DEVELOPMENTAL STAGES OF THREE CALIFORNIA SEA BASSES (*PARALABRAX*, PISCES, SERRANIDAE)

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ABSTRACT

Eggs, larvae, and juveniles of kelp bass, *Paralabrax clathratus,* barred sand bass, *P. nebulifer,* and spotted sand bass, *P. maculatofasciatus,* are described from specimens reared in the laboratory and from specimens collected in the field. Eggs of spotted sand bass are 0.80-0.89 mm in diameter; eggs of kelp bass and barred sand bass are 0.94-0.97 mm in diameter. Larvae and juveniles of the three species may be distinguished by differences in pigmentation during most stages of development. Larvae of the two species of sand bass are indistinguishable during notochord flexion. Yolk-sac larvae of all three species are indistinguishable.

RESUMEN

Se describen los huevecillos, las larvas, y los juveniles de *Paralabrax clathratus, P. nebulifer,* y *P. maculatofasciatus,* tomadas de especímenes cultivados en el laboratorio y de especímenes recolectados en el mar. Los huevecillos de *P. maculatofasciatus* son de 0.80-0.89 mm de diámetro; los de *P. clathratus* y de *P. nebulifer* son de 0.94-0.97 mm de diámetro. Larvas y juveniles de las tres especies pueden ser distinguidos por las diferencias in pigmentación durante casi todos los estadios del desarrollo. Las larvas de *P. nebulifer* y *P. maculatofasciatus* no se pueden identificar durante la flexión del notocordio. Las larvas con saco vitelino no pueden separarse en las tres especies.

INTRODUCTION

Three species of the genus *Paralabrax* commonly occur off California. The kelp bass, *Paralabrax clathratus,* is found from Magdalena Bay, Baja California, to the Columbia River. The barred sand bass, *P. nebulifer,* is found from Magdalena Bay to Santa Cruz. The spotted sand bass, *P. maculatofasciatus,* is found from Mazatlan to Monterey (Miller and Lea 1972). A fourth species, the gold spotted bass, *P. auroguttatus,* has been reported on one occasion (Fitch and Schultz 1978). Prior to this record, the species was known from Cedros Island south to Cabo San Lucas and the Gulf of California (Fitch and Shultz 1978). Larvae of *Paralabrax* sp. have been illustrated by Kendall (1979) from CalCOFI specimens, which we have identified as *P. clathratus*. All three species are found in nearshore areas from the surface to about 600 feet (Miller and Lea 1972).

The kelp and sand basses combined rank second in the California sport fish catch (Oliphant 1979). Identifying these three species in ichthyoplankton collections may be important in monitoring population changes and assessing the impact of human activities on the nearshore environment. This paper describes the early life history of kelp bass, barred sand bass, and spotted sand bass from laboratory-reared and field-collected material.

METHODS

Eggs and larvae of *P. clathratus* were initially reared from artificially spawned eggs. Two ripe kelp bass, a 42-cm female and a 40-cm male, were caught by hook and line near Bird Rock, Santa Catalina Island, California, on June 22, 1978. Gonads were removed from the fish and taken to the laboratory, where eggs were collected into finger bowls. The eggs were flooded with seawater immediately before the introduction of several drops of sperm. The eggs and sperm were agitated for several seconds, followed by several changes of seawater. When the eggs hatched, a mixture of plankton and ground Tetramin was added as food. Although the larvae fed, they did not survive beyond yolk absorption.

Eggs and larvae of *P. clathratus, P. maculatofasciatus,* and *P. nebulifer* were reared from eggs collected off San Diego with plankton nets during May through September 1978 and 1979. For each collection a 60-cm, 505-mm mesh plankton net was towed at the surface for 15-20 minutes. Plankton was placed in 14-liter buckets filled with seawater. The samples were brought to the laboratory, and the fish eggs were sorted from the plankton. *Paralabrax clathratus* and *P. nebulifer* larvae were reared from eggs measuring 0.94-0.97 mm in diameter in several mixed cultures from June 1978 through 1979. Since eggs of two

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species were indistinguishable, developmental series were determined by working backwards from identified juveniles. On July 26, 1979, a large number of eggs measuring 0.82-0.86 mm were sorted from plankton collected off Mission Bay, California. This culture yielded only *P. maculatofasciatus* larvae and juveniles.

Larvae were reared to juveniles in a closed system on a diet of *Brachionus biplicata* and field-collected plankton. After about two weeks, the diet was gradually shifted to field-collected plankton supplemented with *Artemia* nauplii. Representative stages were photographed under anesthesia and preserved in 4 percent Formalin. A series of larvae was stained to study development of head spines. Additional material was obtained from the field collections of various institutions.

DEVELOPMENT

At 19°C, *P. clathratus* hatched at 36-40.5 hours after fertilization. Yolk-sac absorption was complete at 121.5 hours, or about 5 days. In larvae reared at 21°C from eggs collected in the plankton, notochord flexion began 11 days after hatching and was complete in some specimens on day 13. The earliest transformed juvenile was preserved 28 days after hatching.

Hatching time of *P. maculatofasciatus* is uncertain, since all eggs with the same diameter and size of oil globule regardless of stage of development made up the initial culture. All eggs hatched at 21.5°C within 24 hours after collection. Yolk-sac absorption was complete by day 4. Notochord flexion began on day 12 and was complete by day 19. The earliest transformed juvenile was preserved on day 28.

DESCRIPTION OF *PARALABRAX CLATHRATUS* AND *P. MACULATOFASCIATUS* EGGS

Eggs of both species are spherical in shape with clear, unsegmented yolk, a single large oil globule, and a clear, unsculptured chorion. Eggs of *P. clathratus* and *P. nebulifer* have a mean diameter of 0.95 mm, with a range from 0.94-0.97 mm (n=25). The mean diameter of the oil globule is 0.20 (n=25). Eggs of *P. maculatofasciatus* have a mean diameter of .84 with a range of 0.80-0.89 (n=11). The oil globule has a mean diameter of 0.17 with a range of 0.16-0.19 (n=11). Late-stage embryos of both species have similar pigmentation. At 24 hours, the embryo of *P. clathratus* is uniformly pigmented with small (0.1 mm) melanophores on the dorsal surface. Two to four melanophores are present on the oil globule, which lies midway between the head and tail of the embryo.

DESCRIPTION OF LARVAE AND JUVENILES

Paralabrax clathratus ***(Girard 1854) Kelp Bass***

(Figures 1-4)

Distinguishing characters. Preflexion larvae may be distinguished from *P. nebulifer* by the number of the postanal melanophores, and from *P. maculatofasciatus* preflexion larvae by the position of those melanophores. The large ventral melanophore is on the eighth or ninth postanal myomere in *P. clathratus*. In preflexion *P. maculatofasciatus* the large ventral melanophore is on the sixth or seventh postanal myomere. Preflexion *P. nebulifer* have more small postanal, midventral melanophores, 11-20 ($\bar{x}$ = 14.5), than *P. clathratus* 4-8 ($\bar{x}$ = 6.2), or *P. maculatofasciatus*, 6-11 ($\bar{x}$ = 8.0). The abdominal fin-fold pigment is heavier on *P. clathratus* than on the other two species. It forms a heavy broad triangle anterior to the anus. The postanal dorsal pigment patch is retained in *P. clathratus* until after 4.1 mm, but it is lost in *P. maculatofasciatus* by 3.4 mm. Larvae of *P. nebulifer* typically lack postanal dorsal pigment at all stages.

From early flexion (ca. 5.0 mm) through midflexion (ca. 5.9 mm), *P. clathratus* may be distinguished from the other two species by the large postanal pigment patch, the heavy preanal abdominal fin-fold pigment, and the lack of pigment on the lateral line. From late flexion through the end of the larval phase, *P. clathratus* may be distinguished by the presence of pigment on the upper jaw, the heavy pigment on the first dorsal fin, and the absence of pigment on the lateral line. Transformation to the juvenile stage takes place at about 11 mm. At this time vertical bars form on the body; they are quite different from the horizontal stripes of juvenile sand basses. Pigment anterior to each pectoral fin base forms a characteristic acute angle.

Description. Early yolk-sac larvae (Figure 1A) are fairly uniformly pigmented along the dorsal surface from the nape to the end of the tail. Pigment is also present over the oil globule. As the yolk is absorbed the dorsal pigment becomes concentrated into discrete patches. The first dorsal patches to become distinct are lateral to the midline and over the center of the yolk sac.

During the yolk-sac period, the dorsal pigment is concentrated into three areas: over the middle of the yolk sac, over the end of the gut, and midway between the anus and the end of the notochord (Figure 1B). Pigment is also present on the head anterior and dorsal to the unpigmented eyes. Pigment is present lateral to the gut in the region of the yolk sac and ventral to the gut posterior to the yolk sac, becoming heaviest near the anus. A ventral midline series of melanophores is

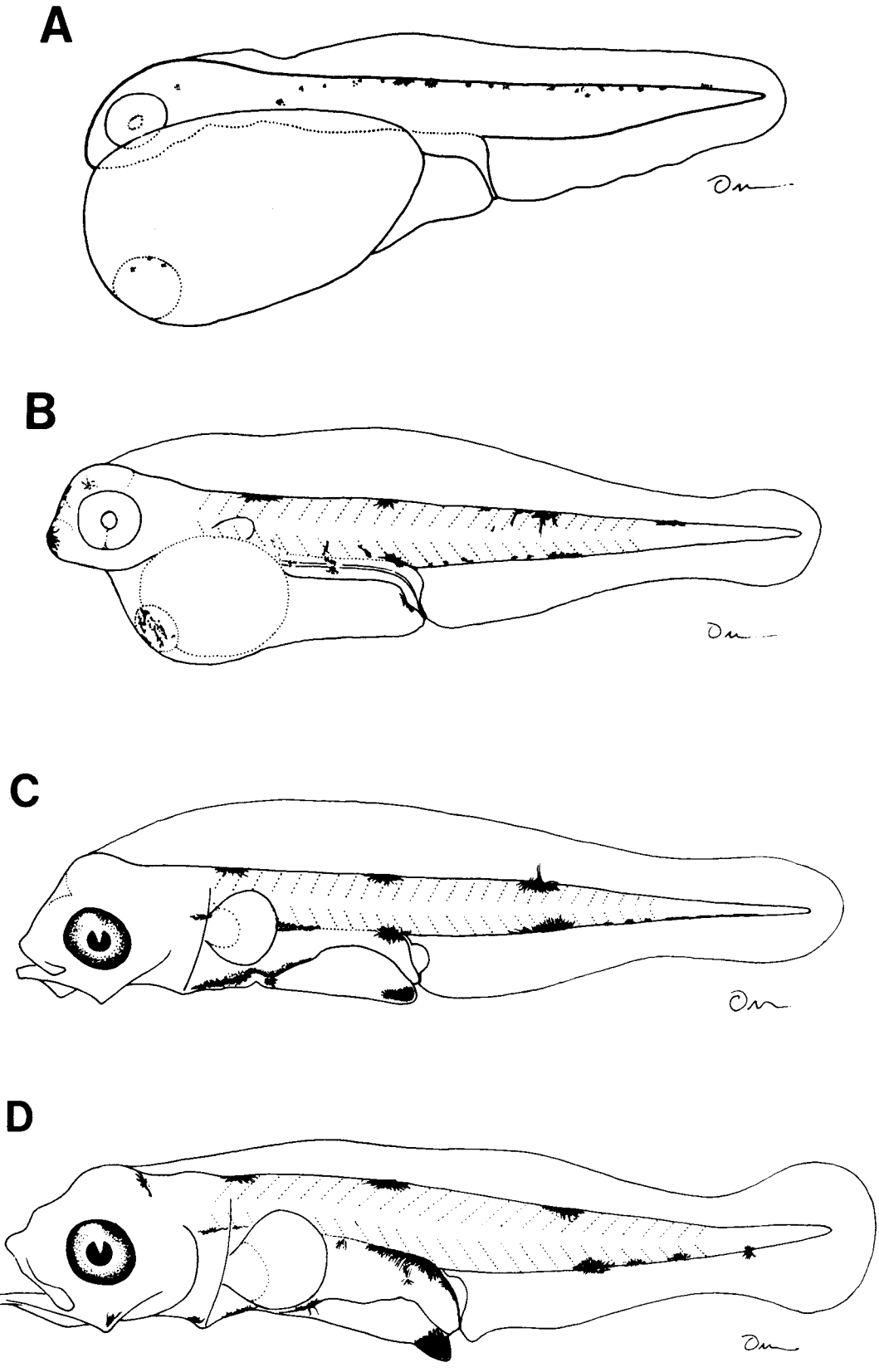

Figure 1. Larvae of *Paralabrax clathratus: A.* 2.2-mm yolk-sac larva, 1 day; *B.* 2.8-mm yolk-sac larva, 1 day; *C.* 3.0-mm preflexion larva, 4 days; *D.* 4.1-mm preflexion larva, 7 days.

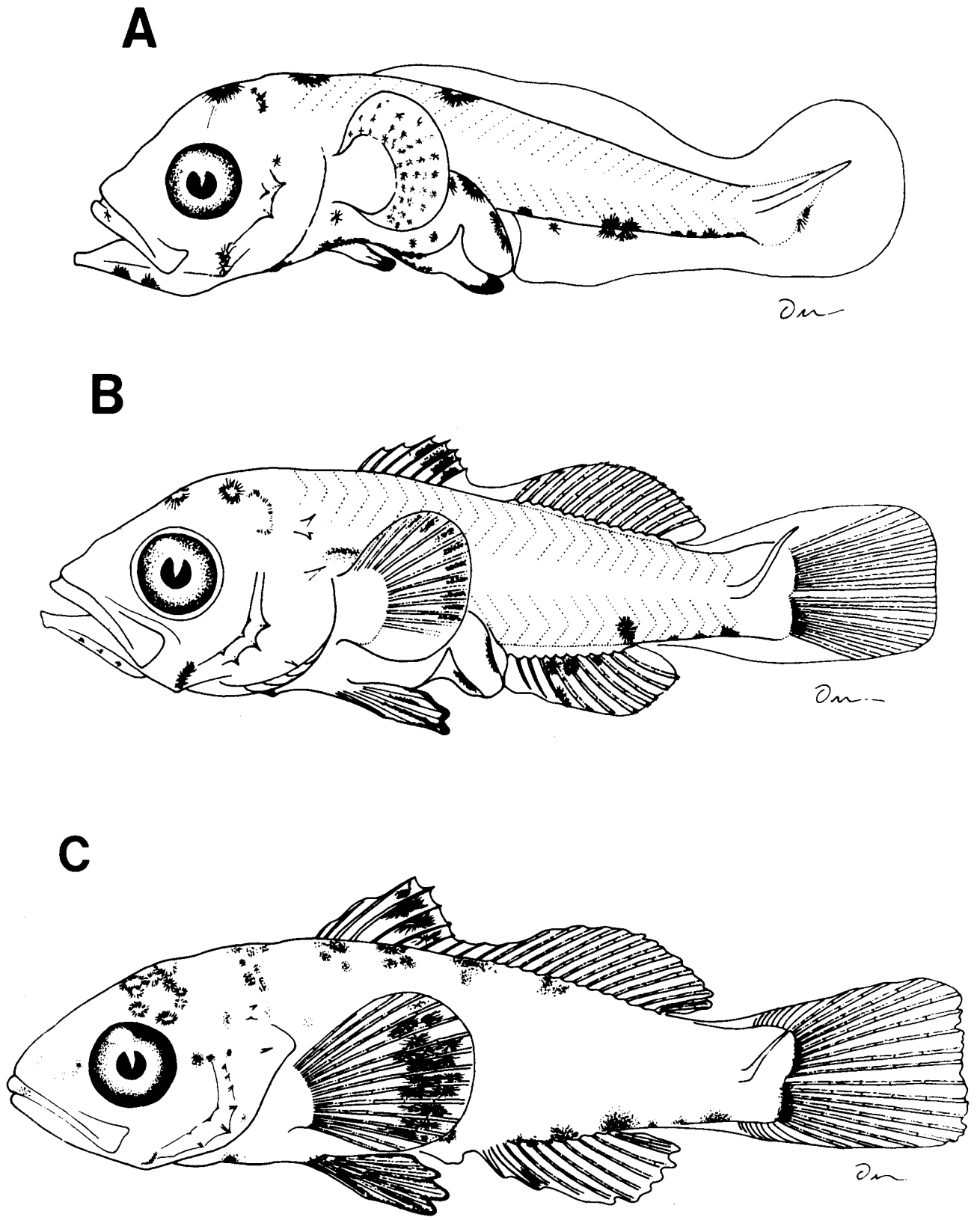

Figure 2. Larvae of *Paralabrax clathratus: A.* 5.1-mm flexion larva, 12 days; *B.* 7.4-mm postflexion larva, 25 days; *C.* 10.0-mm postflexion larva.

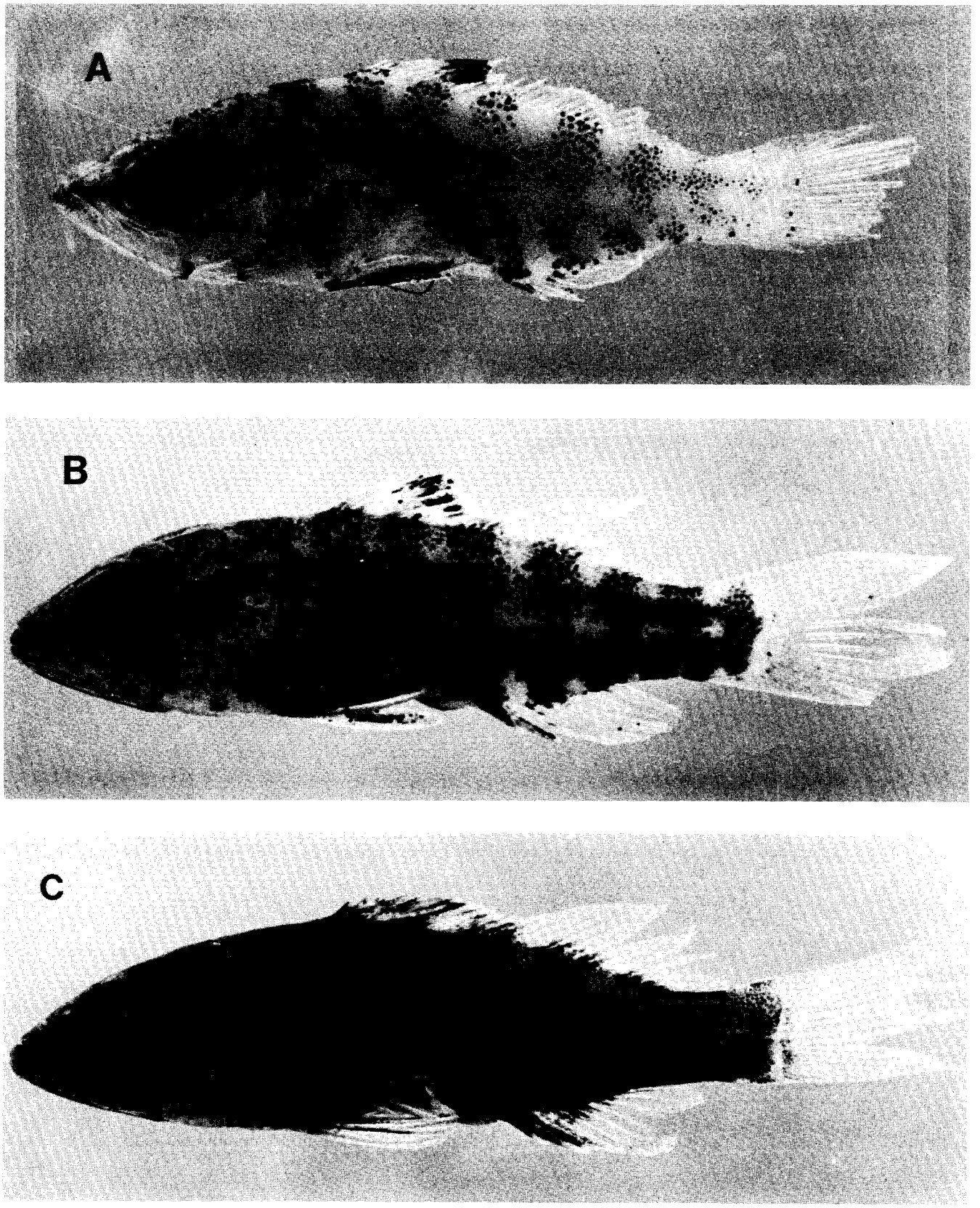

Figure 3. Developmental stages of *Paralabrax clathratus: A.* 11.1-mm transforming specimen, SIO 75-468; *B.* 11.2-mm transforming specimen, SIO 75-468; *C.* 16.6-mm newly transformed juvenile, SIO 75-468.

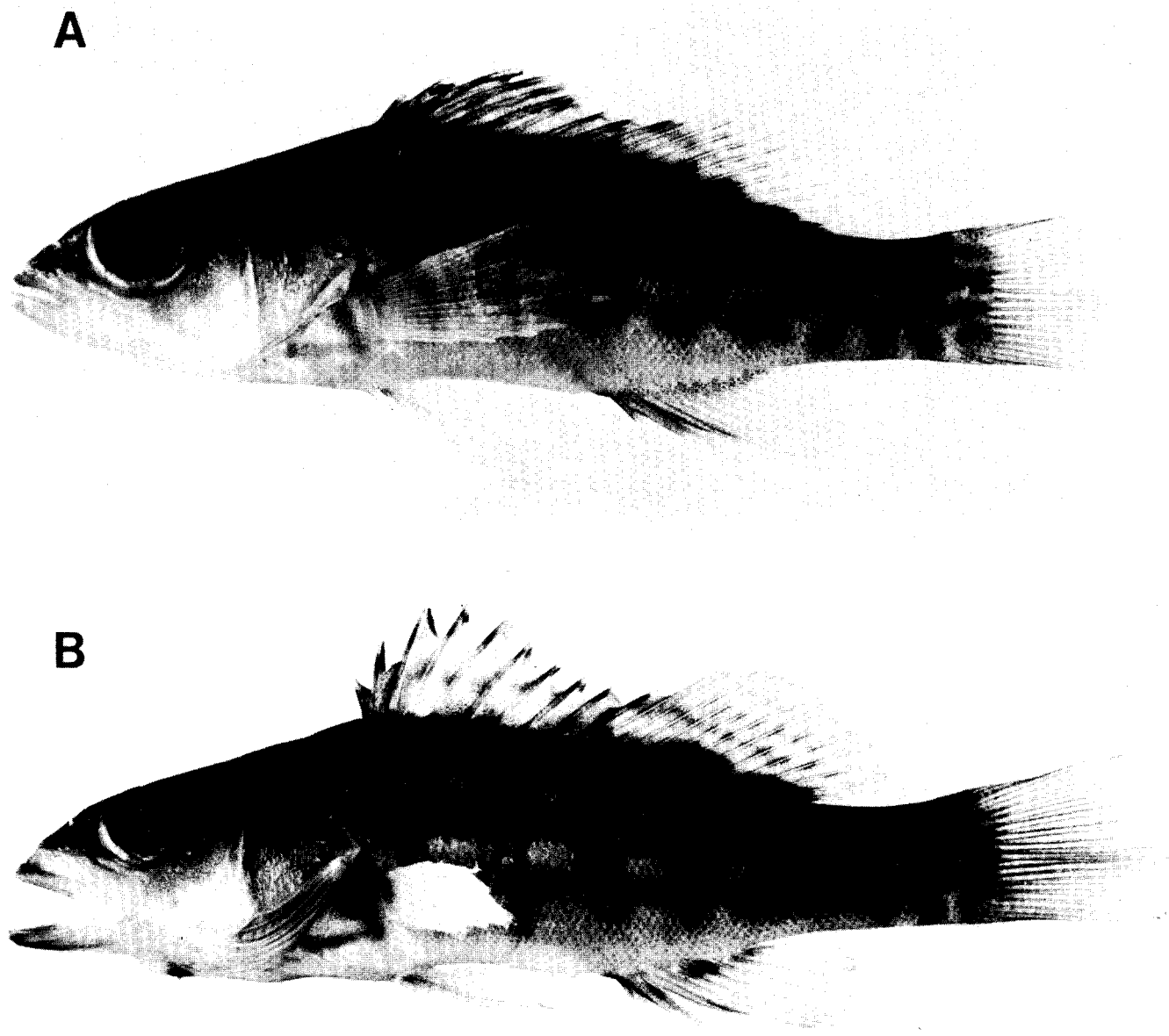

Figure 4. Juveniles of *Paralabrax clathratus: A.* 36.3-mm juvenile, SIO 73-345, Mission Bay, San Diego; *B.* 46-mm juvenile, SIO 73-345, Mission Bay, San Diego.

present from the end of the gut midway to the end of the tail, with heaviest concentration over the anus and midway to the end of the tail. The eyes become pigmented as the yolk is completely absorbed. Pigment on the snout and on the head is lost at this time. Dorsal pigment is concentrated into three large melanophores: midway between the snout and the anus, over the anus, and midway from the anus to the end of the notochord (Figure 1C). Pigment is present dorsal to the gut below the second dorsal midline melanophore at the point where the gut is deflected ventrally from the body. Pigment is present ventral to the gut from the junction of the cleithra posteriorly to the midpoint of the gut. A large, triangularly shaped pigment patch is present in the abdominal fin fold just anterior to the anus. A large ventral melanophore is present midway from the anus to the end of the tail, and a series of small melanophores continues posteriad almost to the end of the notochord.

This basic pigmentation pattern changes only slightly from yolk absorption at about 3.0 mm to just prior to caudal flexion (Figure 1D). Between 4.2 mm

and 4.6 mm, the posteriormost dorsal pigment patch is lost. During this time pigment forms on the dorsal surface of the head and on the isthmus.

During notochord flexion (5.0-6.2 mm), the anal and pelvic fins form, and the abdominal fin fold is partially resorbed. Pigment forms on the pectoral fins and on the upper jaw (Figure 2A). The posteriormost ventral tail pigment becomes associated with the hypurals and, by the end of caudal flexion, forms a line at the posterior end of the hypural bones (Figure 2B). The large ventral tail spot lies at the posterior end of the forming anal fin (Figure 2B). Some of this pigment becomes internal when the fin is completely formed. The more anterior ventral pigment migrates onto the base of the anal fin. The dorsal midline melanophore located above the gut migrates onto the spinous dorsal fin, which forms at the end of flexion. The anterior dorsal midline melanophore either migrates to the head or is lost. It is absent in larvae larger than 6.9 mm. The characteristic triangular patch of pigment on the preanal abdominal fin fold becomes located on the ventral surface of the gut as the fin fold is resorbed (Figure 2B). The pelvic fins become heavily pigmented, particularly at their posterior margins. Pigment is absent over the lateral body surface.

Changes in postflexion larvae from about 7.4 mm to 10 or 11 mm are gradual. The most important pigment change is the addition of pigment on the snout and on the operculum behind the eye to form a prominent horizontal eye bar (Figure 2C). Reared larvae are heavily pigmented on the membranes of the spinous dorsal, pectoral, and pelvic fins, whereas pigmentation on field specimens is usually lighter in these areas. Postanal pigment coalesces along anterior rays, and dorsal pigment coalesces in discrete patches. In some field-collected larvae the vertical barring of the juveniles is faintly visible (Figure 2C).

The development of this striking pattern of vertical pigment bars is shown in the series of transforming individuals (Figure 3). A broad bar extends ventrad from the nape; three bars underlie the spinous dorsal fin; two extend between the soft dorsal fin and anal fin; one is at the caudal peduncle; and one overlies the hypural region. These are partially interrupted by two horizontal stripes: one is a continuation of the stripe through the eye and extends posteriad to the caudal fin base, and the other runs between the pectoral fin base and the caudal base. In larger juveniles the bars and stripes become obscured by the more prominent pattern of large, pale blotches (Figure 4). Juveniles of this stage have a characteristic angulate pigment blotch anterior to the pectoral fin.

The development of prominent vertical barring in early juveniles (Figure 4) may be rapid and associated with environmental stimuli. The juveniles are found under floating kelp where the disruptive coloration of the vertical bars would be cryptic. This type of coloration is also found in carangids and stromateoids that also associate with floating objects.

Kendall (1979) described the general morphology of *Paralabrax* larvae and made comparisons with other serranid genera. His material was not identified as to species, but his illustrations were of *P. clathratus*. We found the larvae of *P. clathratus* to be morphologically similar to the other two species studied (Tables 1 and 2). Ontogenetic trends of increasing snout-anus distance, head length, and body depth, relative to standard length, occur in all three species. Relative eye size decreases during the larval period in all three species and then increases in the juveniles. In *P. clathratus* and *P. nebulifer*, relative snout length reaches a maximum at notochord flexion and declines during later stages, whereas in *P. maculatofasciatus* the maximum is in postflexion larvae (Table 2). Relative snout length is greater in *P. clathratus* than in the other two species during all stages of development, and older larvae and early juveniles of *P. clathratus* have a more pointed snout than the other two species (Table 2).

Kendall (1979) described the complement of head spines for *Paralabrax* larvae (presumably *P. clathratus*), but did not give the sequence of development. The first spines to appear in *P. clathratus* are on the preopercle. At 4.7 mm a single preopercular spine is present in association with a single spine anterior to it on the preopercular ridge. Spines are added dorsally and ventrally to the initial spines to form anterior and posterior preopercular series. A maximum of three spines develops in the anterior series in postflexion larvae. These spines become obsolete at the end of the larval period and are absent in specimens larger than 11.0 mm. The posterior series contains a maximum of 6 spines at the end of the larval period and 7 in transition specimens. Spines continue to accrue on the upper region of the preopercular series in early juveniles, while the spines on the lower portion of the series are lost. Our largest stained specimen had 18 comb-like preopercular spines.

Upper and lower posttemporal spines appear first in a 5.9-mm specimen. The upper spine remains prominent throughout the larval period and is present in juveniles. The lower posttemporal spine disappears during the transitional stage after 10 mm SL.

The spine on the interopercle appears first in a 5.9-mm larva, remains throughout the larval and transitional stages, but is absent in most early juveniles. A subopercular spine was present on one 6.5-mm larva and two transitional specimens but was

TABLE 1
Measurements (mm) of *Paralabrax clathratus*

Age (days)	Body length	Snout to anus	Head length	Snout length	Eye	Body depth at P_2	Caudal peduncle depth	Caudal peduncle length
1	2.2	1.4						
1	2.7	1.4						
4	3.0	1.5	0.6	0.16	0.22	0.4		
2	3.1	1.6	—	—	—	—		
5	3.2	1.7	0.8	0.20	0.28	0.5		
5	3.4	1.8	0.7	0.16	0.30	0.5		
5	3.8	2.0	0.9	0.22	0.28	0.6		
5	3.8	2.1	1.0	0.24	0.28	0.6		
5	4.1	2.2	1.0	0.28	0.32	0.6		
7	4.1	2.2	1.0	0.28	0.32	0.6		
11	4.6	2.4	1.3	0.36	0.40	0.9		
12	5.0	2.8	1.6	0.5	0.5	1.2		
19	5.5	2.9	1.7	0.5	0.4	1.2		
25	5.9	3.3	2.1	0.6	0.6	1.6		
13	6.2	3.8	2.2	0.6	0.6	2.0		
25	6.8	3.9	2.5	0.7	0.7	1.8	0.6	1.2
25	7.3	4.4	2.7	0.7	0.7	2.2	0.8	1.2
—	8.3	5.0	3.0	1.0	0.9	2.4	1.1	1.4
—	8.9	5.2	3.1	0.7	0.8	2.7	1.2	1.4
—	9.2	5.2	3.2	0.8	0.8	2.7	1.2	1.5
—	9.8	5.7	3.6	1.1	1.0	2.8	1.3	1.5
28	10.0	5.8	3.6	0.9	1.0	3.1	1.4	1.7
—	10.3	6.3	4.1	1.1	1.0	3.1	1.3	1.7
—	10.5	6.4	4.1	1.1	1.2	3.0	1.3	1.8
—	10.7	6.4	4.2	1.1	1.2	3.0	1.4	1.8
—	11.3	6.7	4.6	1.2	1.2	3.2	1.5	1.8
—	12.0	7.2	4.7	1.2	1.2	3.6	1.5	1.9
—	12.3	7.5	4.8	1.3	1.2	3.8	1.5	1.9
—	13.0	7.8	5.2	1.7	1.3	3.7	1.7	2.2
—	13.5	8.3	5.2	1.3	1.3	3.7	1.6	2.1
—	14.0	8.8	5.7	1.7	1.3	4.5	1.8	2.2
—	14.2	8.7	5.8	1.5	1.5	4.0	1.8	2.2
—	15.6	9.3	6.2	1.7	1.3	4.6	2.1	2.5
—	15.8	9.3	5.8	1.3	1.7	4.7	2.0	2.6
—	18.2	11.0	6.4	1.5	1.7	5.5	2.6	2.9
—	21.0	12.8	8.0	1.7	2.0	6.4	3.0	3.1
—	23.0	14.0	8.5	2.3	2.2	6.8	3.2	3.5

Specimens between dashed lines are undergoing notochord flexion.

absent on all other specimens examined. The upper opercular spine appears at 6.5 mm and persists throughout development. The lower opercular spine is the last of the head spines to develop and is first evident on a 13.5-mm juvenile.

Development of head spines does not differ significantly among the three species studied. Each type of spine appears at about the same size in the three species, persists to a comparable stage of ontogenesis, and therefore is not helpful in species identification.

Paralabrax nebulifer *(Girard 1854) Barred Sand Bass* (Figures 5-7)

Distinguishing characters. Yolk-sac larvae of *P. nebulifer* were not distinguishable from *P. clathratus* or *P. maculatofasciatus*. Preflexion larvae may be distinguished from those of *P. clathratus* and *P. maculatofasciatus* by the large number, (11-20)$\bar{x}$ = 14.5, of small ventral melanophores on the tail. The second dorsal midline melanophore is more anterior than in the other two species. In addition, most preflexion *P. nebulifer* larvae lack the posteriormost dorsal midline melanophore and have pigment on the horizontal septum. Flexion larvae of *P. nebulifer* may be distinguished from *P. clathratus* by the pigment along the horizontal septum; however, *P. nebulifer* appears to be indistinguishable from *P. maculatofasciatus* at this stage. In postflexion larvae of *P. nebulifer* (ca. 8.8 mm), pigment forms in a broad saddle under the first dorsal fin, rather than in several discrete saddles as found in *P. clathratus*. Similar sized *P. maculatofasciatus* are more heavily pigmented. Early juveniles (ca. 12-16 mm) of *P. nebulifer* are more uniformly pigmented with less pronounced vertical barring than

TABLE 2
Body Proportions of Larvae and Early Juveniles of California *Paralabrax* species

Body proportion*	*Paralabrax clathratus*	*Paralabrax nebulifer*	*Paralabrax maculatofasciatus*
Snout to anus/body length			
Preflexion	529 ± 15 (500-553)	512 ± 12 (500-529)	520 ± 35 (484-556)
Flexion	564 ± 36 (527-613)	577 ± 21 (551-604)	553 ± 35 (521-621)
Postflexion	594 ± 16 (574-621)	582 ± 18 (565-608)	611 ± 18 (597-646)
Juvenile	606 ± 10 (589-628)	607 ± 10 (598-618)	626 ± 14 (607-650)
Head length/body length			
Preflexion	240 ± 27 (200-283)	255 ± 11 (235-270)	224 ± 8 (214-235)
Flexion	335 ± 24 (309-356)	336 ± 23 (306-368)	299 ± 28 (261-345)
Postflexion	375 ± 21 (360-408)	369 ± 18 (353-392)	354 ± 9 (342-364)
Juvenile	386 ± 18 (352-408)	376 ± 7 (369-385)	373 ± 17 (338-389)
Snout length/head length			
Preflexion	258 ± 20 (240-280)	248 ± 45 (150-308)	233 ± 26 (200-267)
Flexion	291 ± 16 (273-312)	264 ± 26 (222-286)	242 ± 24 (200-267)
Postflexion	265 ± 29 (222-306)	241 ± 22 (214-267)	250 ± 16 (226-273)
Juvenile	261 ± 32 (212-327)	221 ± 21 (200-244)	224 ± 32 (190-262)
Eye diameter/head length			
Preflexion	335 ± 46 (280-428)	295 ± 38 (250-356)	337 ± 16 (311-350)
Flexion	276 ± 32 (235-312)	295 ± 25 (267-333)	276 ± 20 (240-300)
Postflexion	273 ± 19 (250-306)	267 ± 18 (242-286)	282 ± 15 (273-303)
Juvenile	251 ± 20 (210-293)	280 ± 17 (255-293)	298 ± 21 (273-341)
Body depth at pectoral fin base/body length			
Preflexion	155 ± 18 (133-196)	184 ± 20 (159-223)	173 ± 25 (143-200)
Flexion	263 ± 45 (218-323)	260 ± 32 (204-265)	227 ± 36 (186-293)
Postflexion	289 ± 12 (265-310)	288 ± 15 (271-307)	288 ± 16 (273-314)
Juvenile	296 ± 13 (273-321)	297 ± 5 (294-304)	304 ± 12 (290-323)
Caudal peduncle depth/body depth			
Preflexion	—	—	—
Flexion	—	—	—
Postflexion	126 ± 13 (88-140)	129 ± 6 (122-136)	128 ± 15 (107-146)
Juvenile	130 ± 8 (122-143)	140 ± 5 (134-145)	153 ± 5 (148-162)
Caudal peduncle length/body length			
Preflexion	—	—	—
Flexion	—	—	—
Postflexion	166 ± 7 (159-176)	146 ± 14 (136-168)	160 ± 10 (146-177)
Juvenile	157 ± 6 (148-165)	149 ± 10 (134-156)	145 ± 7 (136-157)

*Values given for each body proportion expressed as thousandths of body length or head length: mean, standard deviation, and range.

P. clathratus. They have horizontal stripes that are less dense than those of *P. maculatofasciatus*. Large juveniles have a conspicuous diagonal pigment bar below the eye, and two short diagonal bars anterior to the pectoral fin base.

Description. Morphometrics of *P. nebulifer* are presented in Tables 2 and 3. Preflexion larvae are similar to the other two species, but differ in the sequence and detail of pigmentation. The posterior dorsal melanophore is lost at 3.4 mm, in contrast to its loss at 4.6 mm in *P. clathratus* (Figure 5A). The marginal pigment of the abdominal fin fold is comparatively heavier than in the other two species and usually appears as a continuous line. The postanal ventral midline pigment is a continuous series of uniform melanophores from the end of the gut to near the end of the notochord. Pigment appears in the horizontal septum above the anus (Figure 5B) by 3.6 mm.

During notochord flexion additional pigment appears along the horizontal septum above the gut, along the sides of the gut, and on the body below the dorsal fin (Figure 5C). Similar pigment appears in flexion larvae of *P. maculatofasciatus*. Although subtle differences in pigmentation exist between reared specimens of *P. nebulifer* and *P. maculatofasciatus*, identification of field-collected larvae undergoing notochord flexion may not be possible.

Postflexion larvae between 6 and 11 mm add pigment on the head, and on the snout and operculum to form a line of pigment across the eye (Figure 5E). Pigment also appears on the cranium and below the base of the spinous dorsal fin. Late-stage larvae lack the incipient body bars present as dorsal pigment saddles in *P. clathratus* and are generally lighter in pigmentation than late-stage *P. maculatofasciatus* larvae.

Metamorphosis occurs at about 11 mm. The juveniles become heavily and more uniformly pigmented than *P. clathratus* (Figure 6). A dark stripe extends from the snout through the eye and along the lateral line to the base of the caudal fin. A second stripe runs from the base of the pectoral fin to the caudal fin base. The stripes are interrupted by six faint

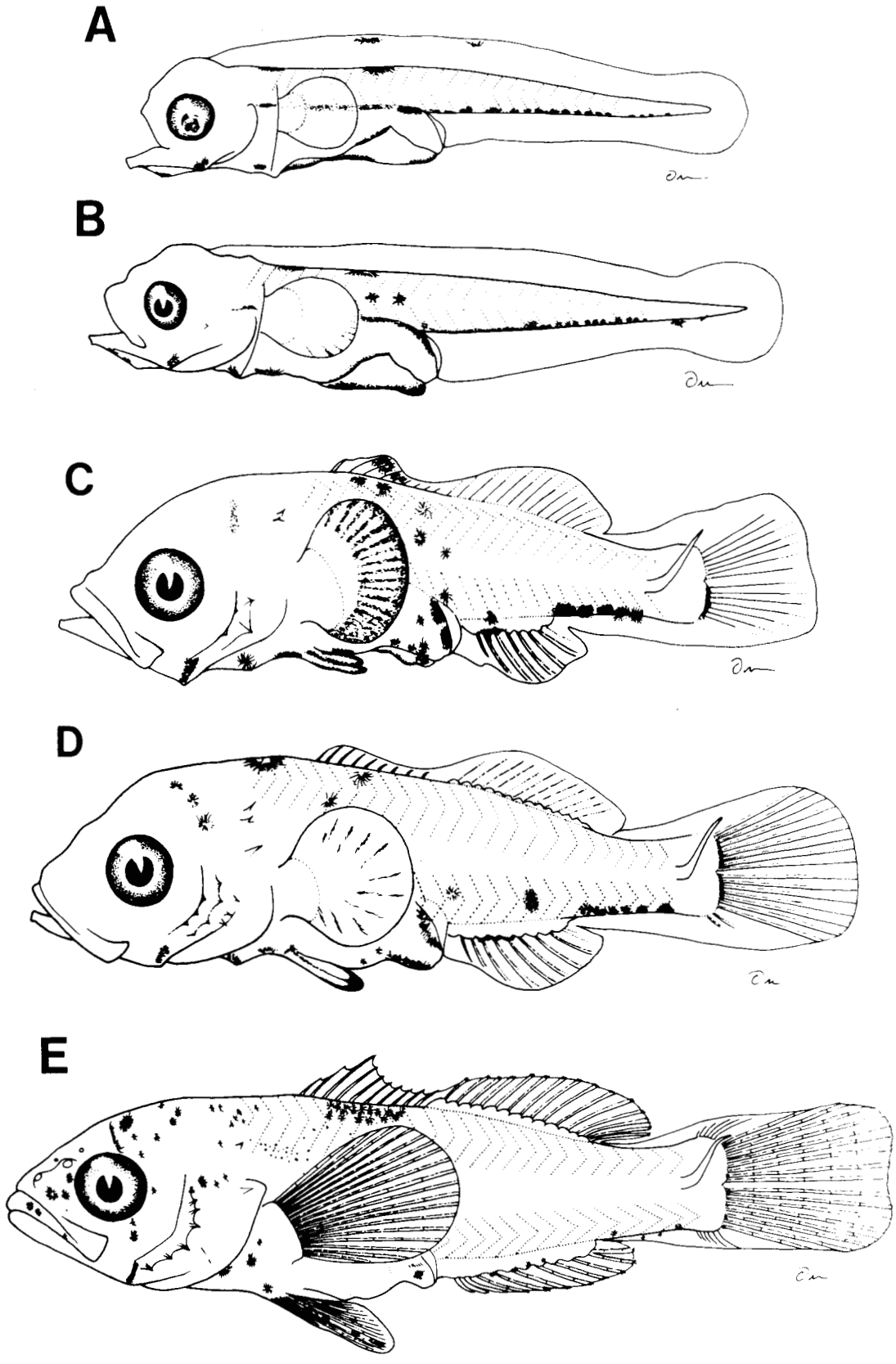

Figure 5. Larvae of *Paralabrax nebulifer: A.* 3.4-mm preflexion larva, 11 days; *B.* 4.4-mm preflexion larva, 10 days; *C.* 5.7-mm flexion larva, 29 days; *D.* 6.8-mm postflexion larva, 22 days; *E.* 9.4-mm postflexion larva.

TABLE 3

Measurements (mm) of Barred Sand Bass, *Paralabrax nebulifer*

Age (days)	Body length	Snout to anus	Head length	Snout length	Eye	Body depth at P_2	Caudal peduncle depth	Caudal peduncle length
11	3.4	1.8	0.8	0.12	0.28	0.76		
14	3.6	1.8	0.9	0.2	0.32	0.64		
11	3.6	1.8	0.9	0.2	0.28	0.64		
14	4.0	2.0	1.0	0.28	0.28	0.68		
14	4.2	2.1	1.1	0.28	0.28	0.72		
—	4.2	2.2	1.1	0.3	0.3	0.8		
10	4.4	2.3	1.1	0.3	0.3	0.72		
16	4.5	2.3	1.2	0.3	0.3	0.8		
17	4.8	2.5	1.3	0.4	0.4	1.0		
22	4.9	2.7	1.5	0.4	0.4	1.0		
25	5.5	3.1	1.8	0.4	0.6	1.5		
29	5.7	3.4	2.1	0.6	0.6	1.6		
22	6.8	4.1	2.3	0.6	0.7	1.8		
—	8.5	4.8	3.0	0.8	0.8	2.5	1.1	1.2
—	8.8	5.1	3.3	0.8	0.9	2.7	1.2	1.2
—	9.2	5.3	3.3	0.8	0.8	2.6	1.2	1.3
—	10.7	6.8	4.2	0.9	1.2	2.9	1.3	1.8
—	11.7	7.0	4.5	1.1	1.3	3.5	1.7	1.8
28	12.5	7.5	4.7	1.1	1.2	3.8	1.8	1.9
—	15.7	9.7	5.8	1.2	1.7	4.6	2.1	2.1
35	16.0	9.8	6.0	1.2	1.7	4.7	2.2	2.5

Specimens between dashed lines are undergoing notochord flexion.

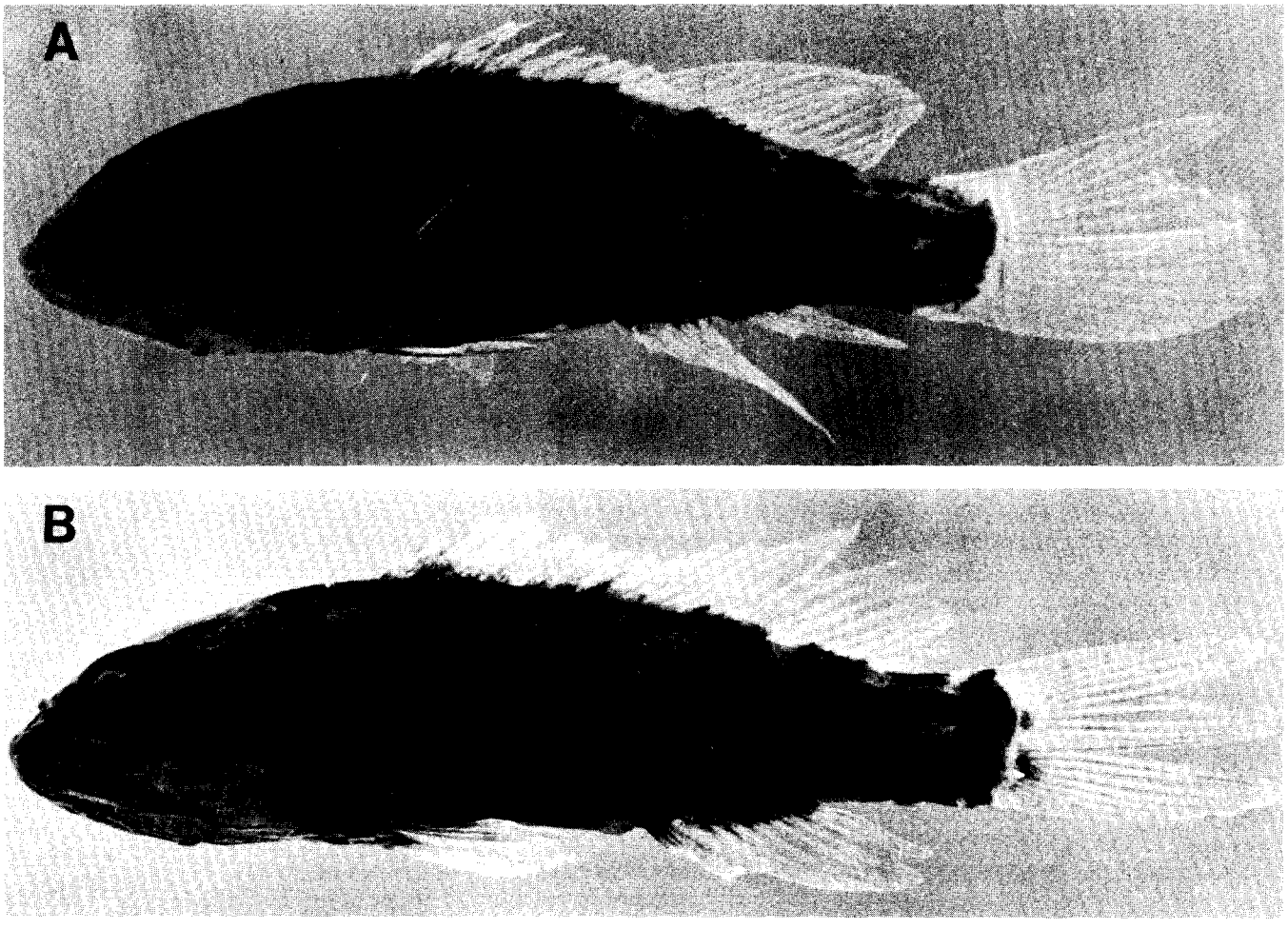

Figure 6. Juveniles of *Paralabrax nebulifer: A.* 10.8-mm newly transformed juvenile; *B.* 13.3-mm juvenile, 28 days.

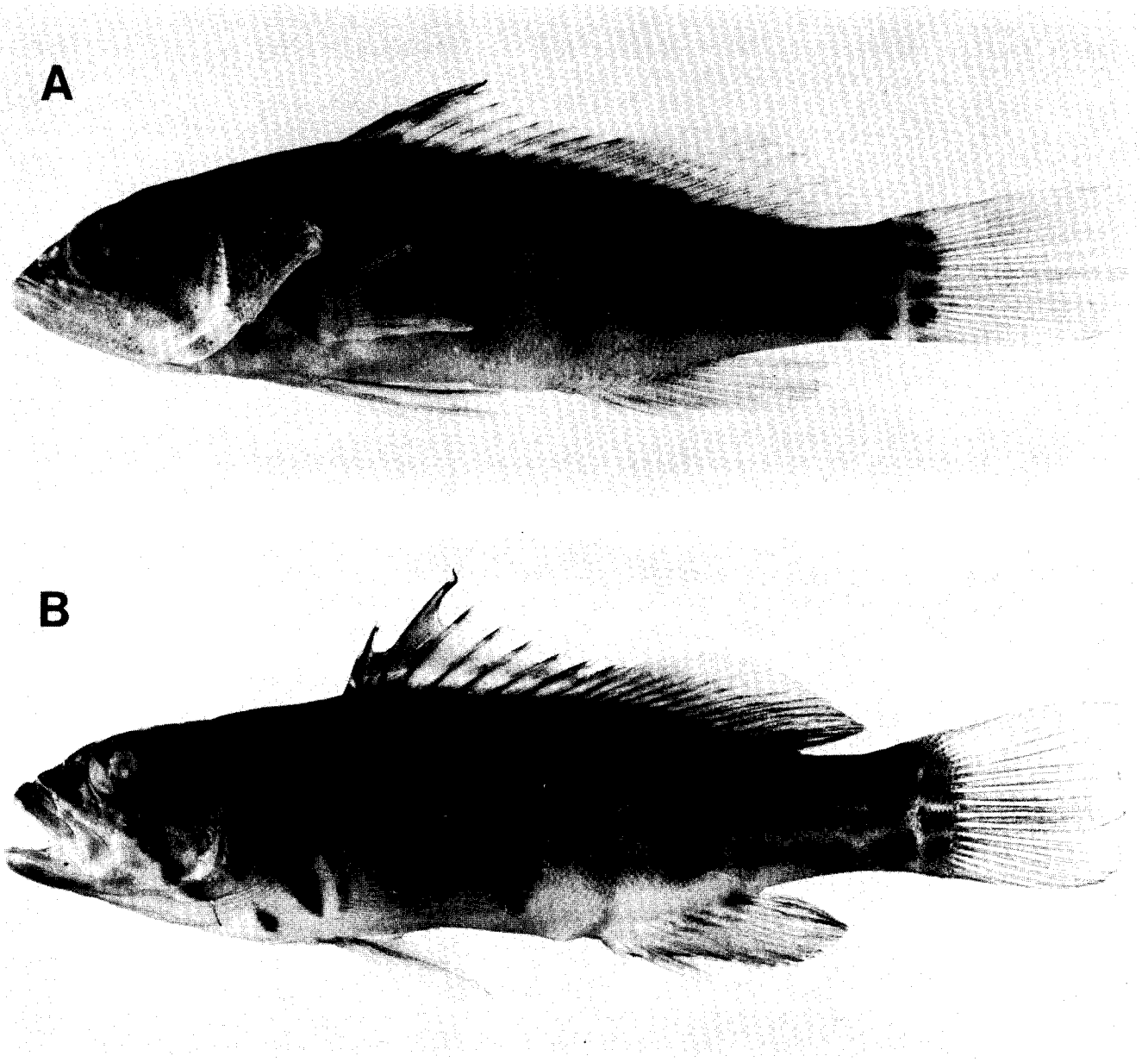

Figure 7. Juveniles of *Paralabrax nebulifer: A.* 33-mm juvenile, SIO 73-345, Mission Bay, San Diego; *B.* 45-mm juvenile, 99 days.

vertical bars: two beneath the spinous dorsal fin, two between the soft dorsal and anal fins, one on the caudal peduncle, and one over the hypural region. The bars extend onto the bases of the dorsal and anal fins (Figure 7). In larger juveniles the axial stripe and the upper portions of the bars blend with the uniformly heavy dorsal pigmentation; however, the bars are readily distinguishable ventrally (Figure 7). Juveniles at this stage have a prominent diagonal bar below the eye and two short diagonal bars anterior to the pectoral fin base (Figure 7).

Paralabrax maculatofasciatus *(Steindachner 1868)* *Spotted Sand Bass* (Figures 8-10)

Distinguishing characters. Preflexion larvae of *P. maculatofasciatus* may be distinguished from those of *P. clathratus* by the shape of the melanistic blotch on the preanal abdominal fin fold and by the absence of a third dorsal midline melanophore in larvae larger than 3.0 mm. Melanistic pigment is almost continuous along the ventral margin of the abdominal fin fold and does not form a triangular patch. Preflexion larvae of *P. maculatofasciatus* may be distinguished from those

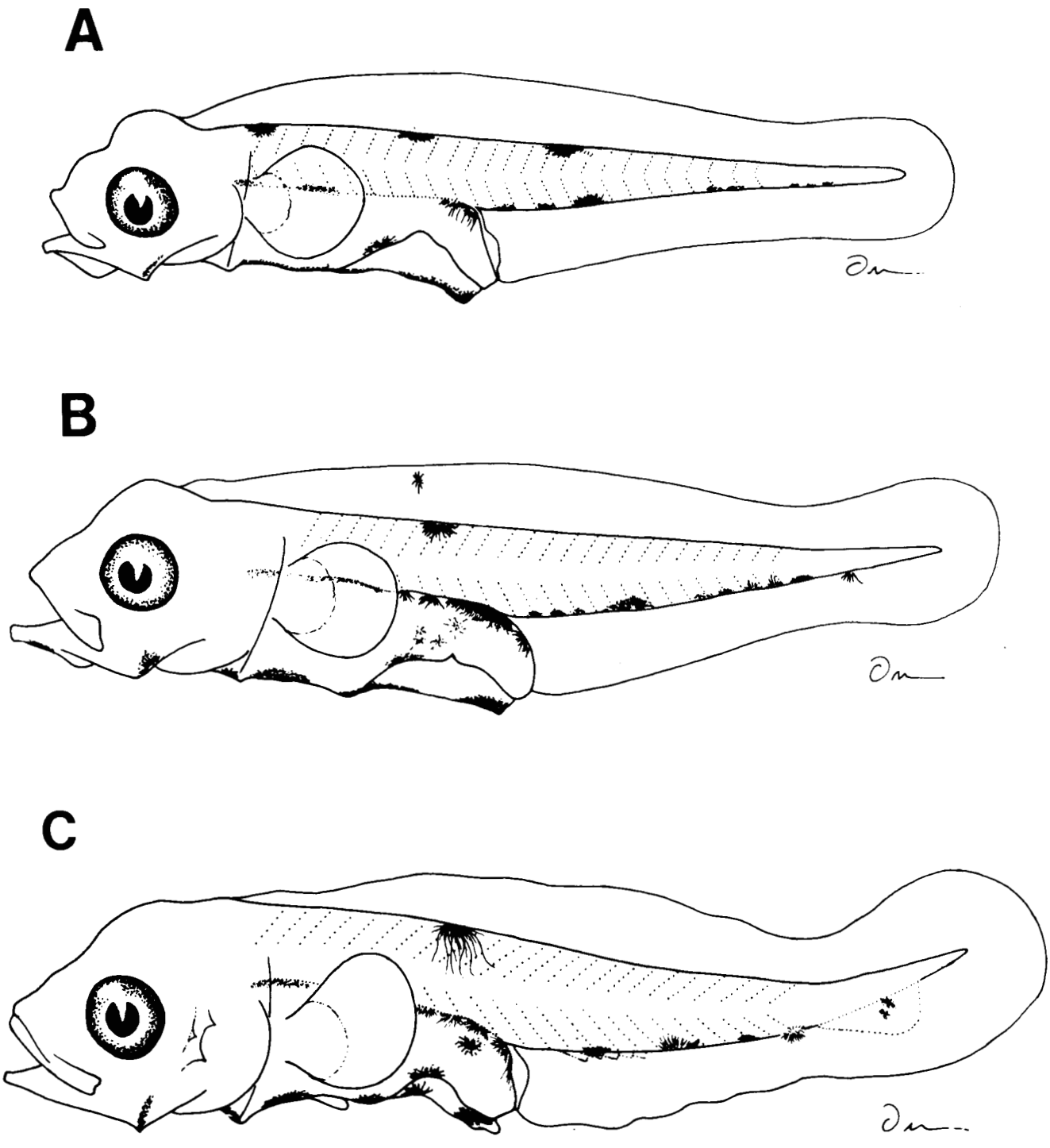

Figure 8. Larvae of *Paralabrax maculatofasciatus: A.* 3.1-mm preflexion larva, 5 days; *B.* 3.6-mm preflexion larva, 8 days; *C.* 4.5-mm preflexion larva, 12 days.

of *P. nebulifer* by the absence of horizontal septal melanophores and by their discontinuous and non-uniform ventral tail pigment.

Flexion larvae of *P. maculatofasciatus* can be distinguished from those of *P. clathratus* by the presence of melanophores along the horizontal septum and on the trunk. Flexion larvae of the two species of sand basses appear to be indistinguishable.

Late postflexion larvae of *P. maculatofasciatus* are distinguished from both *P. clathratus* and *P. nebulifer*

TABLE 4
Measurements (mm) of Spotted Sand Bass, *Paralabrax maculatofasciatus*

Age (days)	Body length	Snout to anus	Head length	Snout length	Eye	Body depth at P_2	Caudal peduncle depth	Caudal peduncle length
2	2.2							
4	2.8	1.4	0.6	0.16	0.20	0.40		
5	3.1	1.5	0.7	0.16	0.24	0.48		
8	3.4	1.9	0.8	0.16	0.28	0.68		
8	3.6	2.0	0.8	0.20	0.28	0.7		
9	4.0	2.0	0.9	0.20	0.28	0.7		
13	4.3	2.3	1.2	0.24	0.32	0.8		
12	4.5	2.4	1.3	0.32	0.36	0.9		
13	4.6	2.5	1.2	0.32	0.36	1.0		
14	4.8	2.5	1.4	0.32	0.4	1.0		
13	5.0	2.7	1.5	0.4	0.4	1.2		
23	5.2	3.0	1.7	0.4	0.5	1.3		
23	5.8	3.6	2.0	0.5	0.6	1.7		
19	6.2	3.7	2.2	0.6	0.6	1.7	0.7	1.1
26	7.5	4.6	2.7	0.7	0.7	2.1	0.8	1.2
21	7.7	4.6	2.8	0.7	0.8	2.1	1.0	1.2
23	8.2	5.0	2.8	0.7	0.8	2.4	1.1	1.3
23	8.6	5.2	3.1	0.7	0.9	2.7	1.2	1.4
25	9.6	6.2	3.3	0.8	1.0	2.8	1.4	1.4
33	10.3	6.7	4.0	0.8	1.2	3.1	1.6	1.4
33	10.8	6.7	4.2	1.1	1.2	3.2	1.6	1.7
28	11.8	7.5	4.4	0.9	1.2	3.6	1.8	1.7
35	13.0	8.2	4.4	1.2	1.5	4.2	2.1	1.9
40	14.5	9.0	5.5	1.2	1.6	4.2	2.2	2.0
38	16.8	10.2	6.3	1.2	1.9	5.0	2.5	2.5
35	18.0	11.2	6.7	1.5	2.0	5.7	2.7	2.6

Specimens between dashed lines are undergoing notochord flexion.

by the heavy pigment over the trunk. Juvenile *P. maculatofasciatus* develop a strongly contrasting stripe that extends from the snout through the eye to the caudal peduncle.

Description. Morphometrics of *P. maculatofasciatus* are given in Tables 2 and 4. Early preflexion larvae of *P. maculatofasciatus* are similar to those of *P. clathratus* in having three dorsal contour melanophores and several rather large melanophores along the ventral midline of the tail (Figure 8A). The line of pigment is almost continuous along the ventral margin of the abdominal fin fold. At about 3.6 mm, the posteriormost dorsal midline melanophore is lost. In some specimens the anteriormost dorsal melanophore is also lost (Figure 8B). After this, no significant pigment changes take place until notochord flexion.

During notochord flexion, lateral pigment is added over the gut, along the horizontal septum, and below the developing dorsal fin (Figure 9A). Following notochord flexion, pigment is augmented over the anterior portion of the trunk, and a conspicuous line of pigment develops on the head from the snout through the eye onto the operculum (Figure 9B and C). At about 11 mm, the conspicuous dark line extends from the snout to the caudal peduncle. A second horizontal stripe broken by unpigmented areas forms along the dorsum from the nape to the second dorsal fin during transformation (Figure 10A). At this stage, a third stripe begins to form from the base of the pectoral fin to the lower base of the caudal fin. The juvenile pigment is characterized by the three prominent stripes, with a background of six vertical bars similar in position to those on *P. nebulifer*. In larger juveniles the bars become larger and more conspicuous and begin to mask the stripes (Figure 10C). Pigment areas begin to break up into spots, a feature that characterizes the adults (Figure 10C). The cheek and lower opercular region are covered with large spots, and the pigment pattern forward of the pectoral fin consists of three distinct spots arranged in a triangle.

DISCUSSION

We have used laboratory-reared larvae as the basis for these descriptions. Pigment in laboratory-reared specimens is often more heavily expressed and certainly better preserved than in field-collected specimens. Considerable variability in pigmentation was observed in the laboratory series. Because of abrasion in the net and differences in preservation, field-collected specimens often lack important characters. In particular, fin folds are seldom present on net-collected larvae. Therefore, some field-collected

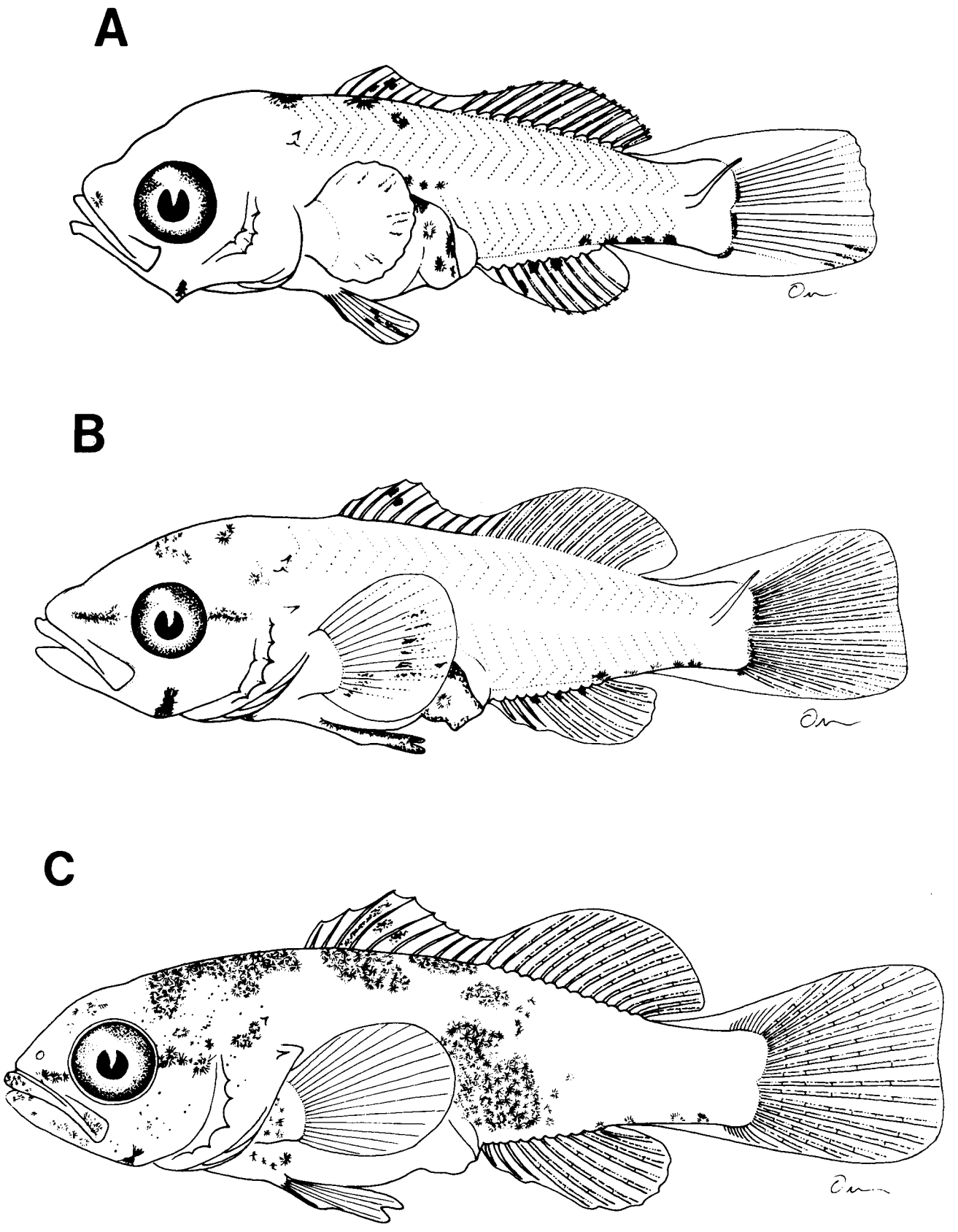

Figure 9. Larvae of *Paralabrax maculatofasciatus: A.* 5.8-mm flexion larva, 23 days; *B.* 7.9-mm postflexion larva, 26 days; *C.* 9.3-mm postflexion larva, 26 days.

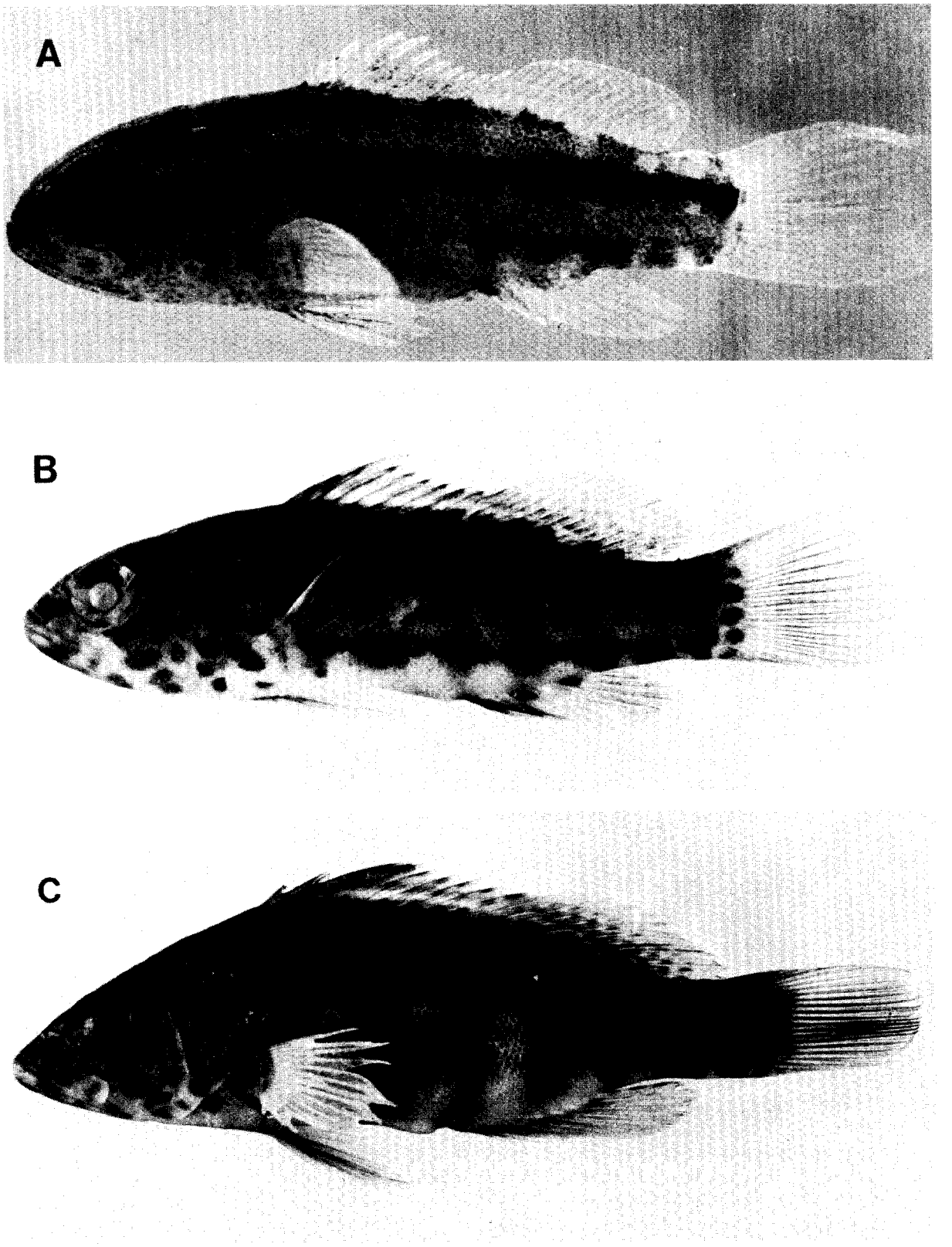

Figure 10. Juveniles of *Paralabrax maculatofasciatus: A.* 12.3-mm juvenile, 40 days; *B.* 29.5-mm juvenile, 49 days; *C.* 46-mm juvenile, SIO 73-345, Mission Bay, San Diego.

specimens often lack important characters. These descriptions are meant as an aid for identifying very similar larvae.

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