

Contributions to the Early Life History of the Spotted Gar, *Lepisosteus oculatus* Winchell, from Hatchet Creek, Alabama

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ABSTRACT

Ontogenetic development of spotted gar, *Lepisosteus oculatus* Winchell, was examined utilizing morphometric, meristic, and pigment characteristics. Wild spawned eggs were collected from Hatchet Creek, in Coosa County, Alabama. Eggs were pigmented with melanophores, spherical, and averaged 4.8 mm in diameter. Recently hatched larva were typical of other species of *Lepisosteus*, possessing an adhesive organ on the snout, a large, ovoid yolk sac, and a weakly developed stomodeum. Larvae had an average of 45.8 preanal and 14.7 postanal myomeres. Spotted gar larvae are darkly pigmented subdermally on the dorsum and lack external melanophores subcutaneously. Larvae grew at an increasing rate over the first 30 days of life. A linear regression line of $Y = 9.476927 + 0.03446913 X$, and a correlation coefficient of 0.965 corresponded with the dependent variable, TL in mm, and the independent variable, time in hours.

INTRODUCTION

Spotted gar occur throughout the Great Lakes, including Lakes Erie, St. Clair, and tributaries of Lake Michigan, extending south through the Mississippi River drainage, including the Illinois and Wabash Rivers, to the Gulf coast. The spotted gar occurs from east-central Texas east to western Florida where the species is sympatric with the Florida gar, *L. platyrhincus*, its sister species (1). Spotted gar occur throughout the lower reaches of the Ohio River basin, occasionally being collected in the lower Ohio, lower Cumberland, Trade-water, and Green rivers of Kentucky (2). In Alabama, the species occurs in the lower arm of the Tennessee River and is widespread in the Tombigbee, Black Warrior, and Alabama rivers (3, 4); it is frequently encountered in the lower Tallapoosa and Coosa River systems (M. Pierson, pers. comm.); and various smaller systems along the coastal plain.

Simon and Wallus (5) summarized and provided original larval descriptions of 4 North American gar species occurring in the Ohio and Tennessee River basins. Information provided by them included spotted gar descriptions of specimens as small as 16.4 mm TL. Heufelder (6) provided additional descriptive

information for spotted gar greater than 35 mm TL and illustrated a 17.5 mm specimen. Echelle and Riggs (7) alluded to differences between gar larvae but could not distinguish between shortnose and spotted gar less than 125.0 mm TL.

The current study includes meristics and morphometrics of all early life history stages of *L. oculatus* from newly hatched to juvenile stages of development.

MATERIALS AND METHODS

Laboratory cultured and wild collected museum specimens were studied for differences in morphology, meristics, pigmentation, and sequential development relative to size. Meristics and morphometrics of *L. oculatus* were determined for 43 eggs and 31 larvae and early juveniles.

A total of 21 morphometric and 9 meristic characters was measured for each specimen following the format provided in Simon and Wallus (4). Eggs were preserved in a chilled borax and sucrose formalin solution to keep egg chorions clear. All measurements were made to the nearest 0.1 mm using a dissecting microscope with an ocular micrometer. Measurements in the text are total length (TL) un-

less otherwise noted. Illustrations were delineated following Sumida et al. (8).

Specimens Examined

Lepisosteus oculatus.—Alabama: Coosa Co., Hatchet Creek, T 23N R 19E S 11, 10 specimens uncatalogued Alabama Power Company (APC) cultured reference material. Alabama: Limestone Co., Tennessee River, Wheeler Reservoir, TV 1718 (1); Jackson Co., Tennessee River, Guntersville Reservoir, TV 222 (10). Tennessee: Marion Co., Tennessee River, Nickajack Reservoir, TV 859 (1); Stewart Co., Cumberland River, Cumberland Steam Plant (RM 103), TV 972 (8). Oklahoma: Marshall Co., UOMZ 36908 (1). Specimens examined are maintained by Tennessee Valley Authority's Larval Fish Identification and Information Center, Norris, TN (TV); Stovall Museum of the University of Oklahoma (UOMZ); and Alabama Power Company (APC), Birmingham, AL.

RESULTS

Spawning.—Adults were observed in a spawning aggregation on 18 May 1989 in Hatchet Creek, a tributary of the Coosa River. The site was adjacent to the head of a riffle with current ranging from slight to moderate. Eggs were extremely adhesive and easily observed scattered over a bedrock substrate in water ranging in depth from 0.4 to 0.8 m.

Eggs.—Eggs of cultured spotted gar from Hatchet Creek, Alabama brood stock were spherical, demersal, extremely adhesive, and averaged 4.8 mm in diameter ($N = 43$, range = 4.08 to 5.40 mm). Egg chorions were sculptured and pigmented with scattered melanophores. Eggs possessed a large perivitelline space and pale yellow yolks. Eggs incubated at 22.2°C hatched after 144 hr.

Larvae—Morphology.—Selected morphometrics are presented in Table 1. Newly hatched larvae (9.8 mm) have a stomodeum, and an unpigmented spherical optic cup. Larvae are without the elongated snout extension characteristic of adult gar, but instead possess an adhesive, papillose suctorial disc. The head is deflected over the yolk sac. Yolk sacs are large, ovoid, often with a pointed tip posteriorly. Yolk coloration is pale yellow in preserved specimens, with a distinct vitelline vein plexus.

Eyes are pigmented by 10.9 mm and become spherical by 11.2 mm. Pectoral buds were present at hatching, and the pectoral fin was formed by 11.2 mm. Suctorial disc slightly compressed, wider than high, mostly absorbed by 13.6 mm, present as a rudimentary disc at tip of extended snout until 17.6 mm. Finfolds present and without anlage of fin rays until 16.4 mm. Prior to pelvic bud formation (at 16.4 mm), a pore was present in pelvic region just anterior to finfold region. Yolk was completely absorbed by 23.9 mm. Flexion occurs after first caudal fin ray formation at 21.9 mm.

At 16.1 to 16.4 mm, fin rays forming in caudal finfold. By 21.9 mm, fin rays are formed in pectoral fins and anal fin, simultaneously. Pelvic fin buds present by 21.9 mm, and first pelvic fin rays formed by 33.5 mm. Incipient dorsal and anal fin margins partially differentiated by 21.9 mm, most differentiated by 23.9 mm. Dorsal finfold originates between preanal myomeres 17 to 36 for 9.8 to 13.5 mm specimens, and between myomeres 42 to 47 for 16.1 to 51.9 mm specimens. Dorsal fin is completely differentiated at lengths greater than 23.9 mm. The upper jaw overhangs the lower jaw at all lengths, and teeth are present at 33.5 mm.

Meristics.—Frequency distribution for preanal and postanal myomeres: preanal 43 (3), 44 (5), 45 (3), 46 (13), 48 (6), 49 (1) ($N = 31$, $\bar{x} = 45.8$); postanal 12 (2), 14 (15), 15 (5), 16 (7), 17 (2) ($N = 31$, $\bar{x} = 14.7$). Total myomeres ranged from 56 to 63. Lengths at first appearance of fin rays and total adult complements are presented in Table 2.

Pigmentation.—Newly hatched larvae (9.8 mm) were much more darkly pigmented than specimens of *L. osseus*. Subdermal pigment was present over the cranium extending onto the future operculum and posterior optic cup; extremely dense pigmentation occurred over the dorsum of the yolk sac and mid-ventrally along the gut. Mid-lateral accumulations of melanophores outlined the anterior apex of each myomere to the tip of the notochord. Finfolds had the characteristic wedges of pigment in place of the future dorsal, anal, and caudal fins. Additional melanophores were present in the anterior and proximal portions of the dorsal finfold (Fig. 1). These pigmentation patterns described are characteristic for larvae until 13.6 mm.

TABLE 1. Morphometry of *Lepisosteus oculatus* larvae grouped by selected intervals of total length (N = sample size). Characters expressed as per cent total length (TL) or head length (HL), with a single standard deviation, and range of values in parentheses.

	9.8-11.2 (N = 5)		13.6-17.6 (N = 4)	
	Mean ± SD	Range	Mean ± SD	Range
Length, % of TL				
Snout length	4.0 ± 0.2	(3.5-4.4)	6.2 ± 1.7	(4.2-7.5)
Eye diameter (a)	28.9 ± 1.2	(27.1-30.3)	27.3 ± 3.1	(24.7-30.8)
Head length	18.4 ± 1.0	(17.4-19.7)	20.8 ± 3.4	(17.2-23.9)
Predorsal length	40.1 ± 7.5	(27.6-47.6)	55.6 ± 14.4	(39.2-66.0)
Preanal length	70.0 ± 2.8	(67.3-74.4)	65.7 ± 4.8	(62.6-71.3)
Dorsal insertion				
Standard length	99.9 ± 0.1	(98.8-99.9)	97.5 ± 2.3	(95.6-100)
Yolk sac length	45.3 ± 3.1	(43.9-50.8)	32.4 ± 1.8	(31.1-33.7)
Disc length	42.7 ± 3.9	(36.1-46.3)		
Fin length, % of TL				
P1	3.9		8.5 ± 1.5	(6.7-9.5)
P2				
Body depth, % of TL				
Head depth at eyes	14.1 ± 0.6	(13.5-14.8)	11.4 ± 1.4	(10.1-12.8)
Head depth at P1	23.7 ± 2.6	(21.5-28.1)	15.0 ± 3.0	(13.1-18.5)
Preanal depth	5.7 ± 0.5	(5.3-6.4)	6.6 ± 0.5	(6.2-7.2)
Mid-postanal depth	4.2 ± 0.7	(3.6-5.2)	5.2 ± 0.6	(4.7-5.8)
Caudal peduncle	2.3 ± 0.4	(1.8-3.0)	4.1 ± 0.6	(3.7-4.7)
Yolk sac depth	22.0 ± 1.6	(20.7-24.8)	18.6 ± 3.2	(16.3-20.9)
Body width, % of HL				
Snout at nares			15.3	
Mid-snout			22.9 ± 4.5	(19.8-26.2)
Snout anterior eyes			32.9	
Head width	60.9 ± 6.9	(55.5-72.1)	52.5 ± 12.6	(42.7-66.7)
Disc width	28.0 ± 7.8	(20.4-38.4)		
Myomere number				
Predorsal		17-36		36-47
Preanal		43-46		43-47
Postanal		12-16		12-17
Total		56-62		58-62

(a) Morphometric based on per cent head length.

(b) Yolk sac absorbed during this interval at 23.9 mm TL.

At 13.6 mm, subdermal preorbital and post-orbital melanophores were observed near the now pigmented orbit; the mandible had bands of melanophores anterior to the orbit; and the operculum had discrete lines of melanophores through the center and ventral margins. Yolk sac pigmentation expanded so that only the ventral portion was without subdermal pigmentation. Mid-dorsally the center of the back is subdermally pigmented with an unpigmented portion immediately below. The mid-lateral is subdermally pigmented in the ventral half of the trunk from the posterior yolk-sac to the notochord. From the anus to the notochord the dorsal half of the trunk is subder-

mally pigmented and has a mid-lateral stripe of non-pigment. Dense cutaneous melanophores occurred over the hypaxial half of the body from the yolk sac to the tip of the notochord. A few cutaneous melanophores occurred in the epaxial musculature posterior to the anus (Fig. 2).

At 16.0 to 17.6 mm, melanophores are scattered anteriorly on the snout and dorsally over the orbit to the opercular margin, forming a stripe. An unpigmented area separates the ventral half of the mandible and lower half of the head. The yolk sac is covered with external melanophores from the head to anus but without a double mid-ventral line of pigment as in

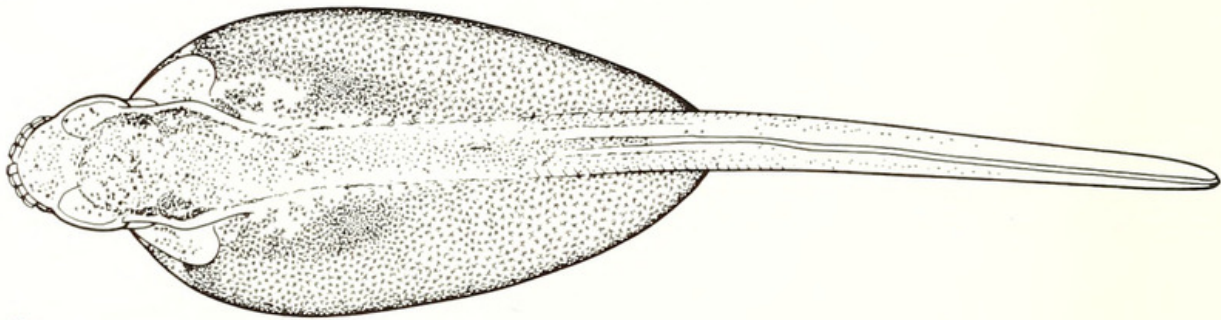
TABLE 1. Continued.

Total length (TL) intervals (mm)						
20.2–23.9 (N = 4)		24.0–26.9 (N = 14)		27.2–35.9 (N = 3)		51.8 (N = 1)
Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD	Range	
12.2 \pm 1.8	(10.3–13.9)	11.0 \pm 0.6	(9.7–12.0)	14.3 \pm 3.6	(11.5–18.4)	20.5
18.9 \pm 0.4	(18.4–19.3)	15.8 \pm 1.7	(14.8–17.8)	15.8 \pm 1.7	(14.8–17.8)	11.6
26.6 \pm 1.3	(25.3–28.0)	25.4 \pm 1.1	(23.5–26.9)	27.2 \pm 3.2	(25.0–30.9)	33.3
68.9 \pm 3.6	(66.2–73.1)	58.2 \pm 12.9	(44.4–89.5)	67.1 \pm 3.7	(63.1–70.4)	71.8
66.7 \pm 2.4	(63.7–71.3)	65.8 \pm 1.2	(63.8–66.9)	64.4 \pm 2.4	(61.8–66.6)	71.2
78.6 \pm 5.6	(74.6–82.6)	67.3 \pm 8.5	(52.6–76.9)	73.3 \pm 4.6	(70.0–76.6)	79.0
95.7 \pm 5.0	(90.0–99.5)	99.4 \pm 0.4	(98.7–99.9)	99.7 \pm 0.1	(99.6–99.7)	99.6
33.7(b)						
6.4 \pm 1.3	(4.9–7.5)	7.0 \pm 0.9	(5.3–8.2)	6.4 \pm 0.2	(6.3–6.6)	4.1
2.7 \pm 0.3	(2.5–2.9)	3.1 \pm 0.4	(2.5–3.9)	3.4 \pm 0.8	(2.6–4.3)	6.8
10.2 \pm 1.0	(9.3–11.3)	8.9 \pm 0.6	(7.8–9.5)	8.6 \pm 1.4	(7.2–9.9)	7.8
9.5 \pm 0.1	(9.5–9.5)	9.3 \pm 0.5	(8.5–10.0)	7.5 \pm 1.9	(5.4–8.9)	8.5
6.4 \pm 0.2	(6.2–6.7)	6.1 \pm 0.6	(4.9–7.1)	5.8 \pm 0.8	(5.6–6.5)	6.2
5.0 \pm 0.4	(4.6–5.4)	4.6 \pm 0.2	(4.3–4.9)	4.3 \pm 0.6	(3.7–5.0)	4.1
4.9 \pm 0.7	(4.2–5.5)	4.4 \pm 0.4	(3.8–4.7)	4.0 \pm 0.4	(3.7–4.4)	4.7
10.2(b)						
14.9 \pm 2.1	(13.3–17.3)	15.4 \pm 1.8	(12.6–17.6)	12.2 \pm 3.0	(10.0–14.3)	
24.8 \pm 4.7	(19.4–27.9)	24.0 \pm 4.3	(16.4–30.7)	17.4 \pm 3.8	(14.7–20.1)	
29.6 \pm 2.7	(27.3–32.6)	30.6 \pm 2.2	(27.0–33.7)	24.3 \pm 2.9	(22.2–26.4)	
35.8 \pm 2.6	(32.9–37.5)	35.4 \pm 2.4	(31.8–38.9)	27.6 \pm 6.3	(23.1–32.1)	
46–48		45–49		46–47		47
44–47		45–49		44–46		46
14–17		14–16		14–16		13
60–62		60–63		60–62		59

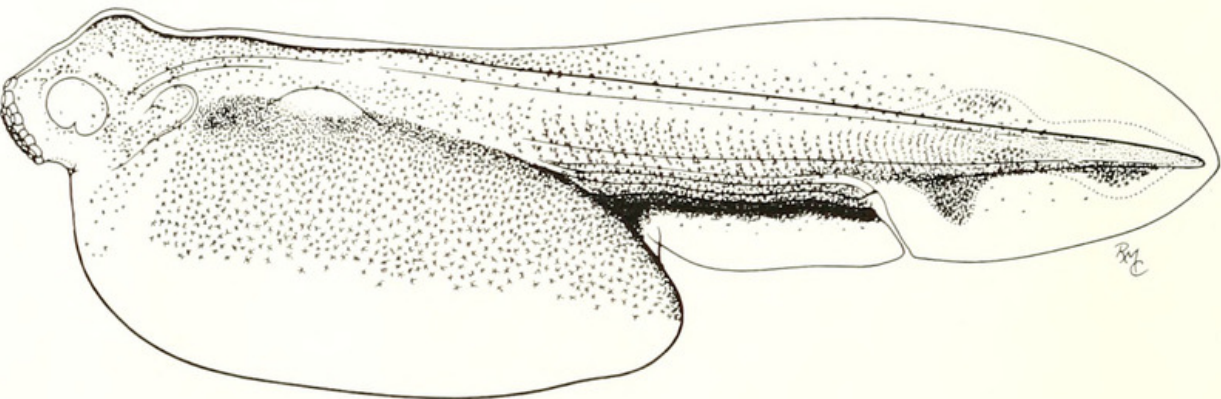
the shortnose gar, *L. platostomus*. Hypaxial musculature has external melanophores distributed along the myosepta to the mid-line. Subdermal pigment blotches were present above the mid-line with few external melanophores above the lateral line. Dorsal and anal finfolds have wedge-shaped blotches posterior to the anus. Another caudal wedge is separated from the finfold wedge by a light area near the base of the caudal peduncle. The caudal finfold was pigmented.

At 20.2 to 26.0 mm, the outside margin of the maxillary is pigmented. Laterally, dark subdermal dorsal blotches are separated by an unpigmented mid-lateral stripe. External cu-

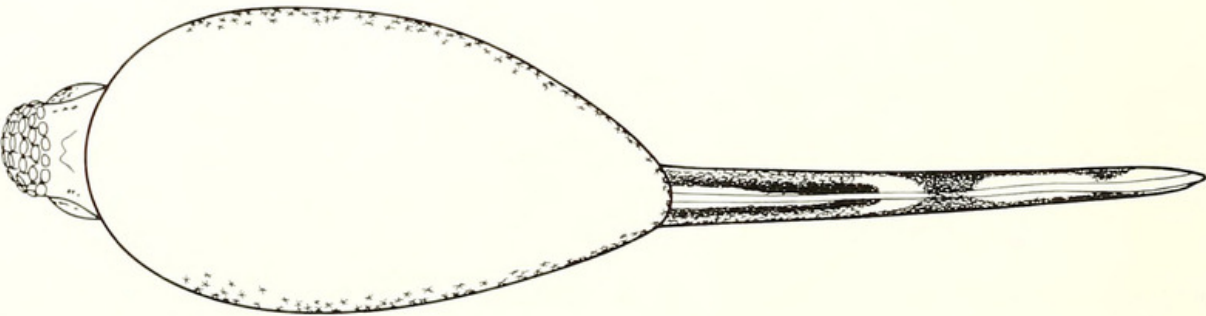
taneous melanophores were adjacent to a darkly pigmented area just ventral to the unpigmented subdermal mid-lateral stripe mentioned above. Few cutaneous melanophores are present anterior to the dorsal fin origin. External melanophores are equally distributed over the postanal myomeres, and a double, mid-ventral stripe of melanophores is present from the head to the anus. At 26.0 to 27.0 mm, scattered cutaneous melanophores are present on the hypaxial half of the body from the head to the anus, while the dorsum is unpigmented. By 28.0 mm, scattered subdermal dorsal pigment borders the lateral unpigmented blotches.



a.



b.



c.

FIG. 1. *Lepisosteus oculatus* newly hatched larva, 9.8 mm TL, from Hatchet Creek, Coosa County, AL. a. dorsal, b. lateral, c. ventral views.

At 33.5 to 51.8 mm, scattered external melanophores cover the entire body except for an unpigmented stripe on the snout and operculum. A few unpigmented subdermal blotches occur along the mid-line, and an unpigmented mid-ventral area is outlined by two rows of melanophores. Distribution of fin pigmentation included the proximal portion of the anal fin rays, wedge shaped pigment present on

differentiating dorsal fin, and scattered pigmentation on caudal fin rays. The pelvic and pectoral fins are unpigmented (Fig. 3).

DISCUSSION

Reproductive behavior is known for only 3 of the 5 North American species of gar. Fish (13) described *L. platostomus* as rushing up streams from Lake Erie during spring and ear-

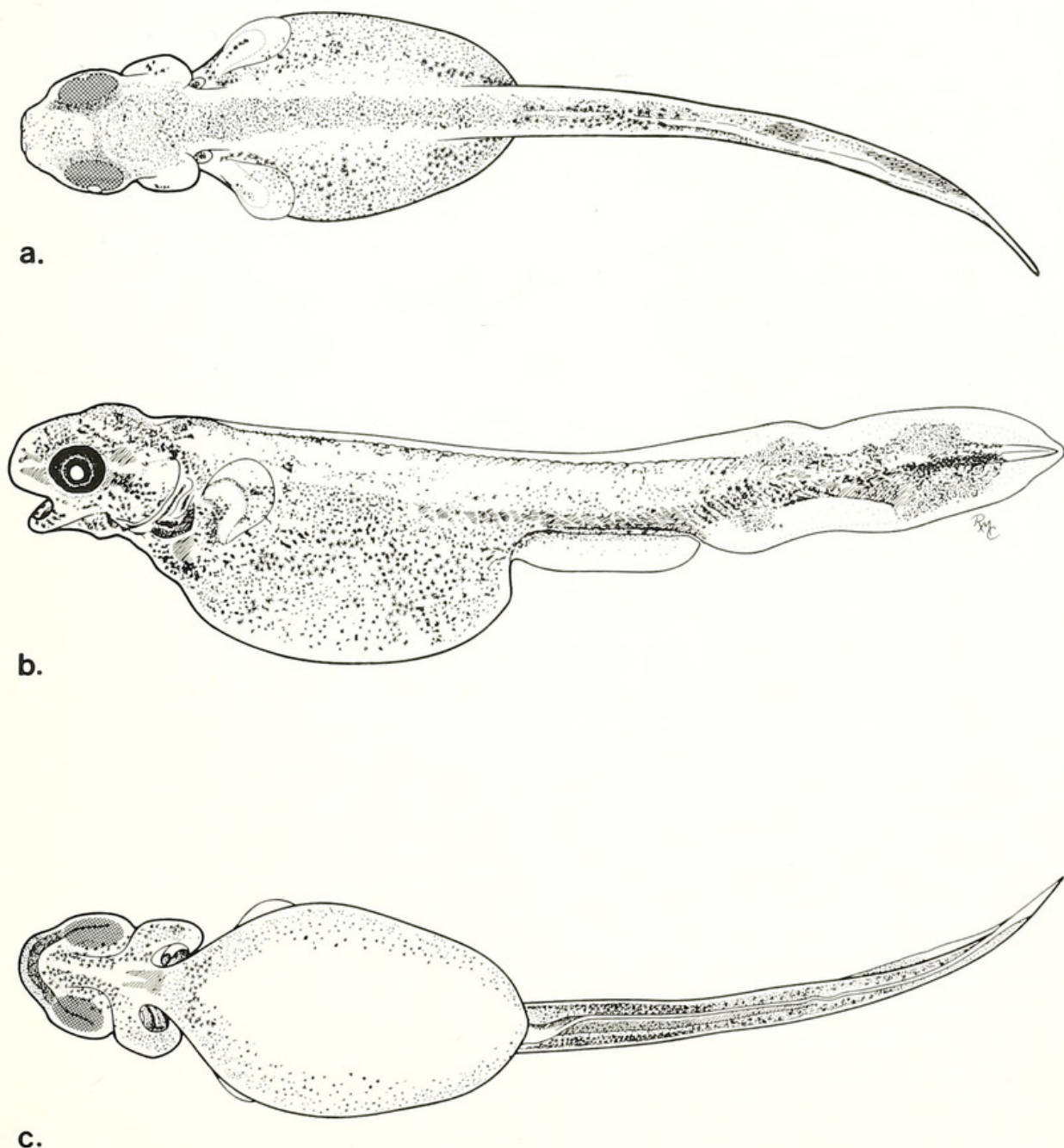


FIG. 2. *Lepisosteus oculatus*, 13.6 mm larva, Hatchet Creek, Coosa County, AL. a. dorsal, b. lateral, c. ventral views.

ly summer. *Lepisosteus osseus* lays eggs beneath bank overhangs over gravel-rubble (14), on algal-covered or bare rocks along wind-swept shorelines and rock points (15), or in shallow littoral zones (7). Echelle and Riggs (7), reported *L. oculatus* spawning on dead vegetation and algal mats in quiet, weedy waters. No observations have been made of reproductive behavior of *Atractosteus spatula* or *L. platyrhincus*, only speculation. Observations made on spawning behavior (EJT, unpublished data) suggest *L. oculatus* utilizes a

variety of habitats, such as *L. osseus*. These differences may be attributable to differences between lentic and lotic habitats. The spawning behavior of *L. oculatus* is similar to that of *L. platostomus* in lotic conditions.

Based on egg sizes reported for *L. oculatus*, significant differences existed between assumed and actual sizes. Riggs and Moore (8), found shortnose gar eggs to average 2.5 mm in diameter. Egg sizes of shortnose gar and spotted gar have been reported to be similar (7). Eggs of spotted gar deposited over a bed-

TABLE 2. Meristic characteristics of spotted gar, *Lepisosteus oculatus* Winchell, including lengths at first appearance and total adult complements.

Fin ray	Present study	Literature
Dorsal fin		
First ray formed	23.9 mm	16.2-19.6 mm ^{5,6}
Adult complement formed	24.5 mm	24.1-26.9 mm ⁵
Adult complement	7-8	6-9 ^{5,6,10,11,12}
Anal fin		
First ray formed	23.9 mm	20.1-23.9 mm ⁵
Adult complement formed	24.5 mm	24.1-26.9 mm ⁵
Adult complement	8	7-9 ^{5,6,10,11,12}
Pectoral fin		
First ray formed	23.9 mm	20.1-23.9 mm ⁵
Adult complement formed	35.9 mm	>38.0 mm ⁵
Adult complement	9-13	9-13 ^{5,6,10,11,12}
Pelvic fin		
First ray formed	33.5 mm	27.1-38.0 mm ⁵
Adult complement formed	35.9 mm	27.1-38.0 mm ⁵
Adult complement	6	5-6 ^{5,6,10,11,12}
Caudal fin		
First ray formed	16.1 mm	16.2-19.6 mm ⁵
Adult complement formed	24.7 mm	27.1-38.0 mm ⁵
Adult complement	12-13	12-13 ^{5,6,10,11,12}

(5) Simon and Wallus, (6) Heufelder, (10) Suttikus, (11) Scott and Crossman, (12) Clay.

rock substrate in Hatchet Creek were spherical and ranged between 4.1 and 5.4 mm. Eggs of longnose gar, *L. osseus*, were ovoid and averaged 4.2 mm by 3.0 mm (5). Eggs described by Riggs and Moore were probably not those of gar. The eggs were described as being in a clear gelatinous substance, thus they may have been amphibian eggs.

Lengths at hatching reported for spotted gar were also significantly different (7). Probable spotted gar were thought to be 7 to 8 mm TL at hatching. Actual hatching lengths for spotted gar were closer to 10 mm TL.

Echelle and Riggs (7) found spotted gar to grow at a rate of 1.7 mm per day with a range between 1.3 to 2.3 mm per day. During our study, larvae grew at a slower rate of 0.83 mm per day. The growth regression line had a correlation coefficient of 0.965 with the line $Y = 9.476927 + 0.03446913 X$. The regression line had the dependent variable length measured as TL (mm), and an independent variable time (hours). Larval spotted gar grew at an increasing rate over the first 30 days of life.

Simon and Wallus (5) provided comparable characteristics for accurate taxonomic diagnosis of Ohio and Tennessee River basin gar. Pigmentation differences reported for spotted

gar to distinguish them from other gar were only provided for lengths greater than 16.4 mm TL. Descriptions provided by Simon and Wallus were supported by our observations. At lengths below 16.4 mm, spotted gar larvae possessed subdermal pigmentation over the dorsum of the gut, and cutaneous pigment more densely distributed over the yolk sac mid-ventrally and postanally, then in *L. osseus*. No information is available for yolk sac *L. platostomus*.

Characteristics provided by Simon and Wallus (5) held for species recognition. Recently hatched *L. oculatus* larvae were typical of other species of *Lepisosteus* possessing an adhesive organ on the snout, a large, ovoid yolk sac, and a weakly developed stomodeum. Larvae had an average of 45.8 preanal and 14.7 postanal myomeres; this differed somewhat from that reported by Simon and Wallus. Their observations on 20 specimens had preanal and postanal averages of 46.7 and 14.2, respectively (5).

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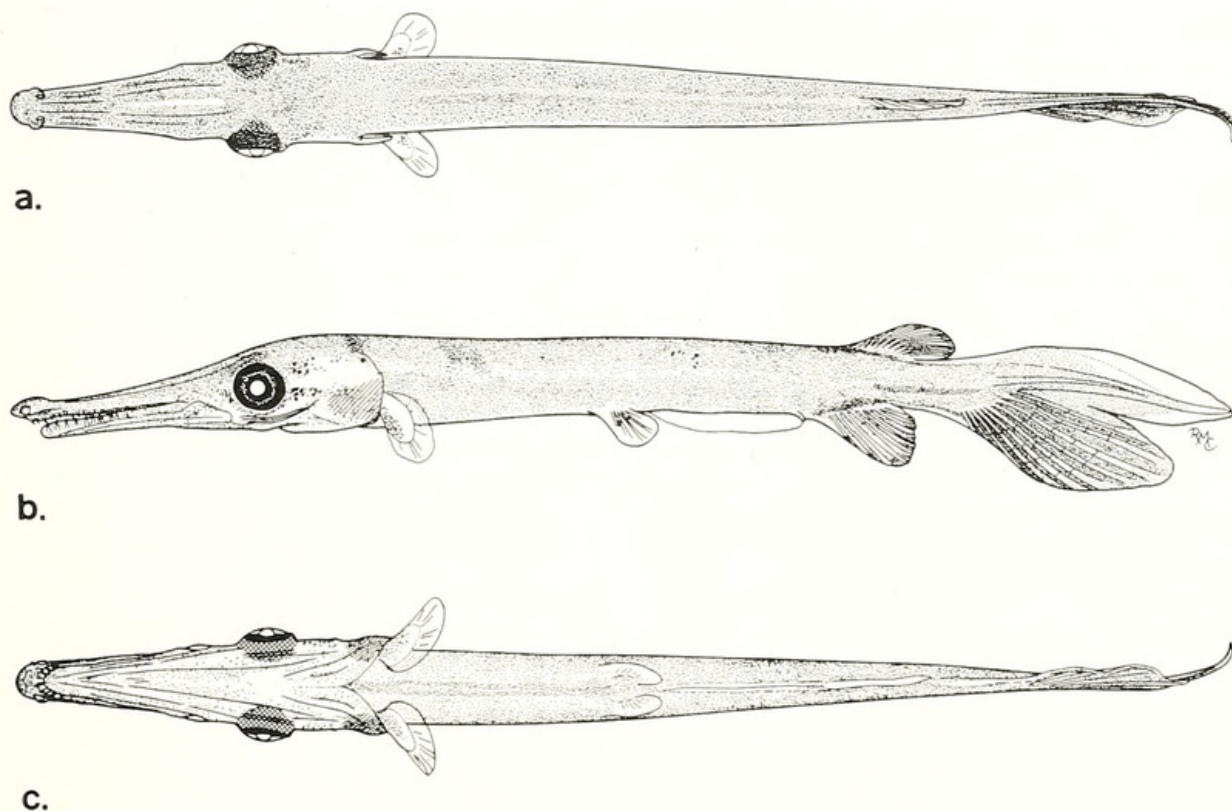


FIG. 3. *Lepisosteus oculatus*, 33.5 mm early juvenile, Hatchet Creek, Coosa County, AL. a. dorsal, b. lateral, c. ventral views.

J. McCormick, Stovall Museum, University of Oklahoma provided a juvenile specimen. R. Clayton provided the excellent illustrations of the 9.8, 13.6, and 33.5 mm specimens. M. Pierson provided laboratory space and logistical support which enabled this study to be completed.

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