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LARVAL DEVELOPMENT OF THE SMALLMOUTH BUFFALO, *ICTIOBUS BUBALUS*

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ABSTRACT

Larval development of smallmouth buffalo (*Ictiobus bubalus*) from the Tennessee River, Alabama, was quite similar to that reported for some other catostomid fishes. Larvae for study were obtained by artificial propagation with the aid of chorionic gonadotropin injections. Larvae hatched 100 hours after spawning, but they were not free-swimming until approximately 80 hours old. Newly hatched larvae average 6.0 mm TL. Smallmouth buffalo larvae initially possesssed a terminal mouth for surface feeding. Scale development began in the tail region and proceeded forward. Most larvae had reached the juvenile stage when they were 26 mm long.

INTRODUCTION

The smallmouth buffalo (*Ictiobus bubalus*) is a catostomid fish native to the midwestern United States from Minnesota to the Gulf of Mexico and from the Ohio River drainage of Pennsylvania southwest to Louisiana. This species usually inhabits deeper, clearer waters having a current (Trautman 1957) and is abundant in the mainstream reservoirs of the Tennessee River.

Larval development of catostomid fishes has been studied by Stewart (1926), Winn and Miller (1954), and Macphee (1960). Winn and Miller (1954), studying postlarval suckers and minnows of the lower Colorado River Basin, suggested that Balinsky's (1948) descriptions of cyprinid larval development could well serve as a basis for catostomids. Macphee (1960) emphasized that the extension of knowledge of larval development of other sucker species was important to form certain generalizations for suckers as a whole. Heard (1958) observed the development of larvae from an assumed cross between a male smallmouth and a female black buffalo (*Ictiobus niger*).

This study was part of general life history investigations by the Tennessee Valley Authority on commercial fish of Wheeler Reservoir, a mainstream reservoir on the Tennessee River in northern Alabama. Collections of postlarvae and juveniles of several catostomids, including three species of buffalo, prompted study of the larval development of the smallmouth buffalo.

MATERIAL AND METHODS

Prespawing adult smallmouth buffalo were collected with a boat-mounted electrofishing unit in March 1968. They were held initially in plywood tanks (2.4 m x 0.6 m x 0.6 m) that contained 756 liters which were supplied with a continuous flow of unfiltered water pumped from the Tennessee River. When ambient river temperature reached 18 C, a pair of ripe adults (female 572 mm, 2.8 kg; male 445 mm, 1.4 kg) was transferred to a temperature controlled 265-liter aquarium, equipped with filtering and recirculating systems, in the laboratory. Water temperatures were maintained at 21 C.

After holding ripe adults in the aquarium for three days, a fish-hatchery formulation of chorionic gonadotropin to induce spawning was injected intramuscularly at the rate of 700 units per pound of body weight for females; males received one-half this rate (Guidice 1964). Spawning occurred approximately 20 hours after injection. Eggs were developed after 100 hours. Within an hour after hatching, approximately 1500 larvae were transferred from the large aquarium to three 37.8-liter aquaria for two days. Some larvae were left in the 37.8-liter aquaria to observe feeding habits, but the majority were transferred to a reinforced plastic wading pool (4.5 m diameter) holding approximately 680 1 of water. Water in the plastic pool contained cultures of *Euglena, Paramecium, Chlorella, Cyclops,* various diatoms, and desmids. After larvae began to feed (four days) a supplement of finely-ground (0.5-0.06 mm particle size) commercial catfish ration was fed daily.

During the first 48 hours after hatching, 10-12 specimens were collected and preserved (10% formalin) every four hours. Usually three of these specimens were examined alive to observe blood flow, pigmentation, and development of mouth parts. Subsequent samples were taken at 24-hour intervals for two weeks and then on a weekly basis until the juvenile stage was reached after seven to nine weeks.

Time and sequence of scale development and the ossification of fin rays was determined by the Alizarin Red S staining technique described by Taylor (1967). Terminology for larval characters was selected from Balinsky (1948), Winn and Miller (1954), Macphee (1960), and May and Gasaway (1967). Body lengths reported are total lengths including the embryonic fin fold and, later, the caudal fin.

Prolarve

Eggs and Hatching—Fertilized eggs averaged 2.2 mm in diameter and adhered to the bottom of the aquarium until hatched. At 21 C, hatching began 100 hours after fertilization and was complete in 108 hours. Tailfirst hatching prevailed, but three larvae emerged headfirst. Appearance and condition of larvae hatching last was the same as for those five to eight hours old. Guidice (1964) reported that smallmouth buffalo eggs hatched within 36 hours after fertilization at 18 C and within 24 hours at 23 C, larvae emerged tailfirst. Heard (1958) reported that the eggs from a black and smallmouth buffalo cross began to hatch after 109 hours at 21 C, but most hatched between 130 and 140 hours.

Newly Hatched Larvae—Newly hatched larvae averaged 6.0 mm TL, the head was bent ventrally, and the eyes were pigmented (Fig. 1A). The mouth and lower jaw were not visible. Auditory vesicles were prominent posterior and dorsal to the eyes, and pectoral fin buds were present. The pericardial cavity was transparent; heart beat and blood flow were clearly visible. A median fin fold was widest at the tail. Several light stellate melanophores, present along the midventral pigment line, became darker after 10 hours. Immediately after hatching, the larvae swam to the surface with erratic, rapid body movements. After reaching the surface, they drifted back to the bottom and rested in a lateral position for 10 to 60 seconds.

One-day Larvae—The average length of 10 one-day

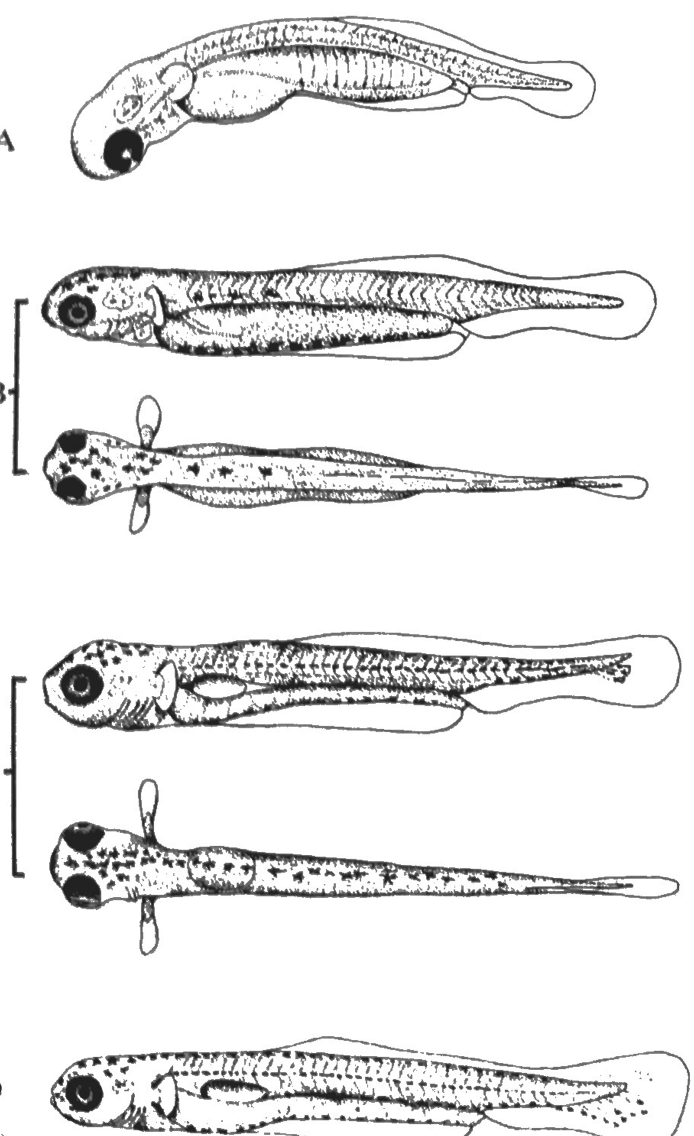

Figure 1. Prolarval and early postlarval stages of *Ictiobus bubalus*. A. 6.0 mm; B. 7.6 mm; C. 9.0 mm; D. 10.3 mm.

larvae was 6.7 mm. Melanophores along the midventral line were the dominant pigmentation, but some were also present in the dorsal, lateral, and head pigment. The mouth was open and was ventral in relation to the eyes since the head was still bent downward. Stewart (1926) noted that the mouth of the white sucker (*Catostomus commersonii*) opened between the first and second day after hatching. Gill slits were functional after 31 hours, and movement of lower jaw and pectoral fins was observed at 35 hours.

Three-day Larvae—Pigmentation increased; the dorsal pigment line contained 20 to 25 dark melanophores. Melanophores were also numerous in the dorsal head region and along the ventro-visceral pigment line (Fig. 1B). The mouth was terminal, and the head was now straight with the body axis. Yolk material was reduced. Average total length for 10 larvae was 8.0 mm. Three-day smallmouth buffalo larvae approximated Stage 30 of Balinsky's (1948) descriptions for cyprinid larvae.

Five-day Larvae—The prolarval period ended between the third and fifth day with the disappearance of yolk material, development of a single air bladder, and the initiation of feeding (Fig. 1C). The terminal mouth opened transversely; the gut was straight. Larvae began feeding near the surface and resting on the bottom in an upright position. Guidice (1964) reported that smallmouth buffalo hatched at 23 C were free-swimming after 36 hours and feeding within 48 hours.

Melanophores increased in the ventro-visceral pigment line, and three to five melanophores were present on the caudal fin along three rudimentary rays. Gill filaments were visible, and the opercle was beginning to form. The end of the notochord was straight.

Postlarvae

One-week Larvae—Ten specimens averaged 9.0 mm. The end of the notochord was upturned slightly (Fig. 1D). The opercle covered the first gill arch, and small melanophores were present along the outer edge of the opercle. Gill arches were pigmented in some of the specimens. Myomeres were distinct, 25 preanal and 8 postanal.

Larvae continued to feed near the surface primarily; however, larvae held in the 37.8-liter glass aquarium appeared to graze algae attached to its sides. Heard (1958) reported similar observations on *Ictiobus* sp. held in aquaria.

Two-week Larvae—The end of the notochord was upturned, and the caudal fin margin was blunt. Unossified caudal fin rays had increased to 12 in most specimens. Two hyplural plates were ventral to the posterior tip of the notochord (Fig. 2A). The fin fold was reduced in the caudal peduncle region. Gill arches 1-3 were covered by the opercle in most specimens. Melanophores increased laterally and internally along the intestine. The mouth was terminal, and larvae appeared to feed at the surface and bottom (0.7 m) of the wading pool.

Three-week Larvae—Anal and dorsal fin buds were present on the 12 larvae examined. Larvae averaged 12.5 mm, and three specimens, 13-14 mm, possessed pelvic fin buds and three to four rudimentary rays in the dorsal fin (Fig. 2B). Pelvic fin buds appeared at a comparable size for white and largescale suckers (Macphee 1960).

The opercle was complete in most larvae and covered the third gill arch in all. A double swim bladder was beginning to form in larvae longer than 13 mm. Caudal fin was emarginate and the heterocercal condition was still evident.

Melanophores were abundant in the dorsal, lateral, and midventral pigment, and a few were present along the anterior base of the dorsal fin. Mouth was terminal and the intestine was straight.

After three weeks, there were significant size differences among larvae of the same age. Until then, the more advanced larval characteristics were possessed by larger specimens. Afterward, larvae began to acquire advanced characteristics at a smaller size; however, sample size was too small to make specific conclusions.

Four-week Larvae—The median fin fold was reduced to a small portion between the anus and pelvic fins. Pelvic fins were paddle-shaped in some specimens. Some larvae had 7 to 10 rays in the anterior part of the dorsal fin and 4 to 6 in the anal fin. The caudal fin was forked, but there was still evidence of the heterocercal condition in the notochord (Fig. 2C).

Average total length of 13 larvae was 14.3 mm; the range was 13.0 to 16.5 mm. Preanal body length was more than twice that of the postanal. A double swim bladder was present and the opercle covered all four gill arches. Melanophores had increased along the rays of the caudal fin.

The mouth was somewhat downturned, and the intestine was s-shaped in the larger specimens. Macphee (1960) reported that in the development of the largescale sucker (*Catostomus macrocheilus*) the lower lip of larvae 13 to 16 mm long gradually changes from an inferior to a posterior position with reference to the upper lip. Thus, the upper lip remains in a terminal position longer than the lower one, and in fish up to 16 mm long the mouth might still be considered terminal although functionally inferior in position. This was apparently true for smallmouth buffalo larvae.

Five-week Larvae—The most significant change after five weeks was that the intestine had begun to coil. One complete loop was present in most specimens, but two larvae 15 mm still had s-shaped intestines. Average total length for eight larvae was 16.4 mm and the range was 15.0 to 17.3 mm. The size at which the intestine of the smallmouth buffalo began to coil compares with that reported for the white sucker (Stewart 1926).

Position of the mouth was not obviously different from the four-week larvae. The larvae fed primarily on the bottom of the wading pool.

Ray development was complete in the anal, caudal, pectoral, and pelvic fins. Rays in the dorsal fin varied from 14 to 27 with order of appearance being anterior to posterior. Part of the median fin fold persisted in the area from the anus to pelvic fins.

Six-week Larvae—Ray development in the dorsal fin was in various stages of completion. In larvae 17 to 20 mm long the dorsal fin was fully rayed (26-28), still incomplete in those less than 17.0 mm. Average total length of 10 larvae was 17.2 mm; the range was 15.0 to 20.0 mm.

The intestine of larger specimens had two loops or coils visible externally at this stage (Fig. 2D). The epidermis and peritoneum in the abdominal region were semi-transparent until larvae were about 21 mm long. A detailed study of coiling and histology of the intestine in the white sucker was made by Stewart (1926). The dorsal lip was at the lower level of the eye, thus the mouth was inferior.

A remnant of the median fin fold was present from the anus to pelvic fins. Melanophores were abundant, with heaviest pigmentation in the occipital region.

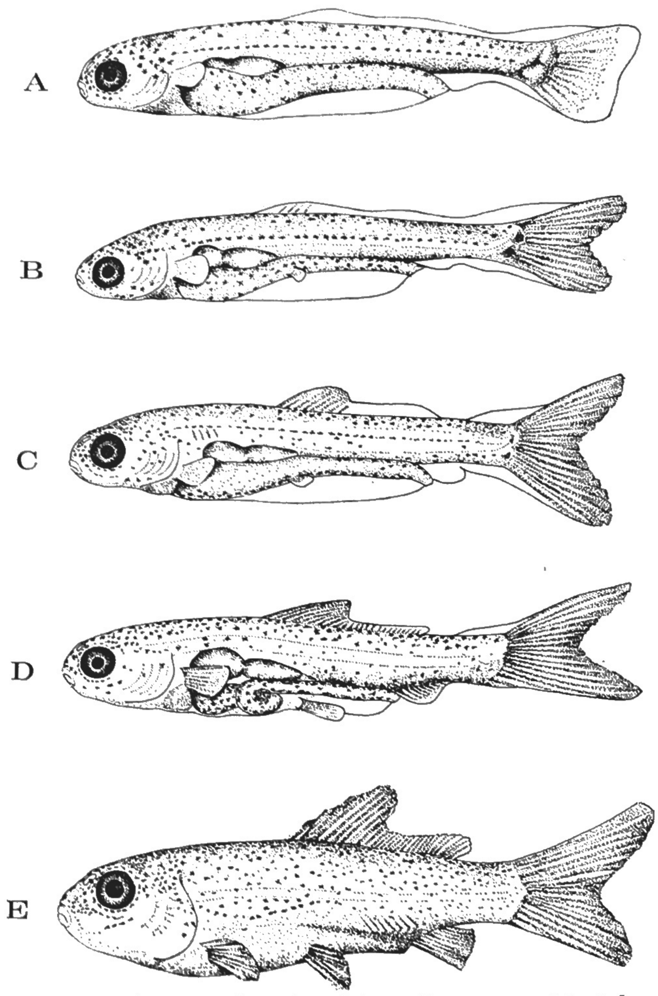

Figure 2. Late postlarval and juvenile stages of *Ictiobus bubalus*. A. 11.0 mm; B. 13.0 mm; C. 16.0 mm; D. 19.5 mm; E 28.5 mm.

Juvenile

The juvenile stage was reached by most smallmouth buffalo between seven and nine weeks (Fig. 2E). According to Balinsky (1948), larval development ended essentially at Stage 43 or when the embryonic fin membrane disappeared and rudiments of scales appeared. We followed the suggestion of May and Gasaway (1967) who defined juvenile fish as one with all fins developed and all spines and/or rays ossified and identical in count with the adult.

After eight weeks the length range was 17 to 32 mm. All fin rays were developed and ossified in fish longer than 20 mm. Fin ray counts were: dorsal—26 to 28, anal—9 to 10, and caudal—18. The preanal distance was greater than twice the postanal distance.

The first scales were observed on stained specimens 23 mm long. Scales were present around the caudal peduncle and laterally in a narrow strip about two-thirds of the distance toward the head. Scalation apparently began in the tail region and proceeded forward. Scale development was complete on specimens 26 mm long and the lateral line was distinct.

The inverted u-shaped mouth was inferior in position. Intestinal loops had increased to five in advanced specimens.

SUMMARY

Larval development of smallmouth buffalo from the Tennessee River (Table 1) was essentially the same as that from a supposed cross between black and smallmouth buffalo from Oklahoma (Heard 1958). Also, development was quite similar to that for the white sucker (Stewart 1926) and largescale sucker (Macphee 1960). Developmental stages also paralleled the concepts developed by Balinsky (1948). Macphee emphasized the closeness of the phylogeny of the Catostomidae in stating that an even closer resemblance exists among larvae than among adults of different sucker species.

Since ages of larvae were known in this study they were included, but as Balinsky (1948) suggested, age would be of little value in distinguishing between species of larvae taken from a composite field collection. There did appear to be a relation between the age and developmental stage; however, insufficient numbers of known age larvae were sampled to correlate age and developmental stages.

TABLE 1. Summary of the developmental stages of larval smallmouth buffalo, Ictiobus bubalus.

Structure	Number of Larvae	Average total length (mm) at which Structure Developed	Structure Disappeared	Structure Development Completed
Pectoral fins*	15	6.0	--	16.0
Yolk sac*	26	--	8.1	--
Heterocercal tail	20	9.4	14.8	--
Dorsal fin lobe	16	10.6	--	--
Anal fin lobe	16	11.0	--	--
Pelvic fin buds	16	13.5	--	--
Dorsal fin rays	11	14.5	--	18.0
Double swim bladder	14	14.7	--	--
Anal fin rays	10	14.7	--	17.0
Pelvic fin rays	10	16.0	--	17.0
S-shaped gut	6	16.0	--	--
Coiled gut	15	17.0	--	--
Median fin fold*	9	--	18.5	--
Scales	8	22.3	--	26.0

* Present in newly hatched larvae.

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