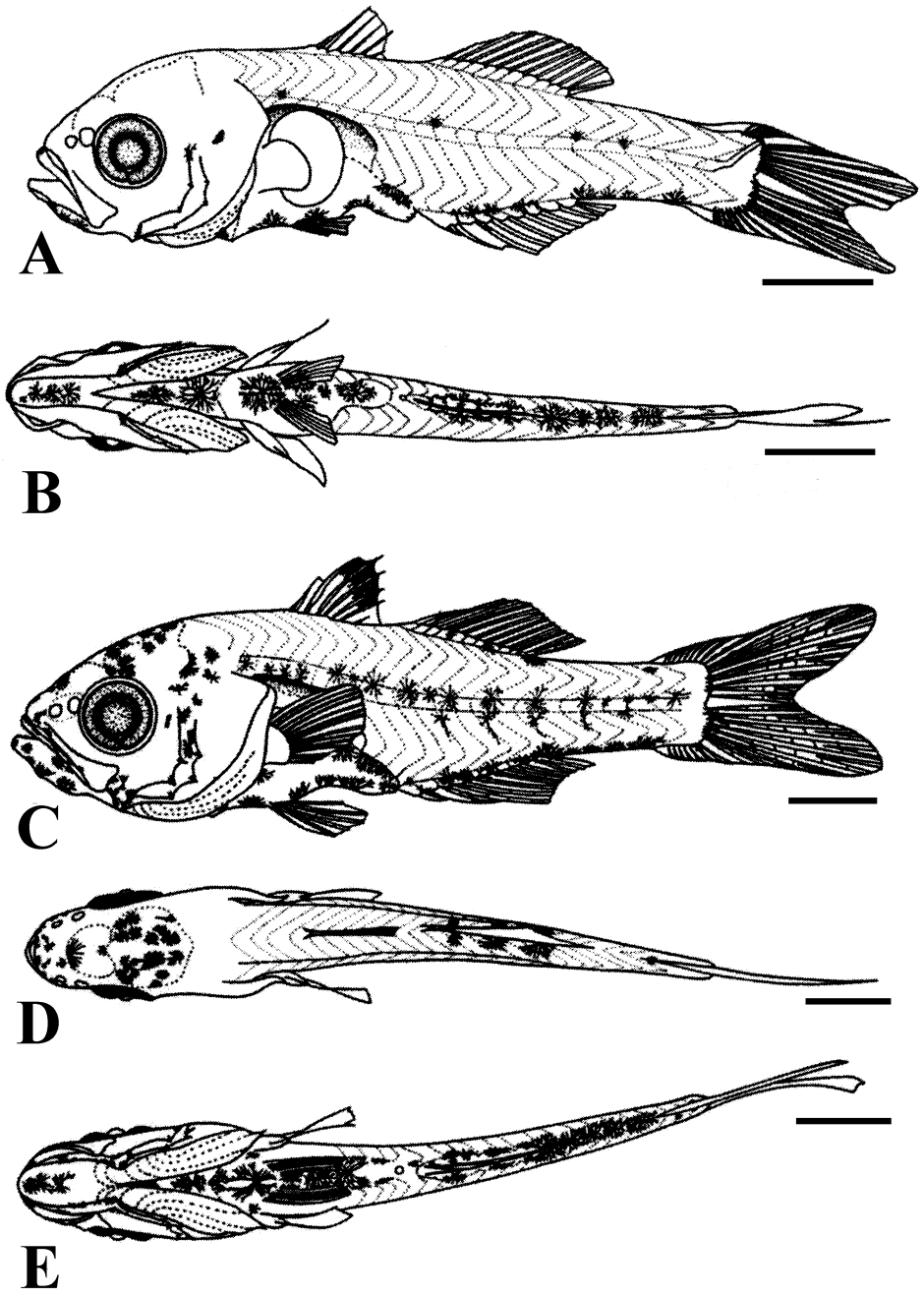

FIGURE 3. Larvae of *Centropomus parallelus* collected in the field: A, 6.5 mm SL (7.9 TL), postflexion; B, ventral view of A; C, 8.0 mm SL (10.0 mm TL), postflexion; D, dorsal view of C; E, ventral view of C. Bar = 1 mm; Bar = 1 mm.

By 2.3 mm NL (Fig. 2C) these bands became less prominent, and only one melanophore of the second band persisted in the ventral midline margin of body above the hindgut. The melanophore of the posterior region of the hindbrain also disappeared. A large dendritic melanophore developed on the ventral region of abdomen by 2.3 mm NL and persisted during all subsequent larval stages (Figs. 2; 3; 4). Some specimens developed an additional melanophore located along the ventral midgut by 2.3 mm NL (Fig. 2C).

By 2.6 mm NL (Fig. 2D) the aforementioned bands disappeared and were replaced by three single melanophores: one in the dorsal region of the future swimblader, one in the hindgut region, and one at the tip of the anus (Fig. 2D). An additional melanophore became visible adjacent to the angle of lower jaw (Fig. 2D).

Pigment was absent from the ventral region of the head as well as along the dorsal midline of the body until the larvae grew to 6.5 mm SL (Fig. 3A). Larvae > 6.5 mm SL developed melanophores dorsally on the head, mainly in the region of the fore- and midbrain (Fig. 3C, D), which gradually increased in number to form a typical pair of dark areas by the end of larval stage by 14.2 mm SL (Fig. 4A,B).

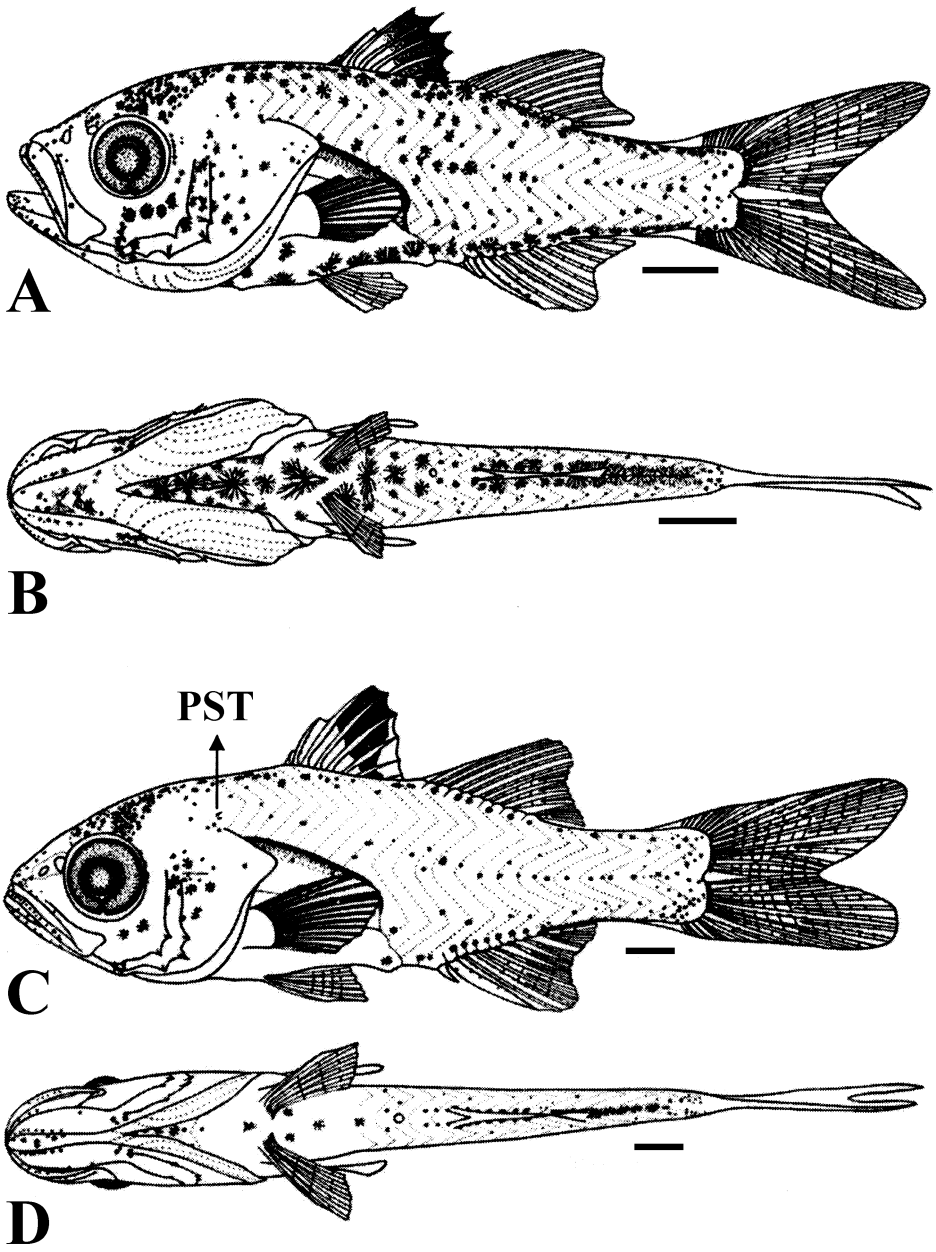

FIGURE 4. Larvae of *Centropomus parallelus* collected in the field: A, 9.6 mm SL (12.1 TL), postflexion; B, ventral view of F; C, 14.2 mm SL (18.3 mm TL), postflexion; D, ventral view of C; PTS = Posttemporal spines; Bar = 1 mm.

On larvae between 3.4 mm NL and 4.7 mm NL, dendritic melanophores appeared ventrally on two regions of the head: adjacent to the cleithral symphisis and in the gular region (Fig. 2E,F,G). By 6.5 mm SL an additional dendritic melanophore appeared in the gular region completing the compliment of four melanophores (Fig. 3B). Pigmentation on the upper and lower jaw initially developed by 8.0 mm SL and thereafter, the number of melanophores increased on the gular region of the upper and lower jaw over the infraorbital, opercular, and preopercular regions (Figs. 3,4).

Melanophores developed on each side of the second dorsal fin base by 8.0 mm SL (Fig. 3C,D); simultaneously, pigments developed on the distal region of the first dorsal fin which rapidly increased in number to form a solid band in larger larvae (Figs. 3C; 4A,B). Caudal fin pigmentation began as some melanophores appeared at the edge of the hypurals coincident with development of caudal fin elements by 3.4 mm NL, and subsequently increased as development proceeded.

By 2.6 mm NL a series of melanophores arose along the ventral margin of the tail (Fig. 2D) and increased in

number and size until 3.4 mm NL (Fig 2F). At that size and in larger larvae, the number of melanophores decreased, and by 4.7 mm SL the areas of pigmentation were limited to a single melanophore at the base of first spine, three melanophores at the bases of the first three anal fin pterygiophores, one immediately behind the last anal fin ray, and one along the ventral margin of the caudal peduncle (Fig. 2F, G). Eventually, these melanophores became expanded to form a dark band in larger specimens (Fig 3A–D).

One external melanophore became temporarily visible on the edge limit of the opercle by 3.4 mm NL (Fig. 2E) and was not visible by 4.7 mm SL (Fig. 2F). An internal melanophore appeared in the upper region of the opercle by 4.7 mm SL. An area of pigmentation became visible along the dorsal margin of the swimblader early in the larval stage (Fig. 2), which became increasingly pigmented as a result in the increase of the number of melanophores during it's development in the later larval stages (Fig. 2E).

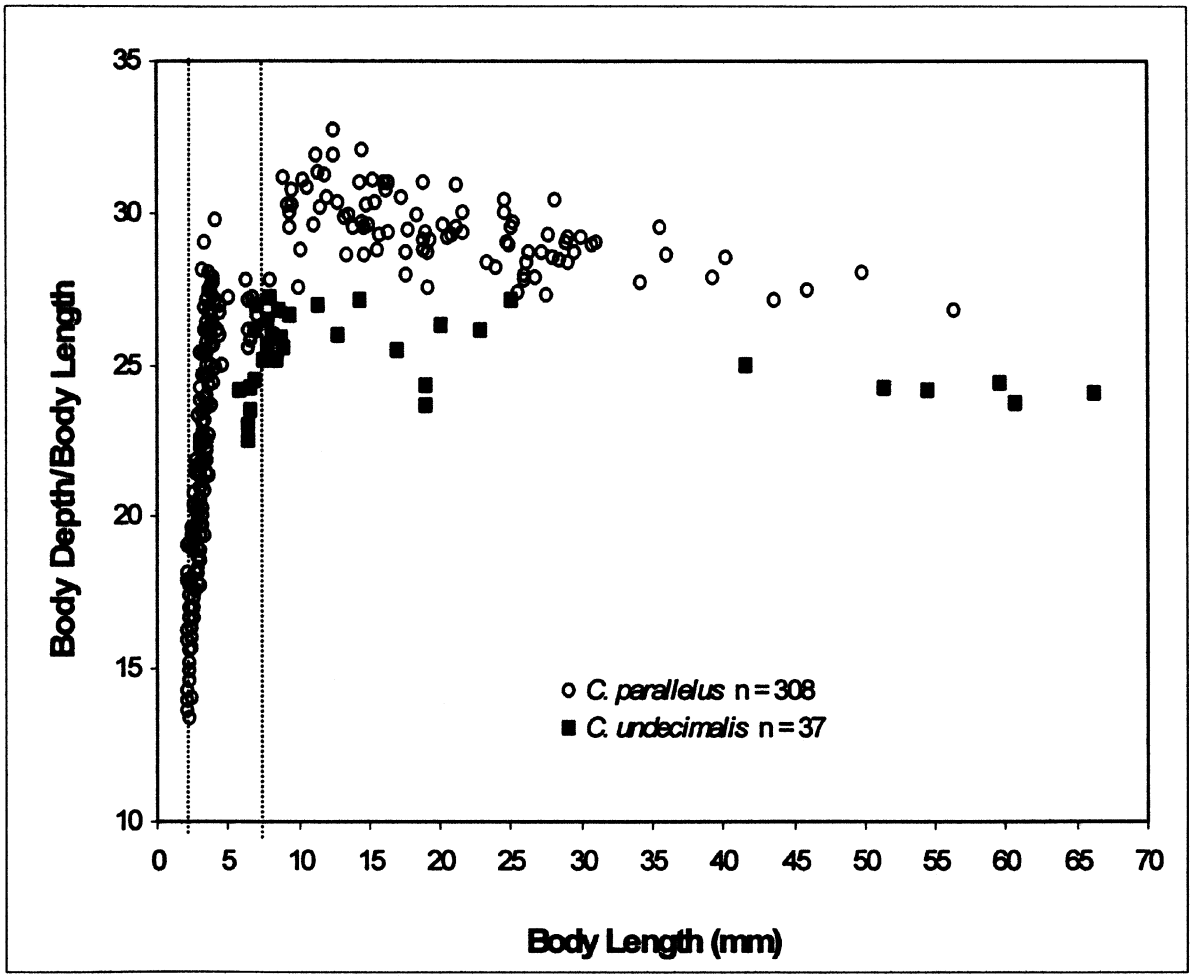

FIGURE 5. Changes of body depth relative proportions to body length for *Centropomus parallelus* and *C. undecimalis*. Body length (BL) is presented in notochord length (NL) for smaller specimens (less than 4.0 mm) and standard length (SL) for larger specimens. The *C. parallelus* specimens, smaller than 5.0 mm, were supplied by the laboratory rearing experiments, and the larger ones were catch in the field.

By 6.5 mm SL, abdominal dendritic melanophores increased on the ventral margins of the pelvic fins, distributed as follow: one immense melanophore anterior to the pelvic fins, one at the base of each pelvic fin, and two posterior to the pelvic fins (Fig. 3A,B). This pattern persisted until 14.2 mm SL (Fig. 4D). During the same size range, internal melanophores developed along the lateral midline of the body proximal to the vertebral column. By 9.6 mm SL, the number of melanophores increased along the dorsal margin of the body from the nape to the posterior of the body and along the ventral margin of the caudal peduncle (Fig. 4A,B). The anterior margins of the myomeres along the midline of the body became pigmented by 9.6 mm SL which became less abundant by 14.2 mm SL (Fig. 4C).

Discussion

Two species of snook, the fat snook, *C. parallelus* and the common snook, *C. undecimalis*, co-occur in the Cananéia-Iguape estuarine system (Figueiredo & Menezes 1980) and the larvae and juveniles of both species were collected and identified in the present study. Based on 47 taxonomic characters, Rivas (1986) distinguished 12 species of *Centropomus* in the world. These he separated into three groups; he placed *C. paralellus* and *C. undecimalis* in the same group because of many similarities. Some distinguishing adult characters of both species, i.e., gill rakers, scale number, and length of the second anal spine (Figueiredo & Menezes 1980, Rivas 1986) were not useful in the present work because these characters were not visible or developed in the early larval stage. Temporal spination in general, and the preopercular spines described in adults by Fraser (1968), had not developed in the larvae and juveniles of both species investigated in our study. Additionally, we found that sizes and shapes of the eggs and oil globules, the lengths of newly hatched yolk-sac larvae, the eye pigmentation, and the sizes at the beginning and completion of fin development and squamation were similar for both species.

Body depth and body width differed between adults of the two species at similar sizes: C. *parallelus* is deeper and more laterally depressed than *C. undecimalis*. Comparative body depth distinguished specimens larger than 10.0 mm SL, the size at which larvae transition the early juvenile stage although the pigment patterns of both species were similar. Descriptions of early morphological and osteological development of *C. undecimalis* were done by Lau and Shaffland (1982) and Potthoff and Tellock (1993), based on rearing experiments using larvae obtained by induced spawning of wild adults collected in Florida. Our BD/BL values for specimens from 10.0 to 25.0 mm SL tended to be lower than those obtained by Lau and Shafland (1982). Also, the post-temporal spine was present in our specimens, but was not observed in the Florida study (Lau & Shafland 1982).

No differences were found in the patterns of pigmentation between early stages (until ~ 2.6 mm NL) of *C. parallelus* and *C. undecimalis* of Lau and Shafland (1982). However, larvae between 2.6 mm NL–7.0 mm SL of *C. undecimalis* in this present study and those described by Lau and Shafland (1982) and Potthoff and Tellock (1993) developed a series of melanophores along the dorsal midline that were absent in larval *C. parallelus* of this study. For specimens > 6.0 mm SL, the pigment pattern along the ventral abdomen was diagnostic for distinguish both species. *Centropomus parallelus* developed a pattern of one large melanophore on the ventral edge of the abdomen anterior to the pelvic fins, plus two pairs of smaller melanophores—one pair close to the anterior base and another pair posterior to the base of pelvic fins (Fig. 4D). This melanophore pattern should be labeled 1:2:2 instead of 1:2:0 as observed in the present work in *C. undecimalis* larvae. However, for late postflexion and early juveniles, this pigmentation pattern became similar for both species and could not be used to distinguish or identify either species.

Our data concerning the size of newly hatching larvae and size of notochord flexion are not directly comparable to those presented by Alvarez-Lajonchère *et al.* (2002) and Cerqueira and Tsuzuki (2009), as their results were expressed in total length, whereas in the present study the measurements are in notochord length. Anyway, the hatching size of fat snook larvae from Cananeia (1.28 ± 0.08 mm NL) is apparently smaller than those from Florianópolis (1.85± 0.08 mm TL). In the our study the notochord flexion began by 3.4 mm NL and was completed by 4.0 mm NL, but in this case the result seems to be close to Lajonchere's Florianópolis larvae that began flexion at 3.55 mm TL and was completed by 4.2 mm TL (Table 2). Cerqueira and Tsuzuki (2009) did not clearly describe the end of the notochord flexion. Some other differences include the eye pigmentation and absorption of the oil globule that occurred earlier in larvae of our study if compared to those reported from Florianópolis. We found that the formation of the dorsal, anal, and caudal fins began later in larvae > 3.0 mm in this study compared to those larvae from the Florianópolis region (Lajonchère *et. al.* 2002). These differences may be the result of variations caused by hydrographic conditions, food and feeding, sample preservation procedures, or analytical methodology.

Our analytical methodology may have influenced the length morphometrics of our specimens, whereas Alvarez-Lajonchère *et al.* (2002), reported sizes of specimens based on ages in days obtained from a spawning event. Because of the variable growth rate among larvae of the same cohort, the differences between the smaller and larger individuals increase with time. Hence, Alvarez-Lajonchère *et al.* (2002) may have reported the different sizes of early stages of development based on age that may have actually been the same sizes we reported. The differences in the diameters of the oil globule may be related to the effects of preservation which may influence the morphology or fracture the oil globule, as observed by Lau and Shafland, 1982 for *C. undecimalis*. Alvarez-Lajonchère *et al.* (2002), measured and made his calculations from freshly obtained larvae, whereas, we used material preserved in buffered formalin.

TABLE 2. Comparative morphological early development of *C. parallelus* and *C. undecimalis*, based on data of the present work and from Alvarez-Lajonchère *et al.* (2002) for *C. parallelus*, and from Lau and Shafland (1982) and Potthoff and Tellock (1993) for *C. undecimalis*.

		Centropomus parallelus		*Centropomus undecimalis*	
		Present work	Alvarez-Lajonchère *et al.* (2002)	Lau & Shafland (1982)	Potthoff & Tellock (1993)
Egg diameter	Min.	0.65 mm	0.60 mm	0.68 mm	
	Max.	0.70 mm	0.72 mm	0.73 mm	
	Mean	0.68±0.02	0.67±0.01	0.70 mm	
	N	61		17	
Oil globule diameter	Min.	0.20 mm	0.17 mm	0.17 mm	
	Max.	0.35 mm	0.22 mm	0.30 mm	
	Mean	0.26±0.04	0.20±0.02	0.23	
	N	28		17	
Length of newly hatched larvae	Min.	1.1 mm NL	1.65 mm NL	1.40 mm NL	
	Max.	1.4 mm NL	1.90 mm NL	1.50 mm NL	
	Mean	1.28 ± 0.08	1.76±0.10		
	N	75			
Eye pigmentation		2.20–2.31 mm NL	2.25–3.25 mm NL	2.10 mm NL	
Oil globule completely absorbed		2.20–2.25 mm NL	2.38–3.65 mm NL	2.20–2.30 mm NL	
Notochord flexion	Begin.	3.4 mm NL	3.55 mm NL	3.6–3.8 mm NL	3.9 mm NL
	End	4.0 mm SL	4.20 mm TL	4.5 mm SL	4.9 mm SL
Caudal fin development	Begin.	±3.1 mm NL		±3.2 mm NL	3.5 mm NL
	End	5.0 mm SL			8.5 mm SL
2nd dorsal fin development	Begin.	3.4 mm NL	2.33–3.73 mm NL	3.6–3.8 mm NL	4.1 mm NL
	End	5.0 mm SL		4.5–5.0 mm NL	4.5–5.7 mm NL
Anal fin rays development	Begin.	3.4 mm NL	2.33–3.73 mm NL	3.6–3.8 mm NL	4.4 mm NL
	End	5.0 mm SL		5.0–7.0 mm SL	5.3 mm SL
Pectoral fin rays development	Begin.	>5.0 mm SL		6.0 mm SL	5.0–6.2 mm SL
	End			7.0–8.00 mm SL	7.3–9.1 mm SL
Pelvic fin rays development	Begin.	6.5 mm SL	3.9 mmNL – 6.0 mm SL	5.0–5.5 mm SL	5.7–6.6 mm SL
	End	7.4 mm SL		6.5 mm SL	6.2–7.2 mm SL
1st dorsal fin development	Begin.	4.3 mm SL		4.5 mm SL	4.5 mm NL
	End	5.0 mm SL		7.0 mm SL	5.2–5.9 mm SL
Scale development	Begin.	14.0 mm SL		13.8 mm SL	
	End	18.1 mm SL		16.4 mm SL	

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