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DESCRIPTION OF EGGS AND LARVAE OF THREE FISHES FROM THE SALTON SEA, CALIFORNIA: *ANISOTREMUS DAVIDSONI* (STEINDACHNER), (PISCES: HAEMULIDAE), *BAIRDIELLA ICISTIA* (JORDAN AND GILBERT) AND *CYNOSCION XANTHULUS* (JORDAN AND GILBERT) (PISCES: SCIAENIDAE)

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ABSTRACT

This paper presents descriptions and illustrations of eggs and larvae of Anisotremus davidsoni (1.56 to 26.50 mm SL), Bairdiella icistia (1.36 to 42.40 mm SL), and Cynoscion xanthulus (1.31 to 43.30 mm SL) collected from January 1987 to September 1989 from the Salton Sea. Description of eggs include embryology, and pigmentation for each species examined. Descriptions of larvae include morphometrics, head spination, fin development, and pigmentation. Distinguishing features are examined for eggs and larvae of all three species.

Eggs are spherical, with typically a single oil globule and an unsegmented yolk. Eggs reared from artificially spawned C. xanthulus as well as wild eggs of A. davidsoni and B. icistia were utilized along with their field caught specimens. Diameters of 307 wild collected A. davidsoni eggs averaged 0.85 mm (range 0.76-0.88 mm), 100 wild collected B. icistia eggs averaged 0.76 mm (range 0.72-0.81 mm), whereas 100 C. xanthulus reared eggs averaged 0.77 mm (range 0.68-0.86 mm). Eggs prior to blastopore closure are indistinguishable. Later staged eggs are generally identifiable based on oil globule position, myomere counts (when present), or pigment patterns. Anterior oil globule position of A. davidsoni distinguishes it from the other two, with both having a posterior oriented globule. Cynoscion xanthulus is separated from B. icistia by having a lower myomere count of 22, while B. icistia has a count of 25 myomeres. Anisotremus lacks lateral nape pigment, whereas B. icistia and C. xanthulus have pigment there. Bairdiella icistia has ventral snout pigment while A. davidsoni and C. xanthulus do not.

Bairdiella icistia and C. xanthulus larvae can be separated from A. davidsoni in having both internal notochordal and external dorsal nape pigment. Bairdiella icistia can

be separated from C. xanthulus by the location of a conspicuous mid-tail melanophore: B. icistia located on 11th postanal myomere; C. xanthulus located on 8th postanal myomere.

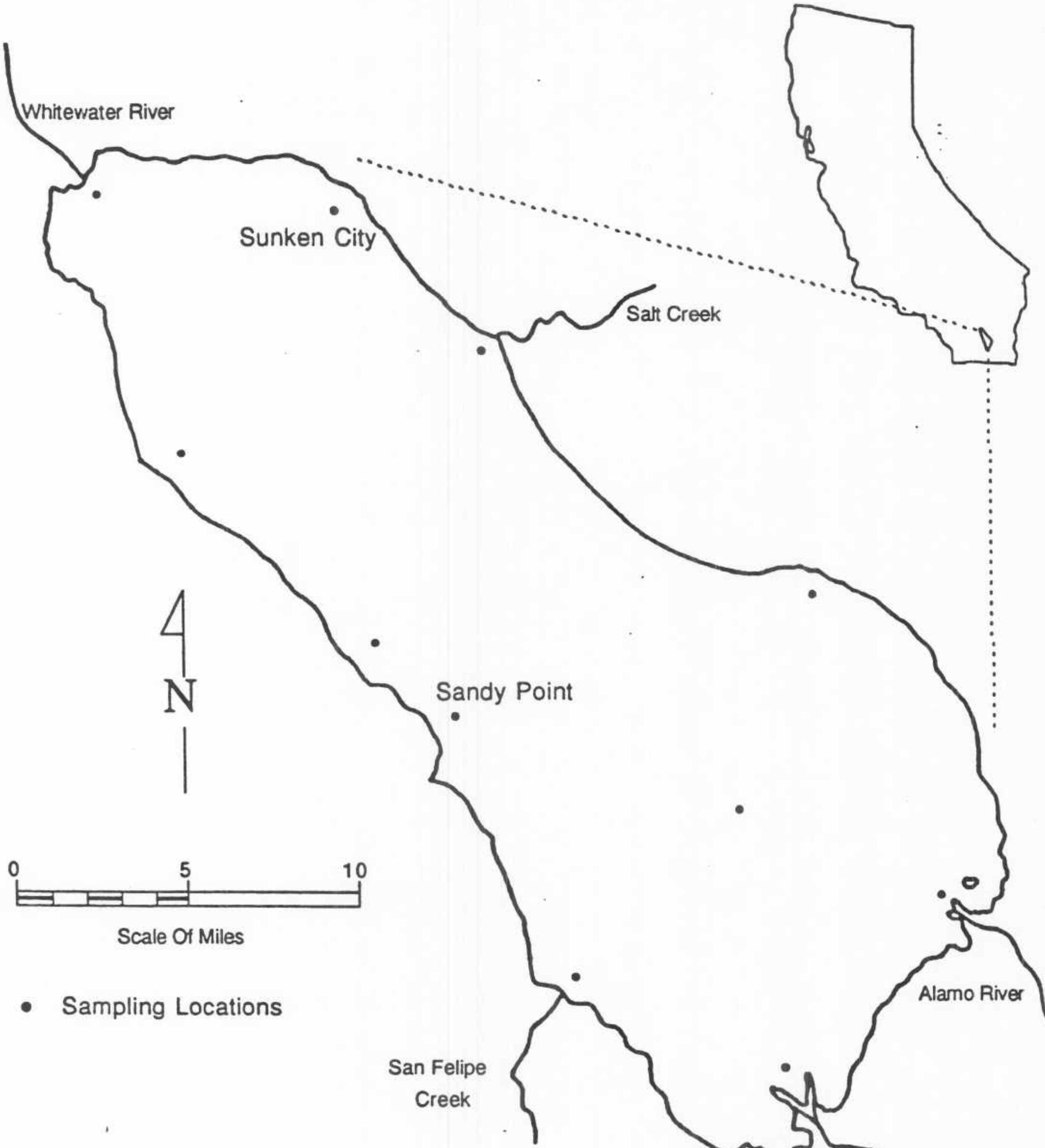
INTRODUCTION

The Salton Sea is a large saline lake, approximately 59 km long and 23 km wide, located in southeastern California at an elevation of 69 m below sea level (Carpelan 1958) (Fig. 1). Water temperatures range from 10 to 36°C, while salinity ranges from 36 to 41 ppt (Walker 1961, Matsui, unpubl.). From 1948 to 1956, 29 species were transported to the Salton Sea from upper Sea of Cortez at San Felipe, Mexico. Of these species, only three survived to form the current sport fishery (Black 1988, Walker, 1961).

The sportfishery includes two species from the family Sciaenidae, orangemouth corvina, C. xanthulus (Jordan and Gilbert), and bairdiella, B. icistia (Jordan and Gilbert), and one species from the Haemulidae family, sargo, A. davidsoni (Steindachner). All three have pelagic eggs and spawn in the spring or early summer (Walker 1961, Matsui in press). The natural range for A. davidsoni extends from Santa Cruz, California, to Magdelena Bay, Baja California, with isolated populations occurring in the Gulf of California (Miller and Lea 1972). Cynoscion xanthulus commonly occurs from within the Gulf of California to Acapulco, Mexico (Walker 1961, Miller and Lea 1972). Bairdiella icistia is native to the Gulf of California (Walker 1961) and ranges from the Pacific coast of Mexico to Almejas Bay, Baja California (Miller and Lea 1972).

Little is known of the early life history of these species, though pigment patterns have been used to identify late-staged eggs (Jordan et al., in press). Considerable literature is available on the early life histories of other species of C. xanthulus in the Gulf of Mexico and the western Atlantic: C. nebulosus (Hildebrand and Cable 1930, Fable et al. 1978, Powles and Stender 1978), C. nothus (Hildebrand and Cable, 1930, Powles and Stender 1978) and C. regalis (Welsh and Breder 1923, Pearson 1941, Powles and Stender 1978). Development of C. parvispinnis from the Sea of Cortez has been examined by

Figure 1. Map of the Salton Sea including sampling locations.



Ramírez-Sevilla et al. (1986).

The development of B. icistia has been described in some detail, (Kuntz 1915, Hildebrand and Cable 1930, Powles 1980). The eggs of B. icistia, including yolk-sac larvae were studied and photographed during temperature and salinity tolerance experiments (May 1975).

The early life histories of other species of Anisotremus have been described. Morphological and osteological development has been examined in A. virginicus (Potthoff et al. 1984). The osteology of A. davidsoni larvae 3 mm or greater from the Southern California Bight will soon be described (Watson, unpubl.). A brief mention of A. davidsoni larvae was made in a comparison to Genyonemus lineatus (Watson 1982).

In this paper, morphology, pigmentation, and meristics of eggs and larvae of A. davidsoni (Haemulidae), B. icistia (Sciaenidae), and C. xanthulus (Sciaenidae) from the Salton Sea will be described and the distinguishing characteristics for separating the three species will also be examined.

MATERIALS AND METHODS

Live eggs were collected from the Salton Sea and used for taxonomic description and general timing of embryological events. Bairdiella icistia eggs were caught during surveys conducted from March through July, 1988, and May 1989, along the western shoreline near the Sandy Point area, A. davidsoni eggs were collected along the eastern shore near the Sunken City area (Fig. 1). Tows were made throughout the day with temperatures ranging from approximately 20.0°C to 30.0°C. A one meter, 333-micron mesh net was towed for one minute at 0.5 m/s to collect the surface samples. Live eggs were maintained in a controlled environment in 40-ppt salinity Salton Sea water at ambient field temperatures until hatching occurred. Approximately 50 to 100 eggs were removed every two hours, measured and staged before preservation in a 5% buffered formalin seawater solution. Embryological stages and pigmentation were thoroughly examined later. A total of 980 B. icistia eggs and 690 A. davidsoni eggs were utilized.

Cynoscion xanthulus eggs were obtained from adults collected from the Salton Sea and kept in Salton Sea water at Occidental College's Salinity Bioassay Laboratory, located at the Southern California Edison's Redondo Beach Marine Laboratory.

The eggs were the result of two spawns on July 23 and July 24, 1989, induced by intramuscular injection of an analog of lutenizing hormone-releasing hormone LH-RHA (Prentice and Thomas 1987). Approximately 2000 live eggs were maintained in 40 ppt Salton Sea water at 25 to 27°C until hatching. Again, eggs were removed every one to three hours, measured live and preserved.

The preserved eggs were used to develop a pigment mapping procedure. Discriminant statistical analysis in conjunction with physical observations were used to determine the distinguishing characteristics of late-stage eggs for the three species (Jordan et al., in press).

In addition to live samples, a total of 534 A. davidsoni, 541 B. icistia and 281 C. xanthulus preserved, field-caught larvae were utilized for morphometric study. Monthly and biweekly ichthyoplankton surveys were conducted from 1987 to 1989 at 11 sites located at the Salton Sea (Fig. 1). Surface and oblique plankton samples were collected with a one meter 333-micron mesh net, equipped with a TSK rotary flowmeter and towed at 1 m/s for two minutes. Each sample was preserved and brought back to the laboratory where they were sorted.

The eggs and larvae from these samples were examined for pigmentation and were measured with the use of a binocular dissecting microscope, equipped with an ocular micrometer. Unless otherwise stated, all measurements and drawings are of field-caught specimens preserved no longer than two years. Specimens were preserved in a 5% buffered formalin seawater solution as described by Smith and Richardson (1977). All drawings were made with the aid of a camera lucida attachment. Eggs were staged using nomenclature from Ahlstrom and Ball (1954), with early, middle, and late stages. Measurements utilized for this study are as follows:

Egg Measurements

Chorion diameter: outside dimension of egg.

Yolk diameter: greatest width of yolk.

Oil globule diameter: largest diameter of single oil droplet.

Larval Measurements .

Notochord length (NL): tip of snout to end of notochord (prior to notochordal flexion).

Flexion length (FL): tip of snout to end of notochord during flexion stage.

Standard length (SL): tip of snout to posterior margin of the hypural plate.

Snout length: tip of snout to anterior margin of eye.

Eye diameter: greatest horizontal dimension of eye.

Head length: tip of snout to posterior margin of the otic capsule or dorsal margin of cleithrum, when present.

Snout to anus length: tip of snout to posterior margin of the anus.

Body depth: vertical height of body at posterior margin of head region.

Head width: width of the head posterior of eyes.

Pectoral fin length: distance from base of fin to tip of longest ray.

Caudal fin length: distance from margin of hypural plate to the longest ray.

Pelvic fin length: distance from base of fin to the tip of longest ray.

Spinous dorsal origin: distance from tip of snout to base of first dorsal spine, measured along midline of body.

Soft dorsal origin: distance from tip of snout to base of first dorsal soft ray, measured along midline of body.

Soft dorsal terminus: distance from tip of the snout to base of last dorsal soft ray, measured along midline of body.

Anal fin origin: distance from tip of snout to base of first anal spine or ray, measured along midline of body.

Anal fin terminus: distance from tip of snout to base of last anal spine or ray, measured along midline of body.

RESULTS

ANISOTREMUS DAVIDSONI

Egg Description

Live A. davidsoni eggs have a clear spherical unsculptured chorion with an unsegmented yolk and narrow perivitelline space. The chorion diameter ranges from 0.76 mm- 0.88 mm with a mean of 0.85 mm (SD = 0.02, N = 307). The perivitelline space ranges

from 0.00 mm - 0.07 mm with a mean of 0.02 mm (SD = 0.06, N = 307). Typically with a single oil globule ranging from 0.15 mm - 0.19 mm with a mean size 0.18 mm (SD = 0.009, N = 295) located in the anterior portion of the yolk mass near the cephalic region after blastopore closure. Multi-oil globule eggs made up approximately 5% of total eggs. Some had as many as 15, which were always clumped together in the vegetatal pole (Table 1, Fig. 2).

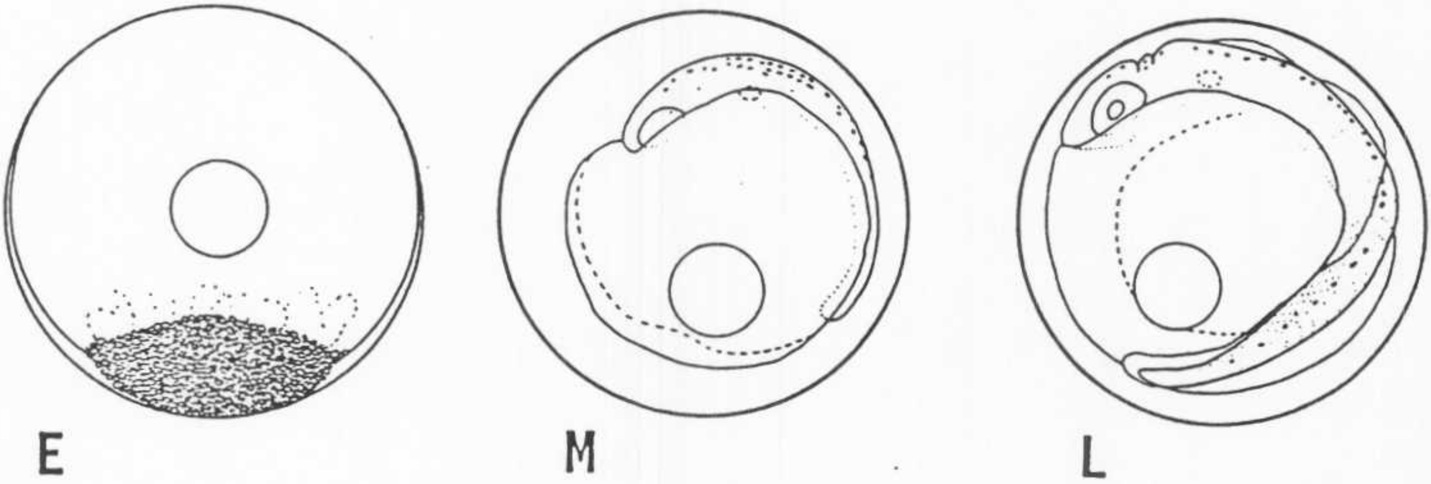
Embryology

Anisotremus davidsoni hatches in 26 hours at 22°C. The morula stage is reached in a mean time of three hours with the oil globule located in the vegetatal pole opposite the blastodisc. Gastrulation begins with the formation of the epiboly at a mean time of six hours. In approximately 10 hours the periblast reaches three-fourth of the way around the yolk and formation of optic vesicles has occurred. Blastopore closure is accompanied by development of the otic capsule with first signs of pigment and developing somites by

Table 1. Egg characteristics for live eggs of the three species of fish in the Salton Sea. A. davidsoni and B. icistia eggs were caught from field surveys while C. xanthulus eggs were obtained from adults maintained in a laboratory and artificially spawned using LH-RHA.

	A. davidsoni	B. icistia	C. xanthulus
Chorion	all species: clear, spherical unsculptured		
diameter (range)	0.76-0.88 mm	0.72-0.81 mm	0.68-0.86 mm
(mean)	0.85 mm (SD = 0.02, n = 307)	0.76 mm (SD = 0.02, n = 100)	0.77 mm (SD = 0.04, n = 100)
Yolk	all species: clear, unsegmented		
Perivitelline space			
(range)	0.00-0.07 mm	0.02-0.24 mm	0.00-0.08 mm
(mean)	0.02 mm (SD = 0.06, n = 307)	0.11 mm (SD = 0.03, n =91)	0.02 mm (SD = 0.01, n = 100)
Oil globule			
diameter (range)	0.15-0.16 mm	0.17-0.21 mm	0.18-0.26 mm
(mean)	0.18 mm (SD = 0.01, n = 295)	0.19 mm (SD = 0.01, n = 80)	0.21 mm (SD = 0.02, n = 96)
Multiple oil globules			
range	2-15	2-8	2-3
percentage	5%	15%	3%

Figure 2. Egg stages of Anisotremus davidsoni: E = Early-stage; M = Middle-stage; L = Late-stage. (Note: Drawing of E is of a live wild collected egg. Both M and L are of preserved field-caught specimens.)



development of somites at 20 hours. The tail is free from the yolk mass moving toward or even with the oil globule in 25 hours.

Egg Pigmentation

Sparse pigment scattered along the neural crest posterior to the optic vesicles, was first observed in A. davidsoni just after blastopore closure. At 14 hours after fertilization, pigment was evenly distributed over the dorsal surface of the embryo, except for the head region which had one or two melanophores present on the dorsal surface (Fig. 2, M). Pigment was rarely ever observed on the snout. After another four hours, the pigment was quite extensive above the hindbrain. At 19 hours, scattered hindbrain pigment moved laterally to form a pair of conspicuous dorsolateral rows of melanophores which parallel the medulla margins. Lateral pigment was never present below these margins throughout the middle and late stages. There are dorsolateral rows of pigment which connect middorsally in the posterior nape region, continuing posteriorly to the end of the embryo. Lateral trunk pigment extended diagonally from dorsolateral anterior trunk region to anus, eventually forming dorsal gut pigment.

Twenty-two hours after fertilization, middorsal caudal melanophores migrate ventrally usually in two places: above the anus and along the eleventh postanal myomere. Although, just prior to hatching, embryos generally display three equally spaced bands or patches of pigment: the first at posterior nape, the second near mid-body, above the anus, and the last at mid-tail, 9-11 postanal myomeres. Oil globules from live eggs often exhibit scattered pigment, sometimes extending onto the surface of the yolk. However, in many preserved specimens, this pigment was not apparent (Fig.

2, L).

Larval Description

Size

Live A. davidsoni yolk-sac larvae, hatched at 21°C, range from 1.68-2.00 mm (NL) (mean = 1.79 mm, SD = 0.13, N = 29). Notochord lengths from yolk-sac larvae that were field caught and preserved in 5% buffered formalin measure from 1.07-2.26 mm (mean = 1.82 mm, SD = 0.15, N = 56). Preflexion larvae notochordal lengths range from 2.01- 3.96 mm (mean = 2.94 mm, SD = 0.50, N = 187). Flexion ranges from 3.52 mm - 5.83 mm (mean 4.32 mm, SD = 0.51, N = 155). Postflexion begins at 5.83 mm (Table 2).

Morphometrics

There is a slight increase in body proportions with size in relative preanal length, head length, and snout length for preflexion to flexion larvae whereas in postflexion each tend to stay relatively constant. Relative head width and eye diameter also stays constant in relation to SL, although both decrease in size relative to an increase in head length. Relative body depth has a constant increase from 25-32% of SL for preflexion to postflexion. Dorsal and anal ray proportions stay constant throughout all postflexion specimens examined up to 25.00 mm. Anus to anal fin origin is quite narrow, ranging from 1% to 8% with a mean of 3.2% by standard length. Scales were first observed in caudal region at 14.50 mm (Table 3).

Table 2.

Anisotremus davidsoni Morphometric Chart

	Size Class (SL in mm)	Snout to Anus			Head Length			Head Width			Snout Length			Eye Diameter			Body Depth		
		$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD
Yolk-Sac	1.51-2.00	0.87	50	0.04	0.39	50	0.03	0.26	49	0.07	0.09	50	0.02	0.18	50	0.01	0.42	48	0.04
	2.01-2.50	0.93	7	0.07	0.40	7	0.03	0.26	6	0.02	0.08	7	0.03	0.19	7	0.01	0.43	6	0.06
Preflexion	2.01-2.50	1.11	50	0.10	0.51	50	0.08	0.35	50	0.06	0.11	50	0.05	0.23	50	0.03	0.54	50	0.07
	2.51-3.00	1.37	50	0.10	0.72	50	0.07	0.49	50	0.04	0.16	50	0.05	0.29	50	0.02	0.71	50	0.08
	3.01-3.50	1.59	56	0.11	0.86	56	0.10	0.55	56	0.04	0.20	56	0.07	0.32	56	0.02	0.85	56	0.08
	3.51-4.00	1.76	31	0.14	0.98	31	0.10	0.61	31	0.07	0.25	31	0.06	0.34	31	0.02	0.95	31	0.10
Flexion	3.51-4.00	1.87	48	0.13	1.07	51	0.11	0.62	51	0.07	0.30	51	0.05	0.36	51	0.02	1.05	48	0.09
	4.01-4.50	2.14	50	0.12	1.26	50	0.09	0.68	50	0.07	0.36	50	0.07	0.39	50	0.03	1.15	50	0.07
	4.51-5.00	2.39	36	0.19	1.48	36	0.19	0.74	36	0.07	0.48	36	0.12	0.42	36	0.04	1.29	36	0.13
	5.01-5.50	2.80	16	0.16	1.75	16	0.17	0.83	16	0.07	0.57	16	0.11	0.48	16	0.03	1.44	16	0.15
	5.51-6.00	2.86	2	0.14	1.80	2	0.06	0.91	2	0.00	0.60	2	0.01	0.48	2	0.01	1.55	2	0.01
Postflexion	5.51-6.00	3.40	1	0.00	2.20	1	0.00	0.91	1	0.00	0.77	1	0.00	0.55	1	0.00	1.84	1	0.00
	6.01-7.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7.01-7.50	4.50	2	0.42	2.47	2	0.35	1.19	2	0.02	0.81	2	0.10	0.70	2	0.03	2.19	2	0.04
	7.51-8.00	4.66	1	0.00	2.68	1	0.00	1.32	1	0.00	0.68	1	0.00	0.80	1	0.00	2.48	1	0.00
	8.01-8.50	5.08	1	0.00	3.00	1	0.00	1.40	1	0.00	1.04	1	0.00	0.80	1	0.00	2.48	1	0.00
	8.51-9.00	5.19	6	0.17	2.93	6	0.13	1.39	6	0.07	0.81	6	0.14	0.87	6	0.02	2.50	6	0.12
	9.01-9.50	5.55	3	0.28	3.20	3	0.08	1.57	3	0.15	0.94	3	0.06	1.06	3	0.16	2.74	3	0.16
	9.51-10.00	5.71	12	0.24	3.33	12	0.26	1.54	12	0.12	0.94	12	0.15	0.96	12	0.06	2.82	12	0.23
	10.01-10.50	6.09	11	0.22	3.44	11	0.10	1.65	11	0.09	0.93	11	0.08	1.05	11	0.05	2.98	11	0.14
	10.51-11.00	6.38	5	0.27	3.64	5	0.15	1.75	5	0.24	0.92	5	0.12	1.11	5	0.09	3.18	5	0.26
	11.01-11.50	6.42	5	0.36	3.94	5	0.08	1.89	5	0.13	1.00	5	0.12	1.18	5	0.01	3.30	5	0.06
	11.51-12.00	6.81	4	0.33	4.17	4	0.10	1.85	4	0.04	1.03	4	0.07	1.27	4	0.07	3.60	4	0.14
	12.01-14.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14.01-14.50	8.67	1	0.00	4.66	1	0.00	2.67	1	0.00	1.36	1	0.00	1.72	1	0.00	5.08	1	0.00
	14.51-15.00	8.84	1	0.00	5.16	1	0.00	2.50	1	0.00	1.17	1	0.00	1.42	1	0.00	4.75	1	0.00
	15.01-16.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16.51-17.00	9.84	1	0.00	5.91	1	0.00	2.75	1	0.00	1.75	1	0.00	1.92	1	0.00	5.33	1	0.00
	17.01-17.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17.51-18.00	10.17	1	0.00	6.25	1	0.00	2.92	1	0.00	1.68	1	0.00	1.88	1	0.00	5.25	1	0.00
	18.01-18.50	10.84	1	0.00	6.41	1	0.00	4.58	1	0.00	1.92	1	0.00	2.08	1	0.00	5.83	1	0.00
	18.51-25.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	25.51-26.00	16.67	1	0.00	9.84	1	0.00	4.58	1	0.00	2.92	1	0.00	3.00	1	0.00	9.00	1	0.00

	Size Class (SL in mm)	Pectoral Fin Length			Caudal Fin Length			Pelvic Fin Length			Spinous Dorsal Origin			Soft Dorsal Origin			Soft Dorsal Termination			Anal Fin Origin			Anal Fin Termination		
		$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD	$\bar{x}$	n	SD
Yolk-Sac	1.51-2.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.01-2.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Preflexion	2.01-2.50	0.21	48	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.51-3.00	0.29	50	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.01-3.50	0.33	55	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.51-4.00	0.38	31	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flexion	3.51-4.00	0.43	51	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4.01-4.50	0.47	50	0.10	0.40	5	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4.51-5.00	0.56	36	0.09	0.57	19	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5.01-5.50	0.68	16	0.10	0.78	15	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5.51-6.00	0.85	2	0.03	1.00	2	0.01	-	-	-	-	-	-	-	-	-	-	-	-	3.20	1	0.00	3.92	1	0.00
Postflexion	5.51-6.00	0.76	1	0.00	1.00	1	0.00	-	-	-	-	-	-	-	-	-	-	-	-	3.68	1	0.00	4.44	1	0.00
	6.01-7.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7.01-7.50	0.97	2	0.05	1.49	2	0.08	0.18	2	0.09	3.17	1	0.00	4.22	2	0.06	5.68	2	0.33	4.57	2	0.26	5.64	2	0.28
	7.51-8.00	1.12	1	0.00	1.58	1	0.00	0.30	1	0.00	3.17	1	0.00	4.33	1	0.00	6.41	1	0.00	4.91	1	0.00	6.00	1	0.00
	8.01-8.50	1.32	1	0.00	1.80	1	0.00	0.48	1	0.00	3.83	1	0.00	4.49	1	0.00	6.75	1	0.00	5.41	1	0.00	6.41	1	0.00
	8.51-9.00	1.35	6	0.19	1.93	5	0.11	0.44	6	0.11	3.46	6	0.19	4.78	6	0.20	6.97	6	0.15	5.41	6	0.20	6.79	6	0.22
	9.01-9.50	1.37	3	0.16	2.15	3	0.20	0.47	3	0.03	3.72	3	0.21	5.23	3	0.35	7.36	3	0.21	5.76	3	0.36	7.11	3	0.43
	9.51-10.00	1.45	12	0.13	2.22	12	0.16	0.68	12	0.15	3.89	12	0.16	5.42	12	0.37	7.34	12	0.66	5.93	12	0.18	7.42	12	0.30
	10.01-10.50	1.65	11	0.09	2.40	11	0.21	0.85	11	0.16	4.12	11	0.16	5.99	11	0.36	8.21	11	0.26	6.44	11	0.42	8.09	11	0.32
	10.51-11.00	1.67	5	0.22	2.52	5	0.08	0.96	5	0.2	4.27	5	0.08	6.22	5	0.26	8.38	5	0.28	6.56	5	0.31	8.41	5	0.33
	11.01-11.50	1.75	5	0.24	2.71	5	0.11	0.88	5	0.12	4.50	5	0.20	6.68	5	0.26	8.78	5	0.22	6.80	5	0.34	8.71	5	0.27
	11.51-12.00	1.90	4	0.17	2.75	4	0.29	1.62	4	0.88	4.99	4	0.32	7.09	4	0.17	9.55	4	0.33	7.30	4	0.25	9.41	4	0.35
	12.01-14.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14.01-14.50	5.00	1	0.00	3.52	1	0.00	2.24	1	0.00	5.17	1	0.00	8.17	1	0.00	11.00	1	0.00	9.17	1	0.00	11.67	1	0.00
	14.51-15.00	2.75	1	0.00	4.00	1	0.00	2.50	1	0.00	5.83	1	0.00	8.84	1	0.00	11.84	1	0.00	9.17	1	0.00	12.00	1	0.00
	15.01-16.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16.51-17.00	3.50	1	0.00	4.33	1	0.00	3.08	1	0.00	6.00	1	0.00	9.50	1	0.00	13.34	1	0.00	10.34	1	0.00	12.84	1	0.00
	17.01-17.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17.51-18.00	7.17	1	0.00	4.75	1	0.00	2.58	1	0.00	6.67	1	0.00	10.17	1	0.00	14.17	1	0.00	11.00	1	0.00	14.34	1	0.00
	18.01-18.50	3.92	1	0.00	5.00	1	0.00	3.58	1	0.00	7.50	1	0.00	11.50	1	0.00	15.00	1	0.00	11.67	1	0.00	14.84	1	0.00
	18.51-25.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	25.51-26.00	5.83	1	0.00	7.30	1	0.00	5.66	1	0.00	10.34	1	0.00	17.17	1	0.00	21.50	1	0.00	17.50	1	0.00	21.50	1	0.00

Table 3. Body proportions of larvae from three Salton Sea species.

Body Proportions	*Anisotremus davidsoni*			*Bairdiella icistia*			*Cynoscion xanthulus*		
Snout to anus/body length									
Yolk-Sac	48.1±3.3	n=57	(41-56)	38.6±3.7	n=68	(33-50)	49.3±2.9	n=63	(44-57)
Preflexion	48.8±3.2	n=187	(39-59)	43.2±5.5	n=214	(33-58)	50.1±3.2	n=130	(42-60)
Flexion	50.5±2.9	n=152	(45-61)	52.3±3.5	n=107	(46-64)	56.0±2.7	n=14	(52-60)
Postflexion	58.8±2.2	n=57	(52-65)	59.5±5.0	n=143	(49-104)	64.1±2.7	n=66	(56-70)
Head length/body length									
Yolk-Sac	21.4±2.4	n=57	(17-31)	19.9±1.7	n=68	(17-24)	22.2±2.0	n=63	(18-27)
Preflexion	25.3±3.2	n=187	(16-35)	26.0±3.8	n=214	(18-36)	26.5±3.3	n=130	(17-37)
Flexion	30.0±3.2	n=155	(24-39)	32.2±2.3	n=107	(26-39)	32.3±3.4	n=14	(27-38)
Postflexion	34.1±1.8	n=57	(31-40)	32.5±3.2	n=143	(25-52)	37.4±3.2	n=66	(28-49)
Body depth/body length									
Yolk-Sac	23.3±2.7	n=54	(17-29)	23.6±3.4	n=68	(18-38)	25.1±3.8	n=62	(16-35)
Preflexion	25.3±2.6	n=187	(18-34)	32.5±3.7	n=214	(22-41)	32.2±3.7	n=130	(24-40)
Flexion	27.4±2.1	n=152	(22-33)	33.5±2.5	n=107	(29-42)	37.6±2.7	n=14	(33-42)
Postflexion	29.5±2.0	n=57	(25-35)	32.8±2.8	n=143	(25-50)	36.1±3.1	n=66	(29-45)
Anus to anal fin/body length									
Yolk-Sac	-			-			-		
Preflexion	-			-			-		
Flexion	4.2	n=1		3.9	n=1		3.6±4.7	n=5	(-4-7)
Postflexion	2.9±2.3	n=56	(-3-13)	5.8±3.3	n=142	(-4-19)	2.1±3.0	n=59	(-11-6)
Snout length/head length									
Yolk-Sac	23.0±5.3	n=57	(12-35)	17.6±5.8	n=68	(6-30)	20.7±5.5	n=63	(11-39)
Preflexion	22.4±6.1	n=187	(10-43)	21.4±5.0	n=214	(5-34)	24.3±6.3	n=129	(11-44)
Flexion	29.9±4.7	n=155	(19-42)	23.6±3.4	n=107	(16-31)	24.9±4.8	n=14	(16-33)
Postflexion	27.6±3.7	n=57	(20-35)	25.9±3.5	n=143	(17-50)	24.5±3.7	n=66	(16-34)
Eye diameter/head length									
Yolk-Sac	47.0±4.3	n=57	(40-58)	51.7±5.0	n=68	(42-70)	51.0±4.6	n=63	(39-63)
Preflexion	39.6±6.1	n=187	(27-60)	44.0±8.1	n=214	(31-100)	42.1±7.1	n=130	(27-69)
Flexion	31.2±3.7	n=155	(24-39)	34.4±2.5	n=107	(24-40)	31.3±5.1	n=14	(23-38)
Postflexion	30.0±2.4	n=57	(25-39)	28.2±4.0	n=143	(21-55)	22.6±2.8	n=66	(14-30)
Head width/head length									
Yolk-Sac	66.5±6.8	n=55	(46-83)	67.7±5.1	n=68	(58-81)	68.3±8.4	n=63	(50-94)
Preflexion	66.6±9.1	n=187	(36-100)	71.0±8.2	n=214	(45-100)	66.2±12.	n=130	(43-100)
Flexion	53.9±7.1	n=155	(39-79)	63.3±5.7	n=107	(51-92)	61.0±6.3	n=14	(50-72)
Postflexion	47.7±4.7	n=57	(41-71)	55.2±9.3	n=143	(35-138)	48.5±6.5	n=66	(34-61)

Spination

The first head spine appears on 2.60 mm specimens and are located on the preoperculum. By 4.51 mm, a compliment of four spines are present on the anterior shelf of the preoperculum. One to 11 spines develop on the posterior preopercular shelf by 14.8 mm. One to four supraocular spines are present beginning at flexion through the series. One to four subopercular and interopercular spines are also present on these specimens. One opercular spine is usually apparent throughout the later part of the postflexion stage beginning at 8.90 mm. Teeth are first observed along the dentary margin at 3.33 mm (Table 4).

Fin Development

The pectoral fin is present in all larvae examined (bud form in yolk-sac larvae), although development of fin rays begins at 5.80 mm with a total of 15 to 16 present by 7.48 mm. The caudal fin begins development at flexion, with a ray count of 11 + 11 at 14.80 mm during postflexion. Soft dorsal rays totalling 14 to 16 and anal rays totaling 9 to 11 are present during the flexion stage prior to spine formation. The 11 dorsal spines and two anal spines are present at 6.98 mm. Pelvic spines and rays become apparent at 8.11 mm (Table 5).

Fin Pigmentation

At 11.5 mm pigment develops at the base of the caudal fin. At 14.0 mm pigment appears on the spinous dorsal fin.

Table 4. *Anisotremus davidsoni* head spines and teeth

Size	Opercular	Subopercular	Interopercular	Temporal (Cleithral)	Lateral Preopercular (Anterior)	Marginal Preopercular (Posterior)	Supraocular	Teeth
02.20	0	0	0	0	0	0	0	N
02.40	0	0	0	0	0	0	0	N
02.60	0	0	0	0	1	0	0	N
02.80	0	0	0	0	1	0	0	N
03.00	0	0	0	0	1	1	0	N
03.21	0	0	0	0	1	1	0	N
03.33	1	0	0	0	2	2	0	Y
03.71	0	0	0	0	2	3	0	Y
04.00	0	0	0	0	2	3	0	Y
04.20	0	0	0	0	2	3	0	Y
04.51	0	0	0	0	4	4	0	Y
04.70	0	1	0	0	3	5	0	Y
04.94	0	1	1	0	4	4	0	Y
05.10	0	2	0	0	4	5	0	Y
05.50	0	2	1	0	4	5	0	Y
05.80	0	1	1	0	4	5	0	Y
06.98	0	4	2	0	4	8	0	Y
07.48	0	2	4	0	4	6	0	Y
08.11	0	2	3	0	4	7	0	Y
08.57	0	3	4	0	4	6	0	Y
08.73	0	1	1	0	4	8	0	Y
08.90	1	4	3	0	4	8	0	Y
09.04	1	2	2	0	4	9	0	Y
10.13	2	3	3	0	4	6	0	Y
11.07	1	3	3	0	4	10	0	Y
12.00	1	3	2	0	4	9	0	Y
14.80	1	1	1	0	0	11	0	Y

Meristics of *Anisotremus davidsoni*

Dorsal Fin	Anal Fin	Pectoral Fin	Pelvic Fin	Principal Caudal Fin	Procurrent Caudal Fin
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	2+2	-
-	-	-	-	2+2	-
-	-	-	-	2+2	-
-	-	-	-	3+3	-
-	-	-	-	3+4	-
15	11	-	-	7+8	-
16	10	-	-	8+8	-
15	11	-	-	8+8	-
16	11	-	-	9+8	1+1
16	09	07	-	9+8	1+0
XI, 14	II, 09	11	-	9+8	4+3
XI, 16	II, 11	15	-	9+8	4+5
XI, 16	II, 10	15	I, 4	9+8	4+4
XI, 14	II, 10	15	I, 5	9+8	6+6
XI, 16	II, 11	16	I, 4	9+8	6+5
XI, 15	II, 09	15	I, 5	9+8	6+6
XI, 14	II, 10	15	I, 5	9+8	5+5
XI, 14	II, 10	15	I, 5	9+8	6+7
XI, 14	II, 10	15	I, 5	9+8	6+7
XI, 14	II, 10	15	I, 5	9+8	8+8
XI, 14	II, 10	15	I, 5	9+8	11+10

Larvae Pigmentation .

Yolk-Sac Larvae

Yolk sac larvae have sparse, scattered head pigment usually with a small, dorsal patch of pigment on the posterior nape. A line of pigment is present along the anterior gut with scattered pigment near the anus. Scattered pigment also may be present on the surface of the oil globule prior to its absorption (although it was not confirmed in preserved specimens).

Three equally-spaced, dorsal, pigment patches are present along the main part of the trunk and tail of the yolk-sac larvae. The first patch is located near the first preanal myomere. The second patch is at the first postanal myomere, just dorsal to the anus. The third patch of pigment also has a ventral component associated with it and occurs at the mid-tail (9-11 myomeres from the anus) (Fig. 3 A).

Preflexion/Flexion Larvae

At the time of yolk-sac absorption, scattered head and nape pigment are no longer apparent. A single melanophore may be visible at the angle of the lower jaw plus pigment along the dorsal surface of the gut remain through these stages (Fig. 3B,C).

Postflexion Larvae

During these stages, one or two melanophores are usually present on the cleithral symphysis. Also, there are three to five melanophores equally space along the ventral

Figure 3. Anisotremus davidsoni larvae: A = 2.22 mm; B = 2.35 mm; C = 4.88 mm; D = 9.28 mm;

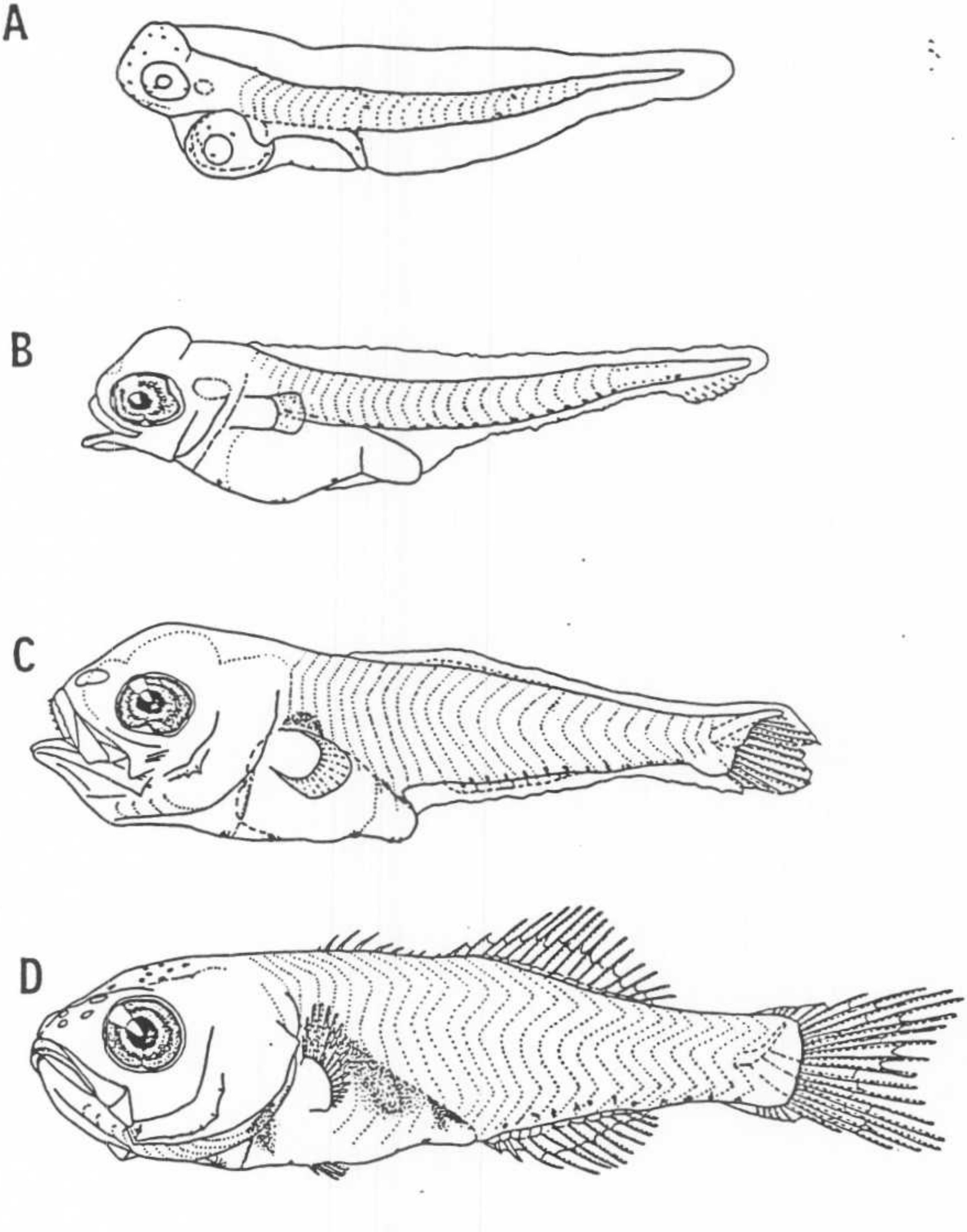
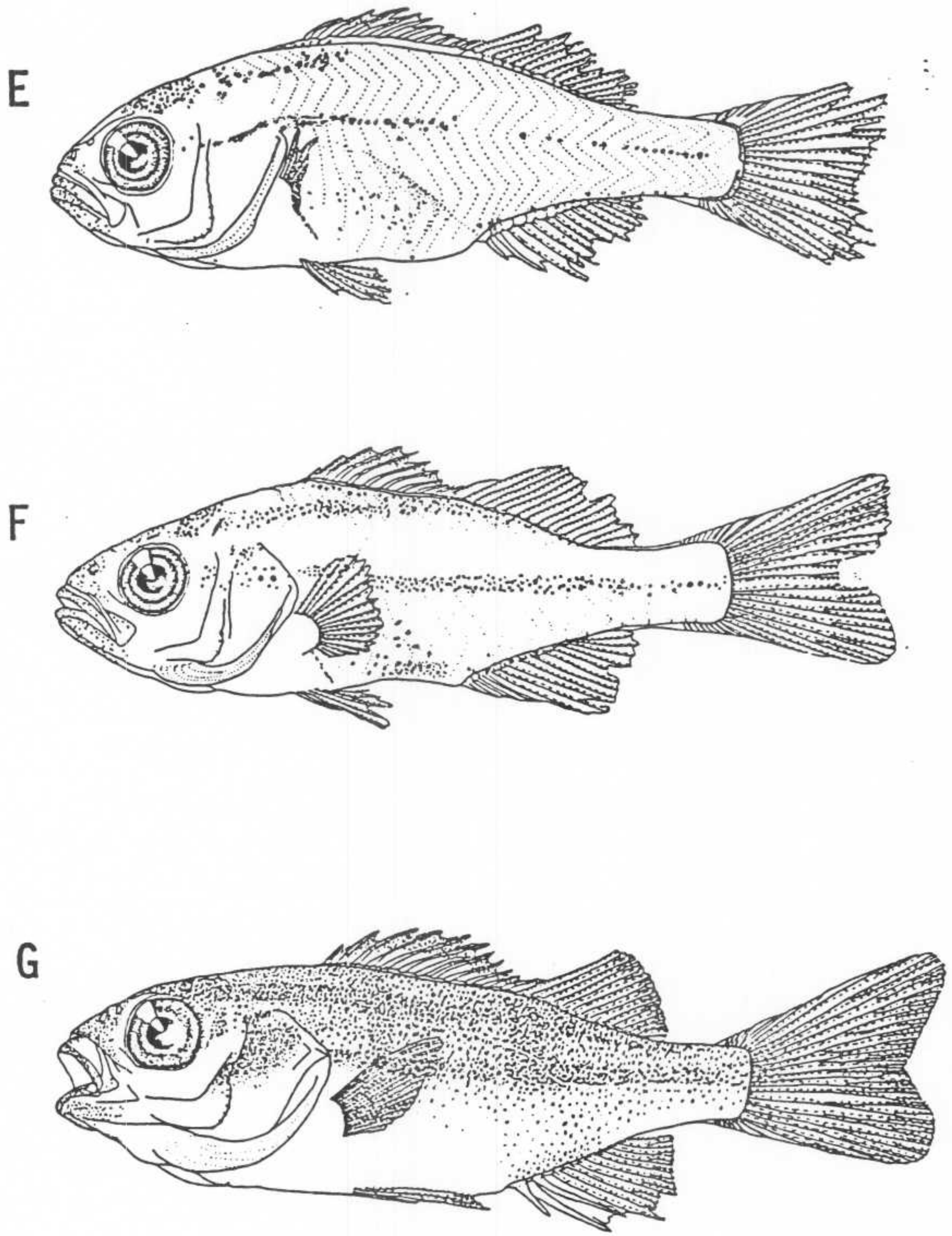


Figure 3 (cont'd). Anisotremus davidsoni larvae:
E = 14.37 mm; F = 17.81 mm; G = 26.50 mm.



midline of the gut with one or two of these melanophores present near the anus. A continuous row of melanophores are present along the ventral midline of the tail, starting from the second or third postanal myomere. A single melanophore is present on the angle of the lower jaw plus pigment along the dorsal surface of the gut present throughout the entire larval series. At 8.00 mm, several large melanophores may be seen on the dorsal surface of the head region above the midbrain. Premaxillary and dentary pigment is present with pigment in the gular region in larvae at 9.0 mm. (Pigment on the dorsal surface of the abdominal cavity becomes internal and extends laterally.) The midventral, postanal pigment also becomes internal at about 9.0 mm (Fig. 3D).

By 11.50 mm , pigment is present on the dorsal surface of the snout, forebrain, and opercular region. Pigment becomes scattered along the lateral gut at this time. Some pigment is also present at the base of the caudal fin.

Three lines of lateral trunk pigment (horizontal stripes) develop during the period from 11.5 - 17.0 mm. At 11.5 mm pigment is observed at the origin of spinous dorsal fin. This pigment extends in a line posteriorly and ends at the terminus of the soft ray dorsal fin by 17.0 mm. Midlateral trunk pigment is first observed at 12.00 mm in the caudal peduncle region and extends anteriorly. At 14.0 mm, more midlateral pigment forms at the operculum and extends posteriorly (Fig. 3E). The pigment becomes one complete midlateral line by 17.0 mm (Fig. 3F). The third line of pigment also begins to form at 14.00 mm. This dorsolateral line of pigment extends posteriorly from the temporal region and parallels the midline pigment. By 19.0 mm this pigment line is complete and ends at the terminus af the soft ray dorsal fin with the first of lateral pigment. Two vertical bars beginning to form ca. 22.20 mm; the larger anterior bar is below the third spine of the spinous dorsal, and the second is directly below the first dorsal ray (Fig. 3G).

BARDIELLA ICISTIA

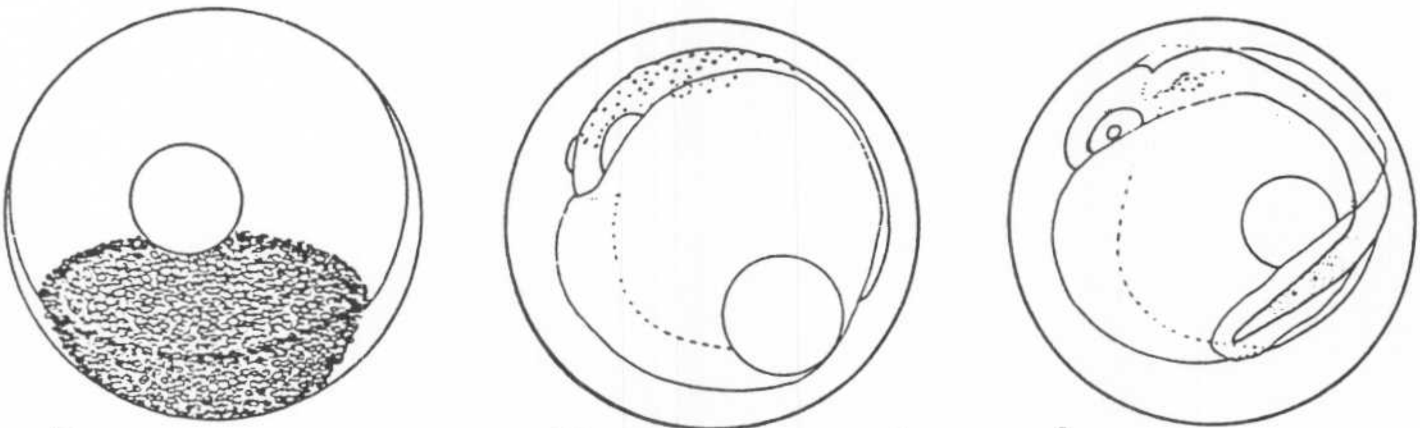
Egg Description

Live B. icistia eggs have a clear, spherical, unsculptured chorion with an unsegmented yolk and a narrow perivitelline space. Chorion diameter ranges from 0.72 mm - 0.81 mm with a mean diameter of 0.76 mm (SD = 0.02,N = 100). The perivitelline space ranges from 0.02 mm -0.24 mm with a mean width of 0.11 mm (SD = 0.03, N = 91). The single oil globule diameter of live eggs ranges from 0.17 mm - 0.21 mm with mean size of 0.19 mm (SD = 0.01, N = 80). Multi-oil globuled eggs made up approximately 15% of eggs. The multi-oil globules, some eggs having as many as eight, were clumped together in the vegetative pole opposite the blastodisc, in early stage eggs (Table 1, Fig. 4).

Embryology

Bairdiella icistia hatches in 20 hours at 27°C. The morula stage is reached in approximately three hours with the oil globule located in the vegetatal pole opposite the blastodisc. Gastrulation begins at a mean time of six hours. In approximately seven hours the periblast reaches 75% of the way around the yolk and the optic vesicles are forming. At nine hours the blastopore closes, followed soon by somite development, development of the otic capsule and the first signs of pigment. The oil globule is usually located in the posterior portion of the yolk mass near the anal region (after blastopore closure). The lens of the eye forms along with the rudimentary anus at approximately 14 hours. At 19 hours the tail extends beyond the oil globule and away from the yolk mass

Figure 4. Egg stages of <u>Bairdiella</u> <u>icistia</u>: E = Early-stage; M = Middle-stage; L = Late-stage. (Note: Drawing of E is of a live wild collected egg. Both M and L are of preserved field-caught specimens.)



E M L

toward the head.

Egg Pigmentation

Pigment is observed at approximately nine hours, after blastopore closure, scattered mid-dorsally slightly posterior to the head. The pigment then becomes scattered unevenly over the entire embryo (Fig. 4M). After approximately nine hours, two pigment saddles extend mid-laterally anterior to and posterior of the otic capsule. At approximately 12 hours a conspicuous transverse line of melanophores forms over the constriction between the midbrain and the hindbrain, plus a pair of dorsolateral rows of melanophores extending posteriorly either resting on, or extending through the otic capsules. Dense head pigment may concentrate along the orbit of the eyes. A few scattered melanophores may be present on the dorsal and ventral snout. A pair of dorsolateral lines of melanophores are visible on the dorsal surface of the embryo at the bend of the somites. Internal pigment may be present on the otic capsules at 14 hours becoming more extensive as the embryo develops. The dorsal tail melanophores increase in number as the tail extends off the yolk. At 18 hours complete myomere counts may be present. Around 19 hours, melanophores on the caudal may migrate ventrally along the 4th, 10th and 18th postanal myomeres forming easily recognized tail bands with the mid-tail band being predominant. Scattered pigment may be present on the oil globule, plus a string of pigment is often present between the anal region and the oil globule. Live eggs often exhibited scattered oil globule pigment, sometimes extending out on the surface of the yolk, whereas in many preserved specimens it was lacking (Fig. 4L).

Larval Description

Size

Live B. icistia yolk-sac larvae, hatched at 26.5°C, range from 1.25 - 2.03 mm NL (mean = 1.70 mm, SD = 0.19, N = 45). Field caught and preserved yolk-sac larvae range is size from 1.36 - 1.73 mm NL (mean = 1.54 mm NL, SD = 0.09, N= 68). Preflexion range in size from 1.52 - 3.93 mm with a mean size of 2.58, SD = 0.62, N = 214). Flexion range in size from 3.52 - 4.88 mm FL (mean = 4.04 mm, SD = 0.27, N = 107). Postflexion for bairdiella begins at 5.31 mm (Table 6).

Morphometrics

Head width and eye diameter for B. icistia decreases slightly in relation to SL, throughout all larval stages. A slight increase does occur though, in head length and snout length relative to SL, whereas snout to anus relative to SL has an increase of 50% to 60% of SL. Dorsal and anal spines and rays generally maintain the same body proportion. The anus to anal fin origin does decrease from 8% to 1% with a mean value of 4%. The body depth relative to SL maintains the same proportion of around 30% throughout all larval stages.

The pectoral fins become visible in bud form only, and the mouth begins to form at 1.50 mm. Eyes become pigmented and yolk is absorbed at around 2.0 mm. Notochordal flexion begins at 3.01 mm with the formation of the dorsal and ventral soft ray buds beginning at about 4.50 mm. The hypural plates become complete at 4.51 mm. The dorsal and anal rays form at 5.01 mm. The pelvics are present at 6.51 mm. Scales first observed in caudal region at 15.00 mm (Table 3).

Spination

The first head spine appears on the preopercular at 2.34 mm, reaching a compliment of six spines on the anterior shelf of the preopercular at 7.63 mm and on the posterior shelf at 11.40 mm. One or more cleithral/posttemporal spines may be present on sizes > 5.61 mm. Supraocular spines, 1-5 may be present on specimens 6.30 mm to 14.00 mm. One or two opercular spines may be present on larvae > 4.88 mm. One to two subopercular spines may be present on specimens > than 6.30 mm with usually one interopercular spine visible by 8.42 mm. Dentary teeth observed at 2.10 mm (Table 7).

Fin Development

The pectoral fin is present in all larval specimens > 1.50 mm examined, although rays begin forming during notochordal flexion, with a full compliment of 17 rays at 9.85 mm. During notochordal flexion the principal caudal rays begin to develop, with a final count of 8 + 9 at 14.00 mm. Soft dorsal and anal rays begin forming at 3.40 mm during notochordal flexion. The anal spines are first observed on specimens larger than 5.19 mm. The dorsal spines appear later on sizes greater than 5.93 mm, reaching a full compliment of 10 - 11 spines by 7.10 mm. The last spines and rays to appear will be the pelvic spines and rays (Table 8).

Table 7. *Bairdiella icistia* head spines and teeth

Size	Opercular	Subopercular	Interopercular	Temporal (Cleithral)	Lateral Preopercular (Anterior)	Marginal Preopercular (Posterior)	Supraocular	Teeth
01.90	0	0	0	0	0	0	0	N
02.00	0	0	0	0	0	0	0	N
02.10	0	0	0	0	0	0	0	Y
02.34	0	0	0	0	0	1	0	Y
02.47	0	0	0	0	0	1	0	Y
02.60	0	0	0	0	0	1	0	Y
02.90	0	0	0	0	0	2	0	Y
03.00	0	0	0	0	1	2	0	Y
03.15	0	0	0	0	2	3	0	Y
03.40	0	0	0	0	1	3	0	Y
03.52	0	0	0	0	2	3	0	Y
03.60	0	0	0	0	3	3	0	Y
03.89	0	0	0	0	3	3	0	Y
04.02	0	0	0	0	3	3	0	Y
04.26	0	0	0	0	3	3	0	Y
04.38	0	0	0	0	4	3	0	Y
04.60	0	0	0	0	4	3	0	Y
04.88	1	0	0	0	4	4	0	Y
05.19	0	0	0	0	4	3	0	Y
05.45	1	0	0	0	4	3	0	Y
05.61	1	0	0	1	3	4	0	Y
05.93	1	0	0	1	4	3	0	Y
06.30	0	1	0	1	5	4	1	Y
06.48	1	1	0	1	5	4	0	Y
06.70	1	0	0	1	5	4	1	Y
07.10	1	1	0	2	5	4	3	Y
07.63	1	1	0	2	6	4	2	Y
08.00	1	1	0	1	5	4	3	Y
08.42	1	0	1	1	5	4	3	Y
08.73	1	0	1	1	4	4	4	Y
09.19	1	1	0	1	6	4	2	Y
09.85	1	1	0	4	4	4	2	Y
11.40	1	1	0	2	4	6	0	Y
12.30	2	2	1	2	4	6	4	Y
13.25	2	1	1	2	5	6	3	Y
14.00	1	0	1	3	4	5	5	Y

Table 8. Meristics of *Bairdiella icistia*

Size (mm SL)	Dorsal Fin	Anal Fin	Pectoral Fin	Pelvic Fin	Principal Caudal Fin	Procurrent Caudal Fin
01.90	-	-	-	-	-	-
02.00	-	-	-	-	-	-
02.10	-	-	-	-	-	-
02.34	-	-	-	-	-	-
02.47	-	-	-	-	-	-
02.60	-	-	-	-	-	-
02.90	-	-	-	-	-	-
03.00	-	-	-	-	-	-
03.15	09	-	-	-	-	-
03.40	17	4	-	-	4+3	-
03.52	10	3	-	-	3+2	-
03.60	14	7	-	-	3+3	-
03.89	10	6	-	-	3+3	-
04.02	17	7	-	-	3+3	-
04.26	16	7	-	-	4+4	-
04.38	19	7	-	-	5+4	-
04.60	18	8	-	-	8+8	-
04.88	27	8	-	-	9+8	-
05.19	27	I, 9	-	-	9+8	2+1
05.45	27	9	-	-	9+9	-
05.61	28	I, 8	06	-	9+8	0+1
05.93	IV, 28	I, 8	12	-	9+8	1+2
06.30	VI, 27	II, 9	08	-	9+7	0+1
06.48	VI, 26	II, 8	05	-	9+8	0+1
06.70	VII, 26	II, 9	07	-	9+7	2+2
07.10	X, 26	II, 8	10	I, 4	9+8	4+4
07.63	X, 27	II, 9	10	5	9+8	4+4
08.00	X, 28	II, 8	14	I, 4	9+8	5+5
08.42	XI, 28	II, 8	11	6	9+8	4+4
08.73	XI, 28	II, 8	12	I, 5	9+8	5+3
09.19	X, 27	II, 9	14	I, 5	9+8	7+5
09.85	X, 28	II, 8	17	I, 5	9+8	7+5
11.40	X, 28	II, 8	17	I, 5	9+9	7+6
12.30	X, 28	II, 8	17	I, 5	9+8	7+6
13.25	X, 28	II, 8	17	I, 5	9+8	7+8
14.00	X, 28	II, 8	17	I, 5	9+8	8+9

Figure 5. Bairdiella icistia larvae: A = 1.68 mm; B = 2.81 mm; C = 4.69 mm; D = 8.08 mm.

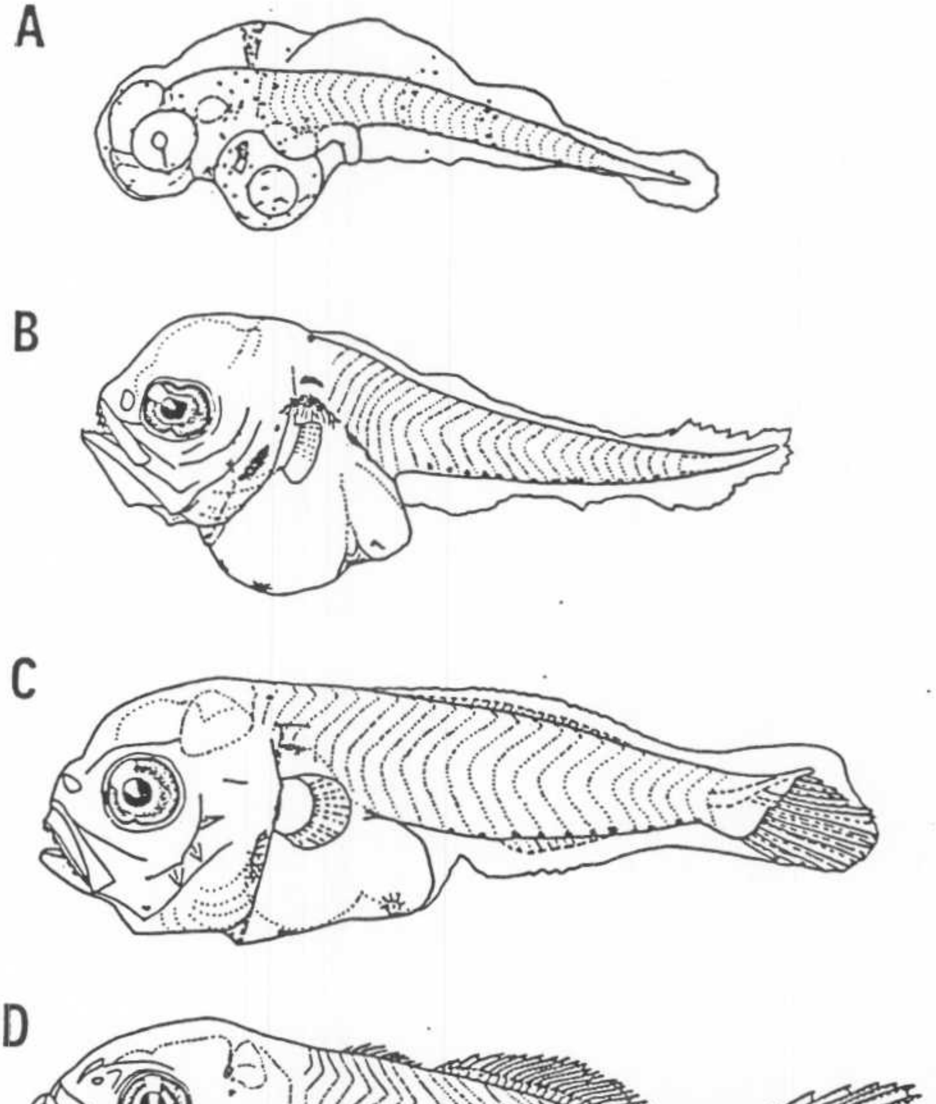
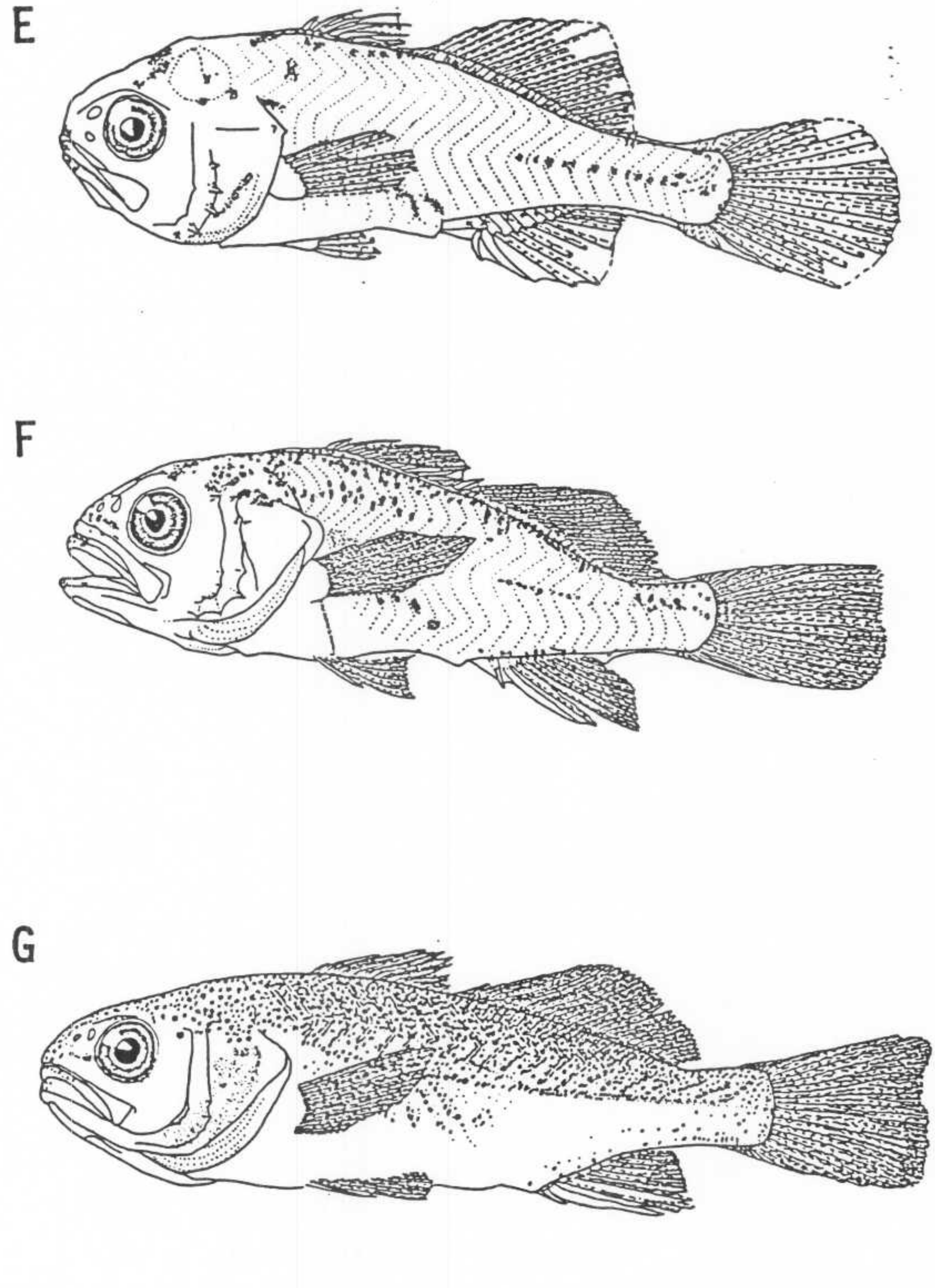


Figure 5 (cont'd). *Bairdiella icistia* larvae: E = 12.78 mm; F = 23.95 mm; G = 35.50 mm



on the anus, present through flexion. Dense pigment initially above the air bladder expands out to cover the dorsal and dorsolateral gut. One to three evenly spaced midventral melanophores are present during this stage, the first located ventroanteriorly. Also, during preflexion a melanophore is usually located at the cleithral symphysis. Dorsal notochordal pigment above airbladder present through flexion. The notochordal pigment in some individuals expanded laterally along the myocomata.

By preflexion, the tail bands disappear, forming a row of continuous midventral melanophores starting from the second or third postanal myomere. A pair of conspicuous midventral melanophores may be present at the 4th and 11th postanal myomeres, (the 11th usually more prominent). This pigment may be visible through flexion with the anal fin bud developing between the two (Fig. 5B,C).

Postflexion Larvae

On the head of postflexion larvae the melanophores on the angle of the lower jaw is usually present through approximately 13.00 mm specimens, including internal pigment on the ventral surface of the developing midbrain just posterior to the eyes present through the entire series. Dorsal gut pigment, although very dark becomes difficult to see as body becomes opaque and too thick to see through. Ventral gut pigment is usually maintained as three midventral melanophores until approximately 13.00 mm. The cleithral symphysis melanophore is present until early postflexion. Anterior hindbrain pigment present on 7.00 mm larvae through sizes too opaque to see through. By 9.00 mm to 12.00 mm head pigment expands out to cover the dentary, snout, premaxillia, and the dorsal surface of the head (Fig. 5E). Pigment on the operculum and midbrain are present by 15.00 mm. Anterior forebrain pigment along with internal snout pigment and orbit pigment may be first seen at 18.00 mm to 20.00 mm.

During postflexion, postanal midventral melanophores become internal and eventually fade from view. At 12.00 mm, pigment is present on the ptergiophore of the anal fin and along the base of the spinous dorsal fin origin (plus continuing posteriorly along the dorsal fin ptergiophores as well). The hypural elements of the caudal fin become pigmented by 12.5 mm, along with a row of mid-lateral pigment extending anteriorly from the peduncle area (Fig. 5E). At 18.00 mm, a dorsolateral line of pigment above the pectoral fin extends posteriorly, both meeting at mid-body at 29.00 mm. Pigment fills in from the fin base to the lateral line by 35.00 mm, in addition scattered pigment may extend below the lateral line (Fig. 5G).

CYNOSCION XANTHULUS

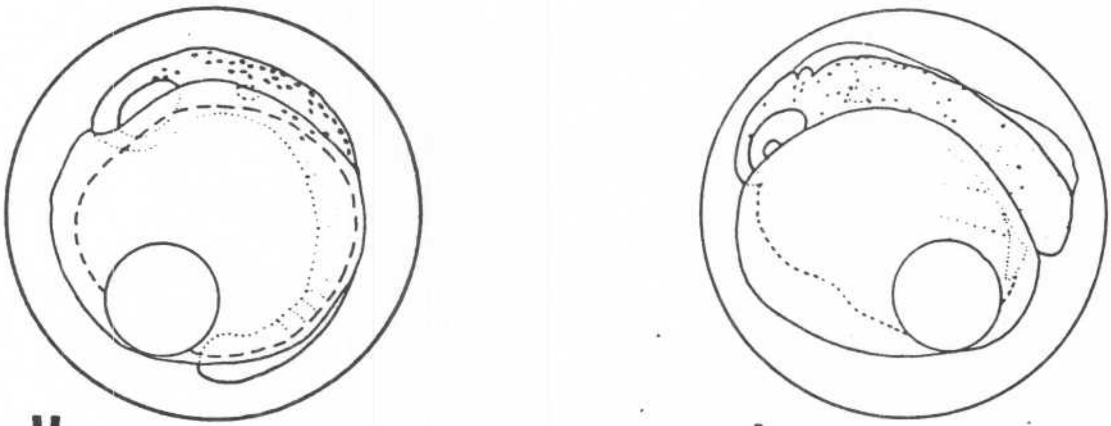
EGG DESCRIPTION

Live C. xanthulus eggs have a clear, spherical, unsculptured chorion with an unsegmented yolk and a narrow perivitelline space. Chorion diameters range from 0.68 - 0.86 with a mean size of 0.77 (SD = 0.04, N = 100). The perivitelline space in live eggs ranged from 0.00 mm - 0.08 mm with a mean width of 0.02 mm (SD = 0.01, N = 100). The single oil globule in live eggs ranged in size from 0.18 mm - 0.26 mm with a mean size of 0.21 mm (SD = 0.02, N = 96). Multi-oil globuled eggs made up approximately 3% of the eggs, with three or less clumped together in the vegetal pole (Table 1, Fig. 6).

Embryology

Cynoscion xanthulus hatches in 17.5 hours at 26°C. The morula stage is reached in approximately three hours with the oil globule located in the vegetal pole opposite the blastodisc. Gastrulation begins at approximately six hours. In seven hours the periblast reaches 3/4 of the way around yolk and formation of optic vesicles has occurred. Blastopore closure, accompanied by the development of otic capsules, dorsal embryo pigment and developing somites occur at nine hours. The oil globule is usually located in the posterior portion of the yolk mass relatively near the posterior end of the embryo. Eye lens form along with rudimentary anus at 14 hours. In 17 hours the tail is free and extends beyond the oil globule.

Figure 6. Egg stages of Cynoscion xanthulus: M = Middle-stage; L = Late-stage. (Note: No early-stage available. Both drawings of M and L are of preserved field-caught specimens.)



M L

Egg Pimentation

Pigment is first observed at approximately eight hours at 26°C, scattered dorsally on the anterior portion of the embryo posterior of optic vesicles (Fig. 6M). At nine hours the scattered dorsal pigment lines up into a pair of dorsolateral rows of pigment located at the dorsal bend of the somites. At 12 hours the dorsolateral row appears to "mirror" the hindbrain posterior to the optic capsule. This hindbrain pigment may expand to form two pairs of dorsolateral rows; one dorsolateral, mirroring the hindbrain and the other resting on the otic capsule. Plus at 17 hours, the dorsolateral paired lines may move centrally to and join with the existing middorsal trunk pigment. At approximately 16 hours, scattered melanophores may be present on the head and snout, plus lateral preanal trunk pigment may be observed on or dorsal to the simple gut. Melanophores on the tail may be observed migrating ventrally at 16 hours along the second, fifth and 12th postanal myomeres. Postanal midventral melanophores may be visible at 17 hours, accompanied by a band of loosely packed melanophores with the mid-tail band being predominant. Live eggs often exhibited scattered oil globule pigment, sometimes extending out on the surface of the yolk, whereas in preserved specimens it usually was lacking (Fig. 6L).

Larvae Description

Size

Live C. xanthulus yolk-sac larvae hatch at a size range of 1.31 - 1.67 mm (mean = 1.45 mm, SD = 0.10, N = 30) at 26.6°C. Field-caught and preserved yolk-sac larvae ranged from 1.31 - 1.74 mm (mean = 1.59 mm, SD = 0.08, N = 63). Preflexion larvae range from 1.52 - 2.87 mm (mean = 2.05 mm, SD = 0.33, N = 130). Flexion larvae range from 2.53 - 3.95 mm (mean = 3.07 mm, SD = 0.42, N = 14). Postflexion begins at 3.80 mm (Table 9).

Morphometrics

Snout to anus and head length of C. xanthulus have a significant increase in size relative to SL; 50-66% for snout to anus and 26-37% for head length for the series. Both head width and snout length relative to SL, have a slight increase during preflexion to flexion, with head width decreasing to 15% during postflexion and snout length remaining at 8% for the remainder of the series. Eye diameter decreases slightly in size relative to SL. Body depth relative to SL increases significantly from 31-38% from preflexion to flexion, then decreases and remains at 33% for the remainder of the larval series. Dorsal spine origin proportion remains constant throughout the larval stage, whereas the dorsal rays and anal spines and rays tend to expand as the larvae continues to grow. Anus to anal fin origin tends to be very narrow, ranging from -1% to 5% relative to SL, with a mean value at 2%, as the anus may protrude beyond the anal fin origin during early postflexion. A loop in the gut is observed at around 2.2 mm along with the development of eye pigment. Scales are first observed in caudal region at 17.00 mm (Table 3).

Head Spination

The first spine to appear on the head is the preopercular at 2.60 mm, reaching a compliment of four spines on the posterior shelf at 4.94 mm and six spines on the anterior shelf of the preopercular by 9.82 mm. A single Cleithral/posttemporal spine is present

Table 9.

Cynoscion xanthulus Morphometric Chart

	Size Class (SL in mm)	Snout to Anus			Head Length			Head Width			Snout Length			Eye Diameter			Body Depth			Pectoral Fin Length			Caudal Fin Length			Pelvic Fin Length			Spinous Dorsal Origin			Soft Dorsal Origin			Soft Dorsal Termination			Anal Fin Origin			Anal Fin Termination		
		x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD	x̄	n	SD
Yolk-Sac	1.01-1.50	0.75	5	0.06	0.36	5	0.01	0.24	5	0.03	0.07	5	0.02	0.17	5	0.02	0.41	5	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.51-2.00	0.79	58	0.04	0.35	58	0.03	0.24	58	0.03	0.07	58	0.02	0.18	58	0.01	0.40	57	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Preflexion	1.51-2.00	0.87	59	0.08	0.44	59	0.06	0.29	59	0.04	0.10	58	0.04	0.20	59	0.02	0.56	59	0.08	0.20	53	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.01-2.50	1.12	59	0.11	0.60	59	0.08	0.40	59	0.08	0.15	59	0.04	0.24	59	0.03	0.72	59	0.11	0.25	57	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.51-3.00	1.35	12	0.09	0.78	12	0.12	0.48	12	0.08	0.19	12	0.05	0.27	12	0.02	0.87	12	0.10	0.29	12	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flexion	2.51-3.00	1.35	9	0.08	0.88	9	0.10	0.34	9	0.05	0.21	9	0.06	0.29	9	0.03	1.04	9	0.10	0.33	9	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.01-3.50	1.98	2	0.09	1.18	2	0.09	0.68	2	0.09	0.31	2	0.00	0.31	2	0.00	1.33	2	0.04	0.50	2	0.18	0.53	2	0.05	-	-	-	-	-	-	1.67	1	0.00	2.35	2	0.26	1.95	2	0.22	2.23	2	0.18
	3.51-4.00	2.08	3	0.15	1.24	3	0.11	0.72	3	0.07	0.33	3	0.04	0.33	3	0.04	1.40	3	0.07	0.37	3	0.00	0.65	2	0.22	-	-	-	-	-	-	2.29	2	0.70	2.51	1	0.00	2.33	3	0.16	2.54	2	0.18
Postflexion	3.51-4.00	2.44	1	0.00	1.52	1	0.00	0.87	1	0.00	0.36	1	0.00	0.38	1	0.00	1.70	1	0.00	0.44	1	0.00	0.85	1	0.00	-	-	-	1.72	1	0.00	2.22	1	0.00	3.12	1	0.00	2.60	1	0.00	3.00	1	0.00
	4.01-4.50	2.52	4	0.15	1.47	4	0.23	0.83	4	0.08	0.37	4	0.00	0.39	4	0.03	1.59	4	0.06	0.62	4	0.09	0.87	4	0.16	0.12	1	0.00	1.87	3	0.16	2.30	3	0.20	3.32	3	0.28	2.72	4	0.09	3.20	4	0.11
	4.51-5.00	2.97	3	0.07	1.69	3	0.34	0.86	3	0.13	0.37	3	0.10	0.39	3	0.07	1.88	3	0.08	0.49	3	0.07	1.16	3	0.20		Bud		2.12	3	0.24	2.68	3	0.09	3.83	3	0.06	3.03	3	0.06	3.58	3	0.13
	5.01-5.50	3.40	5	0.14	1.93	5	0.10	1.10	5	0.08	0.47	5	0.01	0.45	5	0.03	2.08	5	0.15	0.65	5	0.13	1.42	5	0.14	0.16	3	0.13	2.22	5	0.25	2.84	5	0.25	4.40	5	0.20	3.52	5	0.13	4.28	5	0.44
	5.51-6.00	3.56	5	0.30	2.23	5	0.15	1.05	5	0.04	0.61	5	0.08	0.50	5	0.01	2.22	5	0.19	0.69	5	0.16	1.33	5	0.06	0.34	5	0.14	2.47	5	0.18	3.19	5	0.21	4.49	5	0.57	3.49	5	0.27	4.41	5	0.43
	6.01-6.50	3.99	4	0.21	2.35	4	0.18	1.22	4	0.18	0.54	4	0.06	0.53	4	0.04	2.23	4	0.09	0.90	4	0.16	1.67	4	0.29	0.43	4	0.09	2.49	4	0.25	3.35	4	0.10	5.07	4	0.18	4.02	4	0.23	4.90	4	0.27
	6.51-7.00	4.47	4	0.06	2.41	4	0.19	1.19	4	0.04	0.61	4	0.11	0.59	4	0.03	2.41	4	0.22	1.03	4	0.14	2.32	4	1.17	0.67	4	0.10	2.76	4	0.11	3.84	4	0.06	5.61	4	0.25	4.61	4	0.12	5.34	4	0.03
	7.01-7.50	4.54	9	0.19	2.66	9	0.20	1.35	9	0.11	0.66	9	0.10	0.62	9	0.09	2.59	9	0.27	1.20	9	0.17	2.03	7	0.14	0.69	9	0.24	2.94	9	0.16	3.96	9	0.20	5.90	9	0.12	4.76	9	0.09	5.55	9	0.14
	7.51-8.00	5.06	10	0.22	3.01	10	0.30	1.36	10	0.11	0.69	10	0.10	0.65	10	0.05	2.72	10	0.17	1.43	10	0.17	2.40	9	0.30	1.03	10	0.22	3.21	10	0.27	4.38	10	0.16	6.38	10	0.17	5.13	10	0.25	6.12	10	0.26
	8.01-8.50	5.19	2	0.27	3.17	2	0.24	1.50	2	0.03	0.81	2	0.09	0.68	2	0.01	2.99	2	0.13	1.36	2	0.08	2.85	2	0.27	1.28	2	0.03	3.53	2	0.07	4.88	2	0.17	6.84	2	0.12	5.46	2	0.06	5.21	2	1.59
	8.51-9.00	5.71	4	0.15	3.32	4	0.21	1.44	4	0.12	0.81	4	0.09	0.79	4	0.10	3.10	4	0.09	1.84	4	0.21	2.66	4	0.21	1.48	4	0.37	3.81	4	0.03	5.14	4	0.17	7.28	4	0.15	5.88	4	0.14	7.02	4	0.19
	9.01-9.50	5.90	3	0.12	3.55	3	0.25	1.65	3	0.10	0.90	3	0.18	0.75	3	0.05	3.22	3	0.11	1.69	3	0.43	2.90	1	0.00	1.07	3	0.26	3.97	3	0.25	5.24	3	0.17	7.48	3	0.07	6.16	3	0.20	7.09	3	0.21
	9.51-10.00	6.30	1	0.00	3.65	1	0.00	1.54	1	0.00	0.80	1	0.00	0.74	1	0.00	3.34	1	0.00	1.98	1	0.00	3.21	1	0.00	1.42	1	0.00	3.95	1	0.00	5.69	1	0.00	8.26	1	0.00	6.30	1	0.00	7.64	1	0.00
	10.01-10.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10.51-11.00	6.66	1	0.00	4.08	1	0.00	1.76	1	0.00	1.03	1	0.00	0.87	1	0.00	3.64	1	0.00	2.08	1	0.00	3.84	1	0.00	1.98	1	0	4.32	1	0.00	6.25	1	0.00	8.97	1	0.00	7.16	1	0.00	8.50	1	0.00
	11.01-11.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11.51-12.00	7.58	2	0.35	4.50	2	0.26	1.72	2	0.01	1.30	2	0.07	1.00	2	0.13	3.97	2	0.10	2.22	2	0.03	3.87	2	0.04	1.85	2	0.18	4.80	2	0.16	6.72	2	0.20	9.78	2	0.28	7.86	2	0.31	9.38	2	0.04
	12.01-12.50	8.11	1	0.00	4.36	1	0.00	1.98	1	0.00	1.11	1	0.00	0.86	1	0.00	4.33	1	0.00	2.78	1	0.00	4.63	1	0.00	2.10	1	0.00	4.68	1	0.00	6.55	1	0.00	9.82	1	0.00	7.95	1	0.00	9.35	1	0.00
	12.51-13.00	8.26	1	0.00	4.52	1	0.00	2.34	1	0.00	1.09	1	0.00	0.93	1	0.00	4.21	1	0.00	2.49	1	0.00	4.52	1	0.00	2.34	1	0.00	4.99	1	0.00	7.17	1	0.00	10.60	1	0.00	8.57	1	0.00	9.82	1	0.00
	13.01-14.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14.01-14.50	8.89	1	0.00	5.46	1	0.00	2.03	1	0.00	0.93	1	0.00	0.93	1	0.00	4.68	1	0.00	2.49	1	0.00	4.37	1	0.00	2.03	1	0.00	5.92	1	0.00	7.48	1	0.00	10.44	1	0.00	8.57	1	0.00	10.80	1	0.00
	14.51-17.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17.01-17.50	11.40	2	0.21	6.40	2	0.21	2.92	2	0.28	1.33	2	0.05	1.36	2	0.06	5.75	2	0.38	3.95	2	0.07	6.06	2	0.85	4.10	2	0.71	6.83	2	0.83	10.08	2	0.36	14.53	2	0.17	11.80	2	0.07	13.60	2	0.38
	17.51-19.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	19.01-19.50	12.94	1	0.00	7.01	1	0.00	2.81	1	0.00	1.40	1	0.00	0.99	1	0.00	5.92	1	0.00	4.21	1	0.00	7.17	1	0.00	3.12	1	0.00	7.79	1	0.00	11.22	1	0.00	15.28	1	0.00	13.25	1	0.00	15.28	1	0.00
	19.51-22.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	22.01-22.50	15.28	1	0.00	8.42	1	0.00	3.43	1	0.00	2.01	1	0.00	1.56	1	0.00	7.48	1	0.00	4.52	1	0.00	7.48	1	0.00	3.12	1	0.00	8.89	1	0.00	14.50	1	0.00	18.71	1	0.00	15.59	1	0.00	17.93	1	0.00
	22.51-43.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	43.01-43.50	28.69	1	0.00	13.10	1	0.00	5.61	1	0.00	1.39	1	0.00	3.12	1	0.00	12.47	1	0.00	6.24	1	0.00	14.50	1	0.00	8.42	1	0.00	17.30	1	0.00	24.63	1	0.00	36.17	1	0.00	30.24	1	0.00	33.67	1	0.00

from 4.94 to 7.95 mm increasing to four spines by 14.50 mm. One to four supraocular spines may be present by 3.89 mm. A single opercular spine is present throughout the larval series beginning at 5.87 mm. One or two subopercular spines and a single interopercular spine may be present on larvae 5.87 to 14.50 mm. Dentary teeth are observed at length of 2.59 mm. Canine teeth present on specimens > 20 mm (Table 10).

Fin Development

The pectoral fin is observed in all specimens examined although pectoral rays begin to develop at 4.02 mm while a full compliment of 16 rays are reached at 7.04 mm SL. Principal caudal rays are first observed during notochordal flexion, reaching a full compliment by 4.94 mm. Procurrent caudal rays begin to form at 4.02 mm with a final count of 8+9 at 14.50 mm. Soft dorsal and anal rays begin forming during flexion at 3.46 mm, with a full compliment in larvae > 4.03 mm in length. Dorsal spines begin forming at 4.02 mm with eight to nine spines present by 4.94 mm, as well as the second set of dorsal spines. Anal spines are present at 4.94 mm, with the pelvic spines last to become visible by 5.56 mm (Table 11).

Larval Pigmentation

Yolk- Sac

Yolk sac larvae exhibit several small melanophores of similar size and intensity scattered over the entire head. Melanophores may also be present around the orbits of the eyes. Yolk sac larvae exhibit otic capsule pigment which tends to be located ventrally

Table 10. *Cynoscion xanthulus* head spines and teeth

Size	Opercular	Subopercular	Interopercular	Temporal (Cleithral)	Lateral Preopercular (Anterior)	Marginal Preopercular (Posterior)	Supraocular	Teeth
01.80	0	0	0	0	0	0	0	N
02.00	0	0	0	0	0	0	0	N
02.59	0	0	0	0	0	1	0	Y
02.84	0	0	0	0	2	2	0	Y
02.97	0	0	0	0	2	2	0	Y
03.46	0	0	0	0	2	2	0	Y
03.89	0	0	0	0	4	3	1	Y
04.02	0	1	0	0	4	3	1	Y
04.32	0	0	0	0	4	3	1	Y
04.94	0	0	0	1	4	4	1	Y
05.56	0	1	0	1	4	4	1	Y
05.70	0	1	0	1	4	4	2	Y
05.87	1	1	1	1	4	3	0	Y
06.18	1	0	0	1	5	4	2	Y
06.50	1	1	0	1	5	4	2	Y
06.80	1	1	0	1	5	4	2	Y
07.04	1	1	0	1	5	4	2	Y
07.29	1	1	0	2	5	4	2	Y
07.63	1	1	0	1	5	4	2	Y
07.95	1	1	0	1	5	4	1	Y
08.10	1	1	1	3	5	4	3	Y
08.42	1	0	1	2	5	4	3	Y
08.73	1	1	0	2	5	4	4	Y
08.88	1	1	0	2	5	4	4	Y
09.35	1	1	0	2	5	4	3	Y
09.82	1	2	0	2	6	4	4	Y
11.38	1	1	1	2	5	4	2	Y
12.00	1	1	0	2	5	4	0	Y
14.50	1	1	0	4	4	4	4	Y

Table 11. Meristics of *Cynoscion xanthulus*

Size (mm SL)	Dorsal Fin	Anal Fin	Pectoral Fin	Pelvic Fin	Principal Caudal Fin	Procurrent Caudal Fin
01.80	-	-	-	-	-	-
02.00	-	-	-	-	-	-
02.59	-	-	-	-	-	-
02.84	-	-	-	-	-	-
02.97	-	-	-	-	-	-
03.46	14	6	-	-	4+3	-
03.89	16	7	-	-	6+5	-
04.02	V + 20	8	05	-	7+6	1+2
04.32	VI + 19	8	07	-	8+7	1+1
04.94	VIII + I, 21	II, 8	09	-	9+8	3+2
05.56	IX + I, 21	II, 8	09	I, 5	9+8	3+1
05.70	IX + I, 19	II, 8	10	I, 5	9+8	5+3
05.87	VIII + I, 19	II, 8	11	I, 4	9+8	2+1
06.18	VIII + I, 21	II, 9	13	I, 4	9+8	4+2
06.50	VIII + I, 20	II, 8	15	I, 5	9+8	6+4
06.80	IX + I, 21	II, 8	15	I, 5	9+8	4+4
07.04	IX + I, 21	II, 8	16	I, 5	9+8	4+3
07.29	VIII + I, 19	II, 8	16	I, 5	9+8	4+3
07.63	IX + I, 20	II, 8	15	I, 5	9+8	6+3
07.95	IX + I, 20	II, 8	15	I, 5	9+8	6+5
08.10	IX + I, 21	II, 9	16	I, 5	9+8	6+4
08.42	VIII + I, 21	II, 8	16	I, 5	9+8	6+6
08.73	IX + I, 21	II, 9	16	I, 5	9+8	7+7
08.88	IX + I, 21	II, 8	16	I, 5	9+8	6+6
09.35	VIII + I, 21	II, 8	16	I, 5	9+8	6+5
09.82	IX + I, 21	II, 8	16	I, 5	9+8	6+6
11.38	IX + I, 21	II, 8	16	I, 5	9+8	8+8
12.00	IX + I, 21	II, 8	16	I, 5	9+8	8+9
14.50	IX + I, 21	II, 8	16	I, 5	9+8	8+9

in preflexion and disappears by flexion. Early yolk sac larvae have scattered dorsal nape pigment with a line of single melanophores present on the distal margin of the finfold extending posteriorly halfway to the anus. Yolk sac larvae may have scattered pigment on the surface of the yolk membrane and oil globule. Yolk sac larvae have scattered pigment on the dorsal surface of the trunk with bands of loosely scattered melanophores at the second, seventh and 13th postanal myomere. This pigment can be scattered into adjacent myomeres (Fig. 7A).

Preflexion/Flexion Larvae

During preflexion one to several melanophores may be present on top of the head, disappearing entirely by flexion. Pigment on the cleithral symphysis as well as the angle of the lower jaw, and the inside edge of the lower jaw may be present through these stages. Mid-preflexion larvae generally lose dorsal nape finfold pigment, leaving one or two mid-dorsal melanophores, present through flexion.

Dorsal notochordal pigment is visible only during these stages. Located on the dorsal surface of the notochord, directly above the airbladder. Heavy pigment is typically located on the dorsal surfaces of the airbladder and gut during these stages. A single conspicuous melanophore may be located on the anterior surface of the gut, present through flexion. During flexion, two to three pairs of ventrolateral melanophores are present on the gut, increasing to four to five pairs in late flexion (posterior to pelvic fin buds). There may be scattered mid-ventral melanophores on the gut during this stage as well.

Figure 7. Cynoscion xanthulus larvae: A = 1.67 mm; B = 1.90 mm; C = 3.52 mm; D = 8.00 mm.

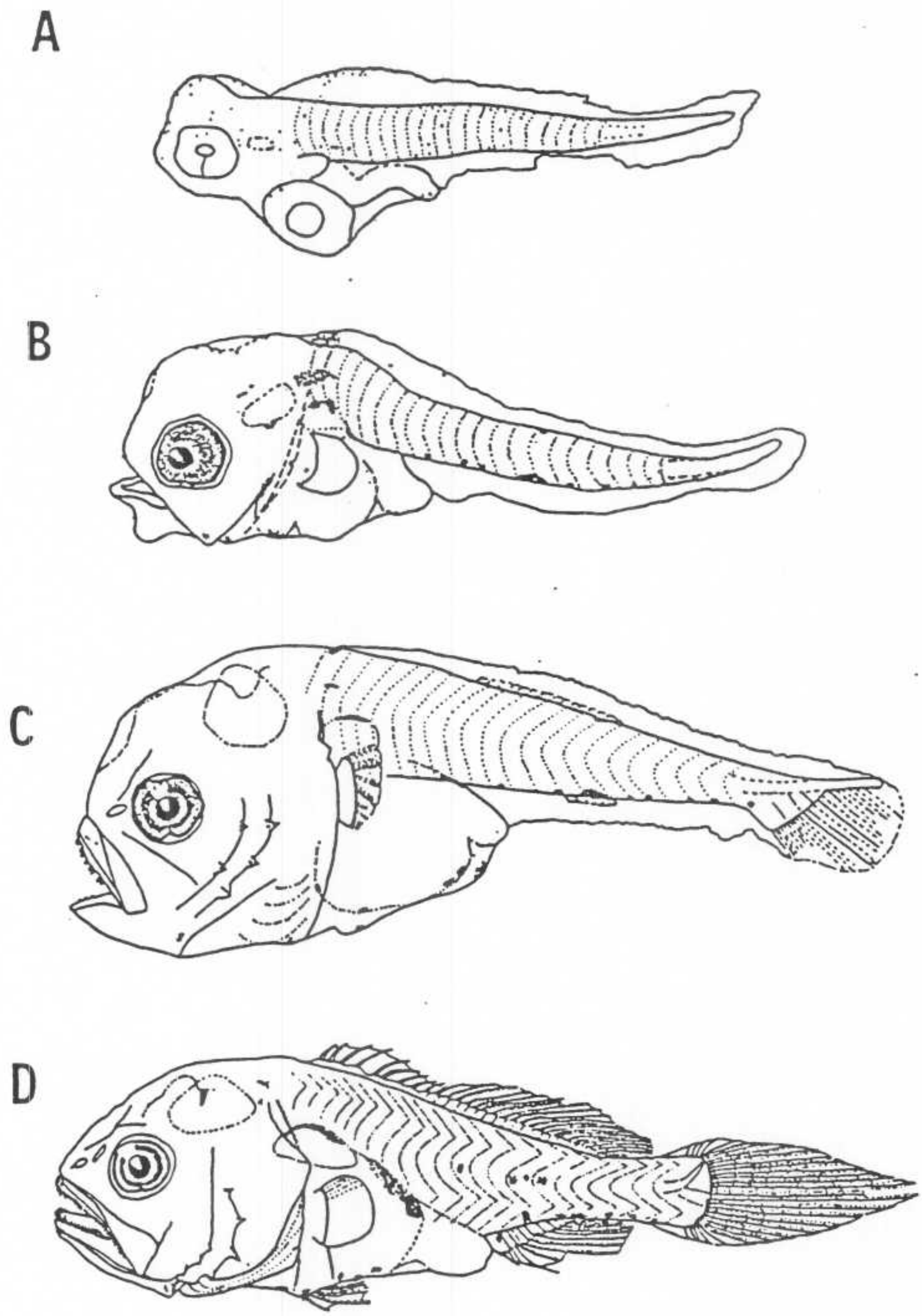
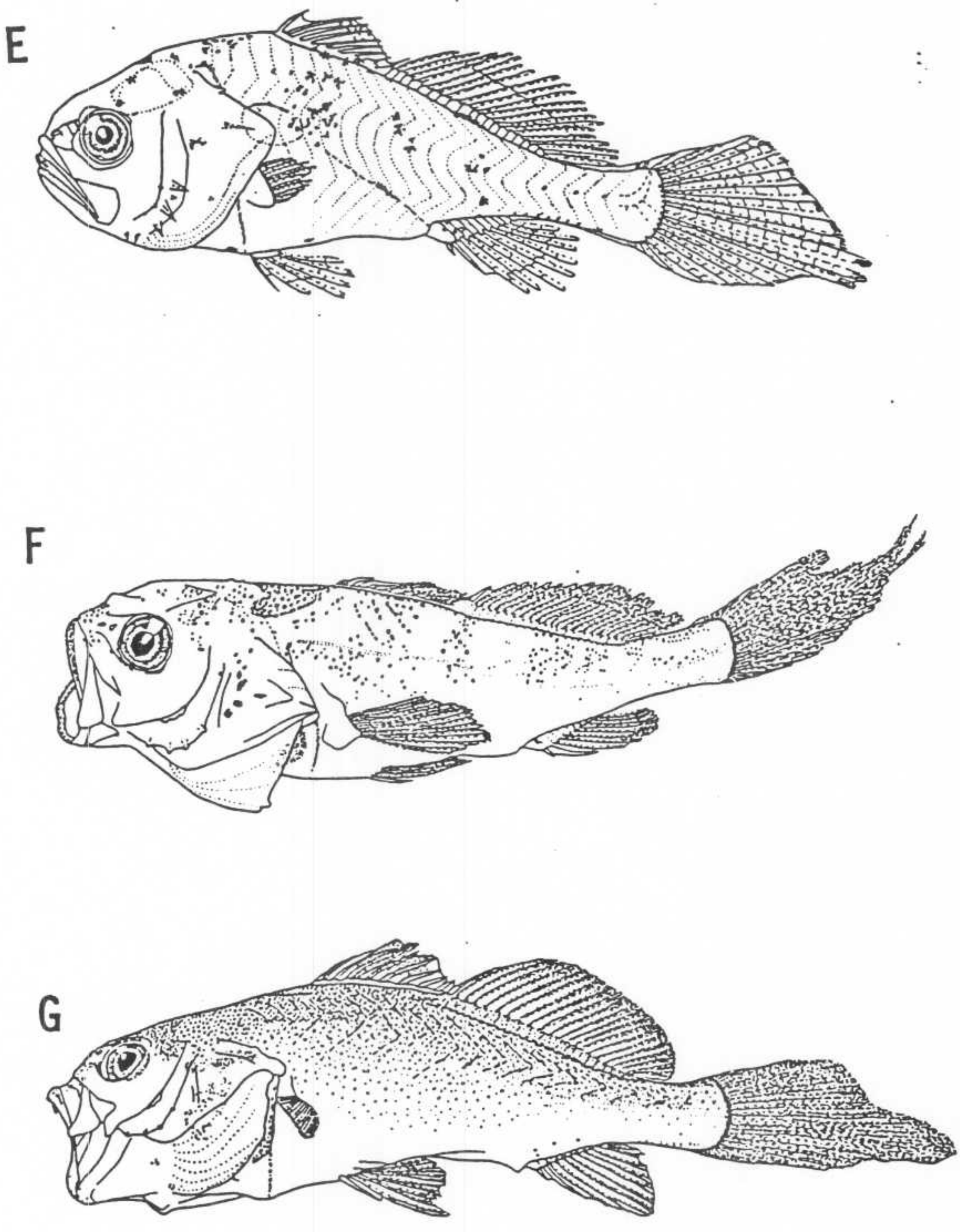


Figure 7 (cont'd). Cynoscion xanthlus larvae: E = 13.87 mm; F = 22.14 mm; G = 43.30 mm



A single melanophore is located at the bend of the hindgut/trunk junction at 2.0 mm, present through flexion, and eventually covering the entire dorsal surface of the ventrally extended hindgut in postflexion.

During these stages the caudal lacks any lateral pigment and is represented by a noncontinuous row of unequally sized midventral melanophores. Most notable a large midventral melanophore, (at mid-tail) located on the 15th myomere is always accompanied by a smaller middorsal melanophore (Fig. 7 B,C).

Postflexion Larvae

Pigment on the angle of the developing lower jaw is present through 22.00 mm specimens. Pigment anterior to the cleithral symphysis is often present through 43.00 mm specimens

Pigment located midway along the inside edge of the lower jaw may be present through early postflexion ca. 8.0 mm. Heavy pigment on the dorsal surfaces of the airbladder, plus dorsal and anterior gut are present until the body wall thickens obscuring pigment.

Dorsal lip pigment is usually present by 7.00 mm during postflexion. Anterior hindbrain pigment is also present at 7.00 mm visible through 20.00 mm, at which point the head becomes opaque obscuring pigment. Operculum pigment is present on larvae > 8.10 mm. By 11.5 mm the dorsal surface of the head, forebrain and midbrain are covered with several large branched melanophores. Pigment on the lower lip, ventral orbit, plus internal and external snout pigment is observed at 16.0 mm. Melanophores are present on the ventral surface of the midbrain at 19.0 mm.

Postflexion larvae usually lacks pigment in the dorsal nape region until approximately 8.5 mm when pigment appears anterior to the spinous dorsal fin origin (Fig. 7 E).

The anterior ventral gut pigment is located externally between the pelvic fins and usually moves internally ca. 15.0 mm to 22.0 mm SL, accompanied by two to three midventral melanophores anterior to the anus.

During postflexion in the trunk/caudal region, three to six small equally sized postanal midventral melanophores may be located anterior to the mid-tail melanophore. Six to ten postanal melanophores may be located posterior of the mid-tail melanophore as well (Fig. 7F). Most postanal midventral melanophores move internal during the postflexion stage, entirely fading from view by 16.00 mm.

Pigment is seen along the ventral margin of the hypural plates as early as 4.5 mm, and by 16.0 mm the entire margin is pigmented. Pigment is present along the spinous dorsal pterygiophores at 9.00 mm, and on the distal margins of the soft dorsal fin membranes, at 20.00 mm (Fig. 7 E,F,G).

Pigment bands are usually present during this stage. Two vertical bands usually line up along the 11-12th myomeres, and the 15-16th myomeres. By 11.0 mm a third band begins to form at the fifth and sixth myomere (Fig. 7E). All three bands are complete at 16.00 mm and may become wider and include pigment along the base of the dorsal fin pterygiophores. Pigment on the lateral line is first observed in the caudal peduncle region at approximately 10.0 mm, becoming complete by 20.00 mm, with pigment filling in dorsally to midlateral, obscuring the vertical bands. By 43.00 mm, pigment generally covers the entire lateral surface of the fish. (Fig. 7G).

DISTINGUISHING CHARACTERISTICS OF THE SPECIES

EARLY-STAGE EGGS

Early stage eggs of the three species are inseparable (prior to blastopore closure) (Figs. 2E, 6E).

MIDDLE-STAGE EGGS

Early intermediate staged eggs (just after blastopore closure) are also inseparable based on size and pigment patterns. Although the position of the anterior oil globule of eggs from A. davidsoni can be separated from the two sciaenids which usually have a posteriorly oriented oil globule (Figs. 2M, 4M, 6M).

Some eggs may be identified based on pigment patterns in the later half of this stage. Anisotremus davidsoni generally lacks any midlateral nape pigment, as well as pigment on the orbits around the eyes, whereas both sciaenids have pigment in this area. Slightly later in this stage, B. icistia develops a single pair of dorsolateral lines of pigment that tend to rest on the otic capsules. Whereas, C. xanthulus tend to have double dorsolateral rows; one resting on the otic capsule, and one slightly dorsal of the otic capsule.

LATE-STAGE EGGS

Eggs of A. davidsoni can be differentiated from the two sciaenids based on the anterior oil globule and pigment patterns located on the embryo. Anisotremus davidsoni lacks midlateral pigment on or near the otic capsule, and any pigment around the orbit of the eyes, whereas both sciaenids have pigment there. In this stage B. icistia has ventral snout pigment whereas both A. davidsoni and C. xanthulus generally lack it. Pigment patterns on the dorsal nape can separate the three species. Anisotremus davidsoni has dorsolateral lines of pigment mirroring the medullary margins. Bairdiella icistia generally has a single pair of dorsolateral lines (either internal or external) on or through the otic capsule. Cynoscion xanthulus generally has a pattern similar to the previous stage with, double dorsolateral rows; one resting on the otic capsule, and one slightly dorsal of the otic capsule. The two sciaenids may also be separated by the postanal myomere counts, B. icistia with > 17, and C. xanthulus with < 16. Generally, B. icistia eggs were always more heavily pigmented than C. xanthulus eggs in all months examined, even though all three species eggs became fainter later in the spawning season (Figs. 2L, 4L, 6L).

YOLK-SAC LARVAE

Anisotremus davidsoni has an anterior oil globule, whereas B. icistia and C. xanthulus have a posteriorly oriented oil globule. Anisotremus davidsoni has a dorsal and ventral pair of melanophores located at mid-body, the dorsal pair is usually slightly anterior to the ventral patch, which is partially located on ventral flexion of the intestine. Both sciaenids lack pigment here, although C. xanthulus has a loose band of pigment at two postanal myomeres, and B. icistia has a band of pigment at four postanal myomeres. Anisotremus davidsoni generally lacked any finfold pigment, whereas both sciaenids have pigment there, with C. xanthulus usually having a line of melanophores along the distil margin of the finfold (Figs. 3A, 5A, 7A).

PREFLEXION LARVAE

Gut shape of A. davidsoni can be separated from the two sciaenids by the absence of any internal dorsal notochordal pigment which both sciaenids possess, in fact this pigment may extend externally along the myocomata in some B. icistia. Both sciaenids have dorsal nape pigment accompanied by finfold pigment, whereas A. davidsoni rarely has a dorsal nape melanophore and usually lacks finfold pigment. Anisotremus davidsoni usually has continuous postanal midventral melanophores of equal size. Bairdiella icistia may have continuous postanal midventral melanophores, but with one larger conspicuous melanophore located at the 18th myomere. Cyanoscion xanthulus has scattered postanal midventral melanophores on about every other myomere with a large conspicuous melanophore, sometimes covering two myomeres, located at the 15th myomere from the head. Cynoscion xanthulus usually has a middorsal melanophore accompanying the larger midventral, which the other two lack (Figs. 3B, 5B, 7B).

FLEXION LARVAE

Anisotremus davidsoni lacks any dorsal nape, or internal anterior notochordal pigment, whereas the sciaenids usually have pigment in this area. Anisotremus davidsoni has continuous equally sized midventral postanal melanophores starting from the 3rd or 4th postanal myomere whereas the sciaenidae have at least one larger conspicuous melanophore. The postanal midventral melanophores are generally the same as preflexion. Worth noting is the large conspicuous midventral melanophore of C. xanthulus is located at the mid point of the anal fin bud, whereas in B. icistia, it is located on the posterior edge of the anal fin bud. Cynoscion xanthulus generally undergo notochordal flexion at a smaller size than B. icistia (Figs. 3C, 5C, 7C).

POSTFLEXION LARVAE

Caudal fin shape can easily separate the three. Anisotremus davidsoni has a forked tail, B. icistia has a round tail, and C. xanthulus has a pointed tail. Vertical bars form on C. xanthulus c.a. 14.00 mm and disappear later in development, ca. 20.00 mm. A. davidsoni develop vertical bars at approximately 22.20 mm which persist through the adult stage, with the posterior bar eventually fading from view. Bairdiella icistia did not form vertical bars in specimens examined but did form horizontal rows starting at 12.00. Anisotremus davidsoni formed three horizontal rows present from 12.50 mm to 29.00 mm. Cynoscion xanthulus generally develop a full compliment of dorsal spines by 5.56 mm whereas B. icistia, spines are formed by 7.10 mm (Figs. 3D,E,F,G;5D,E,F,G; 7D,E,F,G).

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