Transactions of the Illinois Academy of Science
(1988), Volume 81, 1 and 2, pp. 205-210

OBSERVATIONS ON THE REPRODUCTIVE BEHAVIOR AND EGGS OF FOUR SPECIES OF DARTERS, WITH COMMENTS ON ETHEOSTOMA TIPPECANOE AND E. CAMURUM

Lawrence M. Page
Illinois Natural History Survey
Champaign, IL 61820

Thomas P. Simon
Large Rivers Larval Research Station
P.O. Box 727
Grayslake, IL 60030

ABSTRACT

Observations on *Percina phoxocephala*, *Etheostoma sagitta*, *E. jordani*, and *E. punctulatum*, all of which are egg-buriers, bring to 73 the number of darters (and to 81 the number of species of percids) for which descriptions of spawning behaviors have been published. The egg-burying *E. tippecanoe* and *E. camurum* have spawning characteristics that may be preadaptive for the evolution of the egg-clumping behavior found in closely related species.

INTRODUCTION

The observations that follow were made on the reproductive behaviors of darters in aquaria. In each instance, choices were made available to the darters so that they could bury, attach, clump, or cluster eggs, as has been observed in other species (Page 1985).

Previously reported observations on the behaviors of 76 percids, including 68 darters, were summarized by Page (1985). Information on *Etheostoma acuticeps*

published by Simon et al. (1987) and the following observations on the slenderhead darter (*Percina phoxocephala*), arrow darter (*E. sagitta*), greenbreast darter (*E. jordani*), and stippled darter (*E. punctulatum*), bring to 81 the number of percids (and to 73 the number of species of darters) for which descriptions of spawning behaviors have been published.

PERCINA (SWAINIA) PHOXOCEPHALA

Two females and 13 males were collected in the Embarras River, Cumberland County, Illinois, on 1 June 1985 and transferred to a 200 gallon aquarium with a power filter. The filter created a slow clockwise current. Substrates in the aquarium included areas of fine gravel, sand, and mixed sand and gravel. Included as additional potential spawning sites were a large flat rock elevated at one end to create beneath it the kind of cavity used by egg-clumpers and egg-clusterers (Page 1985), other large rocks, aquatic plants (in the center of the aquarium), and a yarn mop near the filter on one side of the aquarium.

Males developed black markings and a bright red-orange band in the first dorsal fin. Females developed swollen abdomens and relatively long genital papillae. Spawning was observed on 8 May, 23 June, and 29 June 1986. During spawning, the female buried her papilla about 1 cm beneath the surface of the substrate. The male mounted the female, forming an "S," with his head on one side and his tail on the other side of the female, as has been described for other darters (e.g., Winn 1958). Each spawning act lasted about four seconds. Each time spawning was observed, the eggs were buried in mixed gravel and sand areas behind (relative to the current) large rocks. Eggs were also found (but spawning was not observed) on 22 May and 19 June (aquarium temperatures ranged from 18-22°C). Eggs (N = 8) were 1.7-1.8 (mean = 1.7) mm in diameter, transparent, spherical, demersal, and nonadhesive; they had moderate perivitelline spaces, pale yellow yolks, and unpigmented chorions. At 22°C eggs hatched in 120-124 hrs.

Earlier ecological studies on *P. phoxocephala* identified the spawning period and habitat but did not include observations on spawning behavior. Thomas (1970) and Page and Smith (1971) found that spawning in central Illinois occurred in June and possibly July in swift-flowing water 15-60 cm deep over gravel. Males moved into this habitat in large numbers before the arrival of females and were thought to establish territories. In our aquarium, males schooled until near spawning time and then dispersed more evenly about the aquarium, a behavior that suggested the establishment of territories.

Observations on spawning in *P. phoxocephala* increase to eight the number of species, and to six the number of subgenera, of *Percina* for which information has been reported. All have been found to be egg-buriers. Egg-burying is the primitive behavior among darters (Page 1985), and we predict that all species of this primitive genus of darters will be found to be egg-buriers.

ETHEOSTOMA (LITOCARA) SAGITTA

One male and two females collected in Stinking Creek, Campbell County, Tennessee, on 13 June 1985 were transferred to a 60 gallon aquarium. One-half of the aquarium bottom was covered with fine gravel, the other was left bare to simulate bedrock. A large rock was placed in one corner of the bare half of the

aquarium and another was partially buried in the gravel. The male was in bright breeding coloration, the females were comparatively dull with some swelling of their abdomens.

On 9 March 1986 (11:30 A.M.; 15.5°C), the male was observed courting the large female and chasing away the small female. Courting consisted of lateral displays to the female with the median fins spread. Eventually the male approached the female and nudged her in the abdomen with his snout. The female inserted her snout into the gravel and seemed to flip gravel forward as she wiggled into the gravel, buried her abdomen, and moved forward slowly with the male positioned above her. The male's body formed an "S," with his head on one side of the female and his tail on the other. Each spawning act lasted about seven seconds, followed by a 15-second break, and then another spawning act. The same pair spawned again on 10 March 1986 (10:30 A.M.; 15.5°C). All spawning occurred in deep gravel. Eggs (N = 5) were 1.8-1.9 (mean = 1.8) mm in diameter, transparent, spherical, demersal, and nonadhesive; they had large perivitelline spaces and uncolored yolks and chorions. At 15.5-16°C eggs hatched in 240-253 hrs.

Etheostoma sagitta is closely related to *E. nianguae*, the two being the only members of the subgenus *Litocara* (Page 1981). Spawning in *E. nianguae* was described by Pflieger (1978). Both species are egg-buriers.

ETHEOSTOMA (NOTHONOTUS) JORDANI

Three males and three females were collected in the Conasauga River, Bradley County, Tennessee, 14 June 1985 and transferred to a 40 gallon aquarium. The aquarium bottom was covered with fine gravel. A flat piece of slate, elevated at one end, and a half flowerpot were provided as potential spawning cavities. The slate and the flowerpot were about 15 cm apart.

Several unobserved spawnings occurred, and 28 eggs were found over a five-month period (29 April to 4 August 1986; 18-21°C). These eggs had been buried in deep gravel away from the cavities, and no more than three eggs were found in a single location. Eggs (N = 19) were 1.7-2.0 (mean = 1.9) mm in diameter, transparent, spherical, demersal, nonadhesive and unclumped; they had narrow perivitelline spaces, pale yellow to uncolored yolks, and unpigmented chorions.

Some species of *Nothonotus* (*E. juliae*, *E. rufilineatum*, *E. camurum*, *E. bellum*, *E. tippecanoe*, and *E. acuticeps*) bury eggs, and some (*E. maculatum*, *E. microlepidum*, *E. aquali*, and *E. sanguifluum*) clump them under large stones (Page 1985; Simon et al. 1987). In the latter group of species, males guard the eggs. Phylogenetic relationships within *Nothonotus* are unclear except for the close relationship among species in the egg-clumping (i.e., *E. maculatum*) group (Page 1985). *E. jordani* clearly lies outside the *E. maculatum* group as indicated both by its morphology (Zorach 1969) and by its egg-burying behavior.

ETHEOSTOMA (NOTHONOTUS) TIPPECANOE AND E. (N) CAMURUM

We also observed *E. tippecanoe* and *E. camurum*, two species of *Nothonotus* reported in the literature to be egg-buriers (Trautman 1957; Mount 1959; Warren et al. 1986). Our observations agreed with those of earlier reports, but offered additional insight into how egg-clumping in the *E. maculatum* group of *Nothonotus* may have evolved.

Two male and two female *E. tippecanoe* collected in Tippecanoe River, Pulaski County, Indiana, 27 July 1985 were placed in a 20 gallon aquarium with a substrate of fine gravel and several fist-sized quasi-rectangular rocks. The larger male, which became brilliant orange on the side, dark orange above, and had a dark blue breast used his caudal and anal fins to excavate a cavity beneath one of the large rocks. Although no way in and out of the cavity was apparent, we later discovered upon lifting the rock that a male and two females were in the cavity. Subsequent observations revealed that females buried themselves completely in the gravel during egg-laying, and that the male remained above the gravel directly over them.

Similar behavior was observed in *E. camurum*. Two males and three females (from Tippecanoe River, Pulaski County, Indiana, 27 July 1985) were placed in a 30 gallon aquarium with a large flat rock elevated at one end. Half of the aquarium bottom was uncovered, and fine gravel covered the other half. A disc-shaped sponge filter was located in one corner. Several spawnings were observed in April and May 1986. Some spawnings occurred over the gravel in the open; at other times, the female wedged her body between the filter and the side of the aquarium. The larger male mounted the female and kept his body parallel to hers. The female remained more or less stationary during the spawning act, producing a partially buried, grape-like mass of eggs similar to that described for *E. camurum* by Mount (1959). After spawning, the female wiggled forward and lifted her tail, appearing to expose her genital papilla to the male. The male joined her and spawned again. Each spawning act lasted about 15 seconds, with about 30 seconds between acts, and with the female swimming forward a few cm between each act. As in *E. tippecanoe*, a hidden spawning site (beside the filter) often was chosen.

Earlier observations on spawning in *E. tippecanoe* (Trautman 1957; Warren et al. 1986) did not mention the habit of burying beneath rocks and other objects. However, Warren et al. (1986) made the interesting observation that egg-burying in *Nothonotus* differs fundamentally from that in *Oligocephalus* in that females remain buried and eggs are laid "in small clusters (e.g., *E. tippecanoe*) or in large clumps (e.g., *E. camurum*, Mount 1959)." In *Oligocephalus*, females are much more active and eggs are scattered within the loose substrate. The preferences for burying eggs beneath rocks and laying them in clumps seem preadaptive to the evolution of egg-clumping behavior (Page 1985) in the *E. maculatum* species group of *Nothonotus*.

Eggs of *E. tippecanoe* (N = 7) were 1.3-1.4 (mean = 1.4) mm in diameter, transparent, spherical, demersal, and adhesive; they had narrow perivitelline spaces, amber yolks, and unpigmented chorions. At 22°C eggs hatched in 144-168 hrs. Eggs of *E. camurum* (N = 21) were 1.6-2.2 (mean = 1.8) mm in diameter, transparent, spherical, demersal, and adhesive; they had narrow perivitelline spaces, uncolored yolks, and unpigmented chorions. At 22°C eggs hatched in 168-240 hrs.

ETHEOSTOMA (OZARKA) PUNCTULATUM

Two males and one female from Osage River, Missouri, 11 January 1985, were observed spawning in a 40 gallon aquarium many times between February and late June 1986. The aquarium contained fine gravel and a large rock, elevated at one end

to create a cavity. During spawning, the female swam forward and buried her body about half-way in the gravel. With his head lifted, the male positioned himself beside and parallel to the female. The female spawned with both males, but only with one at a time. Each spawning act lasted about eight seconds. Spawning fish were more active than were those of species of *Nothonotus*, often swimming in and out of the gravel as observed in species of *Oligocephalus*. Temperatures ranged from 18-22°C. Eggs (N = 37) were 2.0-2.4 (mean = 2.1) mm in diameter, transparent, spherical, demersal, and nonadhesive; they had narrow perivitelline spaces, pale yellow yolks, and heavily pigmented chorions. At 22°C, eggs hatched in 121-136 hrs.

Observations have been made previously on three members of the subgenus *Ozarka*. *E. cragini* was observed in an aquarium to bury its eggs in fine gravel (Distler 1972), and *E. boschungi* and *E. trisella* have been observed to attach eggs to vegetation in seepage areas (Boschung 1979; Ryon 1986).

Unfortunately, vegetation was not available in the aquarium in which *E. punctulatum* spawned, and only floating vegetation was available to *E. cragini* (Distler 1972). A preference by these two species for rooted vegetation similar to that used as a spawning site by *E. boschungi* and *E. trisella* cannot be ruled out. The potential for darters to revert to a more primitive spawning behavior was demonstrated by the observations made on *E. nigrum* by Forbes and Richardson (1908). Although *E. nigrum* is an egg-clusterer (Winn 1958; Page 1985), it reverted to the more primitive mode of egg-burying when held in an aquarium without objects on which to cluster eggs.

> "The species [*Etheostoma nigrum*] spawns in spring, from the last of April to the first of June. Females were depositing their eggs in our aquarium at Meredosia, April 28 and 29, 1899. In the act of spawning the male rode on the back of the female, with ventrals astride, and pectorals and ventrals in active vibration as the pair moved about on the bottom. The eggs are emitted at intervals, and from time to time the female raises a cloud of sand by a vigorous beating with the tail, perhaps for the purpose of covering them." (Forbes and Richardson 1908:296-297).

Since species can revert to more primitive behaviors, aquarium-held fishes must be allowed to choose from among all plausible spawning substrates. *E. cragini* and *E. punctulatum* should be listed only provisionally as egg-buriers.

ACKNOWLEDGMENTS

We extend special thanks to Nancy Garcia, whose abilities to keep and spawn darters in aquaria resulted in the observations reported here. B.M. Burr, R. Coleman, R.J. Goldstein, R. Wallus and the members of the Michiana Aquarium Club assisted us in collecting brood stock. The manuscript was read and improved by N. Garcia, M.L. Warren, Jr., and C.E. Johnston.

LITERATURE CITED

Boschung, H. 1979. Report on the breeding habits of the slackwater darter (Precidae: *Etheostoma boschungi*) in the Cypress Creek watershed. Submitted to U.S. Dept. Agric. Soil Cons. Serv., Auburn, Alabama.

Distler, D.A. 1972. Observations of the reproductive habits of captive *Etheostoma cragini* Gilbert. Southwest Nat. 16:439-441.

Forbes, S.A., and R.E. Richardson. 1908. The fishes of Illinois. Ill. Nat. Hist. Surv., Urbana, Illinois. 357 p.

Mount, D.I. 1959. Spawning behavior of the bluebreast darter, *Etheostoma camurum* (Cope). Copeia 1959:240-243.

Page, L.M. 1981. The genera and subgenera of darters (Percidae, Etheostomatini). Occas. Pap. Mus. Nat. Hist. Univ. Kans. 90. 69 p.

Page, L.M. 1985. Evolution of reproductive behaviors in percid fishes. Ill. Nat. Hist. Surv. Bull. 33(3):275-295.

Page, L.M., and P.W. Smith. 1971. The life history of the slenderhead darter, *Percina phoxocephala*, in the Embarras River, Illinois. Ill. Nat. Hist. Surv. Biol. Notes 74. 14 p.

Pflieger, W.L. 1978. Distribution, status, and life history of the Niangua darter, *Etheostoma nianguae*. Missouri Dept. Conserv. Aquatic Ser. 16. 25 p.

Ryon, M.G. 1986. The life history and ecology of *Etheostoma trisella* (Pisces: Percidae). Am. Midl. Nat. 115:73-86.

Simon, T.P., R. Wallus, and K.B. Floyd. 1987. Descriptions of protolarvae of seven species of the subgenus *Nothonotus* (Percidae: Etheostomatini) with comments on intrasubgeneric characteristics. Am. Fish. Soc. Symposium 2:179-190.

Thomas, D.L. 1970. An ecological study of four darters of the genus *Percina* (Percidae) in the Kaskaskia River, Illinois. Ill. Nat. Hist. Surv. Biol. Notes 70. 18 p.

Trautman, M.B. 1957. The fishes of Ohio. Ohio State Univ. Press, Columbus. 683 p.

Warren, M.L., Jr., B.M. Burr, and B.R. Kuhajda. 1986. Aspects of the reproductive biology of *Etheostoma tippecanoe* with comments on egg-burying behavior. Am. Midl. Nat. 116:215-218.

Winn, H.E. 1958. Observations on the reproductive habits of darters (Pisces-Percidae). Am. Midl. Nat. 59:190-212.

Zorach, T. 1969. *Etheostoma jordani* and *E. tippecanoe*, species of the subgenus *Nothonotus* (Pisces: Percidae). Am. Midl. Nat. 81:412-434.