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Herbert T. Boschung

David Nieland

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BIOLOGY AND CONSERVATION OF THE SLACKWATER DARTER, ETHEOSTOMA BOSCHUNGI (PISCES:PERCIDAE)

Herbert T. Boschung and David Nieland
Department of Biology
The University of Alabama
University, Alabama 35486

Abstract

The slackwater darter, Etheostoma boschungi, has a disjunct distribution in tributaries to the south bend of the Tennessee River in Alabama and Tennessee. The species requires two distinctly different, but necessarily adjacent, habitats in order to complete its life cycle. The non-breeding habitat is typically a slow-flowing stream with silt and gravel substrate and accumulations of organic detritus. The breeding habitat is winter seepage water in open pastures or wooded areas. The larvae, after reaching about 12 mm standard length (SL), return to adjacent streams. Lowering of the groundwater table and urbanization are threats to the survival of this species.

Introduction

The slackwater darter, Etheostoma boschungi, was described by Wall and Williams (1974) from specimens collected in Cypress Creek, Lauderdale County, Alabama; Flint River, Madison County, Alabama; and Buffalo River, Lawrence County, Tennessee. Although this species was originally placed in the subgenus Oligocephalus, Williams and Robison (1980) later erected a new subgenus (Ozarka) to contain E. boschungi, E. punctulatum, E. cragini, E. pallididorsum, and E. trisella. The species of Ozarka are medium-sized darters, ranging from 40-70 mm SL, that typically inhabit gentle riffles and slackwater areas of small to medium-size, shallow, upland tributary streams (Williams and Robison 1980).

Etheostoma boschungi differs from all other forms of Ozarka in having the following combination of characters: two anal spines; lateral line with 45-58 scales, 34-38 of which are pored; soft dorsal fin usually with 11-12 rays; a bold blue-black subocular bar; three prominent dorsal saddles; and 35-37 total vertebrae (Wall and Williams 1974; Williams and Robison 1980). In the field, specimens in the water can readily be identified by the three prominent saddles and wide subocular bar. Wall and Williams (1974) presented no evidence of significant variation in this species.

The following publications complete the bibliography on the slackwater darter: metabolism, critical oxygen tension, and habitat selection (Ultsch et al. 1978); an account of the species in the Atlas of North American Freshwater Fishes (Boschung 1980); an abstract on life history notes (Boschung 1979a); and papers proposing to recognize the species as threatened or endangered in Alabama (Ramsey 1976), in Tennessee (Starnes and Etnier 1980), and nationally (Deacon et al. 1979). Page (1983), Kuehne and Barbour (1983), and Boschung et al. (1983) each included an account and color photograph of E. boschungi in their books. Data presented in the present paper are mostly from reports by Boschung (1976, 1979b) to the U.S. Department of Agriculture (USDA) and the Soil Conservation Service (SCS), and the Slackwater Darter Recovery Plan (Boschung 1984) for the U.S. Fish and Wildlife Service. Since these reports have limited distributions in the scientific community, a compendium of our knowledge of the biology and conservation of the slackwater darter is presented here.

Distribution and Habitat

Distribution. The slackwater darter is only known from five streams, all tributary to the south bend of the Tennessee River: (a) Buffalo R. system, Lawrence Co., TN: South Fork, 15.8 km N of Lawrenceburg, at U.S. hwy 43 and upstream; Chief Cr., at TN hwy. 20, about midway between Henryville and Center; (b) Cypress Cr. watershed (exclusive of Little Cypress Cr.), Wayne Co., TN, and Lauderdale Co., AL; (c) Shoal Cr., Lawrence Co., TN, near Lawrenceburg (one collection; Page 1983); (d) Swan Cr., Limestone Co., AL, near Athens, and (e) Flint R. system, Madison Co., AL: Copeland Branch on West Limestone Rd; West Fork at U.S. hwy. 431; Briar Fk. at U.S. hwy. 431 (Fig. 1).

The physiographic area occupied by Etheostoma boschungi is the Highland Rim of the Nashville Basin. Congeners more or less limited to this area include E. blennius, E. duryi, and E. tuscumbia. With the exceptions of Flint River and Swan Creek, current distribution of the slackwater darter is restricted to those headwater streams rising from the highlands of Lawrence and Wayne counties, TN. The darter is not known from Elk River, the largest tributary in the south bend of

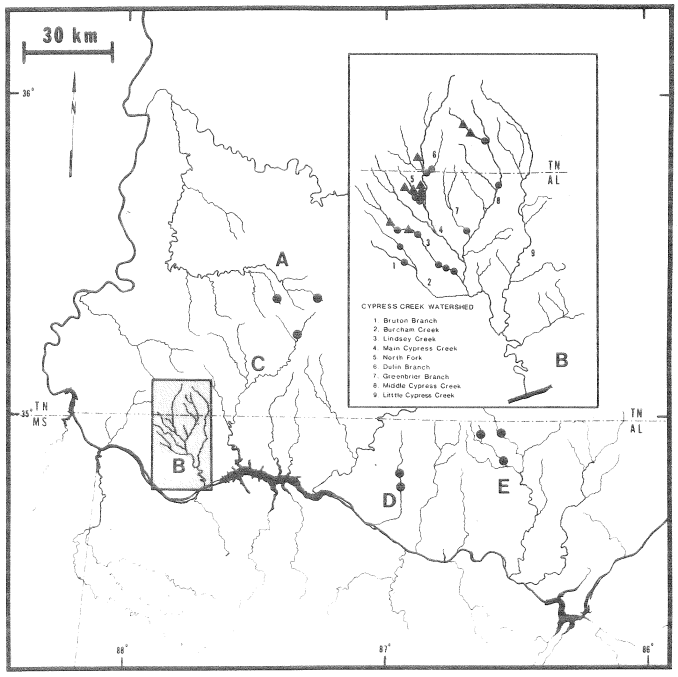

Figure 1. South bend of Tennessee River, Alabama and Tennessee. A - Buffalo River, B. Cypress Creek (and inset), C - Shoal Creek, D - Swan Creek, E - Flint River. Dots indicate localities for Etheostoma boschungi. Triangles on Cypress Creek inset indicate known breeding habitats.

the Tennessee River, even though the Elk is situated between the Buffalo and Flint rivers, streams in which the darter does occur. It also is not known from southern tributaries to the south bend of the Tennessee River.

Origin. Etheostoma boschungi may be derived from parental Ozarkian stock from Arkansas and Missouri, and probably evolved following isolation resulting from some vicariant event, such as formation of the Mississippi embayment. The five disjunct populations are probably remnants of a past continuous and more ubiquitous distribution. Possible reasons for reduction in geographic distribution of the species are discussed later in this paper.

Non-breeding habitat. The slackwater darter's non-breeding habitat comprises small (60 cm wide and 15 cm deep) to moderately large (12 m wide and up to 2 m deep) streams. Current is usually slow, ranging from still to 0.34 m/sec. under normal conditions. In small streams, individuals show no position preference; however, in larger streams, such as Lindsey Creek, they seem to be situated near banks or in bank undercuts. They also occur over gravel infiltrated by silt, over silt and mud, or over a combination of these, but have not been observed over clean gravel in swift streams, or in swift areas. The species shows a preference for accumulations of detritus, such as small twigs and rotting leaves, but not for large masses of newly-fallen, compacted leaves. Apparently their migrations are not impeded by moderate riffles or shallow water. Oxygen does not seem to be a habitat-limiting factor, inasmuch as individuals are tolerant of rather low oxygen levels; they inhabit water during the summer that would not be habitable without a downward shift in critical oxygen tension (Ultsch et al. 1978). Physical nature of the stream probably is the main factor limiting the distribution of this species.

Breeding habitat. The breeding habitat of the slackwater darter invariably is seepage water in open fields and woods. Water in these places is usually about 4 to 8 cm deep, and flows slowly into an adjacent stream. Since the breeding site typically is 30-45 cm above the adjacent stream, the stream must periodically rise to provide ripe darters access to their breeding grounds.

Locations and characteristics of the known breeding sites, all in the Cypress Creek watershed, are as follows: (1) AL, Lauderdale Co., Elijah Branch, trib. to North Fork of Cypress Cr.; Threet, AL quadrangle, T1S, R12W,S12; elev. 680 ft.; soil type, Lee cherty silt loam; water source, wet weather seepage; vegetation, open pasture, with Juncus and Eleocharis; (2) AL, Lauderdale Co., off North Fk. of Cypress Cr.; Threet, AL quadrangle, T1S,R12W,S8; elev. 655 ft.; soil type, Lee and Lobelville cherty loam; water source, wet weather seepage; vegetation, semi-wooded, partly open, sparse sweetgum and beech, Panicum and Festuca; (3) AL, Lauderdale Co., trib. to main Cypress Cr.; Threet, AL quadrangle, T1S,R12W,S8; elevation 640 ft.; soil type, Staffell and Bodine, Etowah silt loam, Lee cherty silt loam; water source, wet weather seepage and spring; vegetation, wooded, partly open, mixed hardwoods, Festuca; (4) AL, Lauderdale Co., off Lindsey Cr.; Threet, AL quadrangle, T1S, R13W,S24; elev. 695 ft.; soil type, Lobelville cherty silt loam; water source, wet weather seepage; vegetation, wooded, sweetgum and red maple; (5) AL, Lauderdale Co., off Lindsey Cr.; Threet, AL quadrangle, T1S,R12W,S29; elev. 620 ft.; soil type, Lee cherty silt loam; water source, wet weather seepage; vegetation, wooded, river birch, alder, sweetgum, willow, Eleocharis, Fontinalis; (6) TN, Wayne Co., trib. to main Cypress Cr., ca. 0.5 mi. NW of Cypress Inn, Cypress Inn; TN-AL quadrangle; elev. 690 ft.; water source, wet weather seepage; vegetation, open pasture, Juncus, Eleocharis, Festuca; (7) TN, Wayne Co., Middle Cypress Cr., ca. 4 mi. NE of Cypress Inn, Cypress Inn; TN-AL quadrangle; elev. 830 ft.; water source, spring and seepage; vegetation, open pasture, Juncus, Eleocharis, Ranunculus; (8) TN, Wayne Co., Middle Cypress Cr., ca. 4 mi. NE of Cypress Inn, Cypress Inn; TN-AL quadrangle; elev. 840 ft; water source, wet weather seepage and spring; vegetation, open pasture, Juncus and Callitriche.

Essential habitat. Both the non-breeding and breeding habitats described above are necessary for sustaining populations of Etheostoma boschungi. Obviously these two distinctly different habitats must be adjacent. It appears that the limiting factor relative to reproductive success is the breeding habitat. The declining groundwater table probably has adversely affected the number of breeding sites, and thus has limited the geographical distribution of the species.

Figure 2. Eggs of Etheostoma boschungi on submersed leaves of rush (Juncus sp.).

Life History Aspects

Reproduction. The sequence of events in the reproductive chronology of the slackwater darter was observed in the Cypress Creek watershed during 1978-1979 as follows:

10 November-31 January - adults aggregate for spawning migration, nuptial colors developing, gametes developing; 10 January-10 February - spawning migration; 20 January-28 February - nuptial colors reach maximum development, gametes fully developed; 31 January-10 March - adults reach breeding habitat; 20 February- 20 March - territoriality and courtship; 28 February- 31 March - spawning activity; 20 March-30 April - larvae develop in breeding habitat; 20 April-31 May - larvae leave breeding habitat.

Exact timing of the above undoubtedly varies from year to year, depending upon temperature and rainfall. There is no evidence of spawning when water temperatures are less than 14°C. Observations on North Fork of Cypress Creek suggest strongly that slackwater darters assemble in certain places downstream of the breeding site, and then make a unified final surge to the spawning area. This behavior permits the entire breeding deme to take advantage of a single high-water event that will "lift" the darters into the spawning area.

The spawning act has not yet been observed; however, a male was observed "guarding" a clump of rush (Juncus sp.). His behavior was aggressive, as he attacked a straw probe placed nearby. Several days after this observation, eggs were found on the Juncus that had been guarded by the male. These were arranged either singu-

larly or in two's or three's (Fig. 2).

Fecundity. Estimates were made of the number of eggs produced per female. Three specimens averaged 320 ripe eggs; however, another had approximately 1000 eggs in some stage of development. Based on a cursory inspection of swimming larvae, the annual replacement potential is impressive.

Growth. The initial growth period is rather rapid. Specimens in early April are about 10-12 mm SL, but by early June have doubled in length. By the end of the first year, most are 28-32 mm SL. Year-round length-frequency data are not available, but it appears that most specimens collected at any given time are either in the 1- or 2-year class. We believe that few, if any, live more than three years. The largest known specimen is 65 mm SL. Growth-rate data appear in Figure 3.

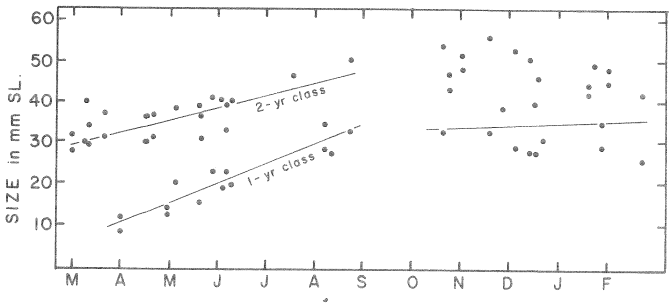

Figure 3. Distribution of minimum and maximum sizes of Etheostoma boschungi, 1 March to 20 February. N = 339.

Food. Stomachs of 80 specimens of E. boschungi, 25 mm SL or greater, were examined (Table 2). Thirty were from breeding habitats from the Cypress Creek watershed, whereas the remainder were from various non-breeding habitats throughout the same area. The overlap between diets of slackwater darters occupying the two habitats was quantified, using Pianka's (1973) equation in which zero indicates no overlap and one indicates complete overlap. The value obtained was 0.135, which indicates little similarity between diets. It is obvious that this darter is capable of shifting its diet concomitant with a shift in habitat.

Species Associates. The following forty fish species in 12 families are known to occur with E. boschungi: Ichthyomyzon gagei, Lampetra aepyptera (Petromyzontidae), Esox americanus, E. niger (Esocidae), Campostoma anomalum, Clinostomus funduloides, Hemitremia flammea, Nocomis micropogon, Notropis ardens, N. c. chrysocephalus, N. coccogenis, N. fumeus, N. telescopus, Phoxinus erythrogaster, Pimephales notatus, Rhinichthys atratulus, Semotilus atromaculatus (Cyprinidae), Catostomus commersoni, Erimyzon oblongus, Hypentelium nigricans, Moxostoma duquesnei, M. erythrurum (Catostomidae), Ictalurus natalis (Ictaluridae), Aphredoderus sayanus gibbosus (Aphredoderidae), Fundulus catenatus, F. olivaceus (Cyprinodontidae), Gambusia a. affinis (Poeciliidae), Ambloplites rupestris, Lepomis cyanellus, L. macrochirus, L. megalotis, Micropterus dolomieui, M. punctulatus, M. s. salmoides (Centrarchidae), Etheostoma caeruleum, E. duryi, E. flabellare, E. simoterum, E. cf. squamiceps (Percidae), Cottus carolinae (Cottidae). The most common associates of the slackwater darter are (in order of percent occurrence): Clinostomus funduloides, Etheostoma cf. squamiceps, Campostoma anomalum, E. flabellare, E. duryi, Hypentelium nigricans, and Fundulus olivaceus. As expected, the least frequent associates are large-stream inhabitants, such as species of the genera Moxostoma and Micropterus.

Predators. Although many fish species may possibly prey on slackwater darters should the occasion arise, green sunfish (Lepomis cyanellus) and pirate perch (Aphredoderus sayanus) were the only fishes actually found to have slackwater darter remains in their stomachs.

Conservation

Population size. Those populations of slackwater darters outside the Cypress Creek watershed appear to be small in terms of numbers of individuals, probably because of a paucity of essential habitat. A total of only 89 specimens are known from 8 localities in 4 stream systems outside Cypress Creek. Of these, 41 were collected (20 subsequently released) from Copeland Branch (Flint River system) on 24 October 1970; however, subsequent attempts to find specimens at this site and elsewhere in Flint River have failed.

TABLE 1

Stomach contents of Etheostoma boschungi from Cypress Creek watershed, Alabama and Tennessee

	Percent of Stomachs in which Food Organisms occurred			Mean Number of Food Organisms per Stomach		
	Non-breeding Habitat	Breeding Habitat	Total	Non-breeding Habitat	Breeding Habitat	Total
	N=50	N=30	N=80	N=50	N=30	N=80
Crustacea						
Ostracoda	....	6.67	2.50	....	0.07	0.03
Copepoda	....	3.33	1.25	....	3.40	1.28
Isopoda	....	23.33	8.75	....	0.30	0.11
Amphipoda	....	36.67	13.75	....	1.50	0.56
Decapoda	....	.....	3.75	0.06	....	0.04
Insecta						
Ephemeroptera	46.0	30.00	40.00	0.62	0.43	0.55
Trichoptera	4.0	.....	2.50	0.08	....	0.05
Coleoptera	2.0	6.67	3.75	0.02	0.07	0.04
Diptera	6.0	20.00	11.25	0.12	0.47	0.25

Cypress Creek, exclusive of Little Cypress Creek, is the stronghold of the slackwater darter, and we had earlier estimated its numbers there to be around 3,600 (Boschung 1976). In December 1978, we attempted to estimate the population size in Cemetery Branch, a tributary to North Fork of Cypress Creek. Cemetery Branch is near three known breeding sites. Mark-and-recapture studies in a 27 m long section of stream resulted in a population estimate between 103 and 195. It must be pointed out, however, that estimating numbers of slackwater darters is difficult because of the tendency of this species to congregate. In this instance, the group was assembled in a relatively small area, unable to proceed with its upstream migration to the spawning grounds until rains came that would enable flood waters to lift individuals over barriers. Thus, the above population estimate for this small section of stream certainly should not be regarded as representative of population size of the species throughout its range, or even within the Cypress Creek watershed itself. Overall, we think that its numbers in places other than Cypress Creek are dangerously low.

Threats to survival. The factor that appears to limit the abundance and distribution of the slackwater darter is suitable habitat. Habitat has undoubtedly decreased in both quality and quantity during the past 200 years because of man's activities. The remaining refuges are subject to a number of threats:

1. Spreading urbanization is a potential threat to the physical integrity of habitats. Homes, shopping centers, and industrial parks must be built away from essential habitats. The building of ditches designed to drain areas with shallow ground water is also a threat. Farming and cattle raising are the principal industries surrounding the darter's habitat. Since the breeding habitats are so limited, even a small chemical spill or biological pollutant could exterminate a breeding population.

2. Degradation of surface and ground water caused by toxins, pesticides, fertilizers, industrial and domestic wastes from sewage lines and septic tank seepage, and stockyard runoff are very real threats to E. boschungi.

3. Slackwater darter breeding habitats are "logical" sites for farm fish ponds. Much of the year the sites are too wet to plow, and since they abound in rush and spike-rush (Eleocharis sp.), they are undesirable areas for pasture. Probably a number of breeding sites for E. boschungi are now inundated by farm ponds.

4. On occasion, breeding sites may be destroyed by beaver ponds, as happened in the case of the first slackwater darter breeding site discovered, on Bruton Branch of Burcham Creek. Although farmers usually will destroy beaver dams, in the above instance this was left intact.

5. The U.S.Department of Agriculture, Soil Conservation Service has been studying the Cypress Creek water-

shed for a number of years relative to flood control. Studies by Boschung (1976, 1979b) were utilized in the decision to revise the SCS's original plan. The final watershed plan was developed in concert with other federal agencies, including various offices of the U.S. Fish and Wildlife Service, to ensure that the results of SCS's flood-control plan will not adversely affect the slackwater darter.

Conservation measures. Habitat preservation obviously is of prime importance in conservation of the slackwater darter. The fact that it inhabits relatively small to moderate-sized streams may be regarded as an advantage; such streams are easily monitored, and the disjunct occurrence of populations makes the species less subject subject to widespread eradication resulting from a major ecological disaster (e.g., a massive chemical or oil spill) than would be true for a big-river species. On the other hand, reproductive success of this fish is dependent more than for most species upon maintenance of proper groundwater levels, which are not easily controlled. Intelligent water conservation methods are required, which should not involve widespread dam building. Finally, this species probably could be cultured successfully in a hatchery, providing care is taken to regulate water levels on a seasonal basis.

Acknowledgments

Most of our knowledge of the distribution and biology of the slackwater darter resulted from studies sponsored by the U. S. Department of Agriculture, Soil Conservation Service, Auburn, AL. Thomas S. Jandebeur, who made numerous collections in the south bend of the Tennessee River in search of the darter, is responsible for its discovery in Swan Creek. Also, Tom was the senior author's able companion in the field on numerous occasions, as were Mason Dollar, John Hall, Leroy Koch, Patrick O'Neil, Benjamin Wall, James D. Williams, and John S. Williams. Additional collectors were J. A. Collins, Larry Davenport, Christopher Dyer, Mike Carroll, Thomas Gritzmacher, Benjamin Richey, George Smith, Fred Tatum, and John Weaver. Lawrence Page shared his knowledge of the slackwater darter in Shoal Creek. We thank these friends and colleagues for their valuable contributions to this study.

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FISHES OF THE NORTH FORK HOLSTON RIVER SYSTEM, VIRGINIA AND TENNESSEE

Joe C. Feeman, Jr.
Tennessee Valley Authority
Norris, Tennessee 37828

Abstract

Recent surveys by the Tennessee Valley Authority (over 100 collections from 1971-1983), along with extensive historical collections, have shown the North Fork of the Holston River system to have a diverse fish fauna. Annotated accounts of 73 species, representing 11 families, are presented along with comments on distribution, habitat preference, and protective status. A discussion of past disturbances and their effects on the fish fauna are also presented.

Introduction

Since 1971 personnel of the Tennessee Valley Authority (TVA) have taken over 100 fish samples in the North Fork of the Holston River system. Samples were taken from 1971-1977 in order to monitor faunal recovery from pollution and to determine mercury levels assimilated by the fishes. From 1977-1983 collections were taken in conjunction with various other projects, including a search for suitable transplant sites for Conradilla caelata (Conrad), an endangered mussel species, and collections of selected fish species for research in mussel life history studies.

Numerous other collectors have sampled the North Fork system, beginning with Cope's collections in October 1867 (Cope 1868). Other publications dealing with fish collections in this system include Jordan (1889), Patrick (1961), Ross and Carico (1963), Hill et al. (1975), and Feeman (1980). Collection records that have not been reported in the literature were obtained from R. E. Jenkins. Also included are early TVA collections taken in the 1930's by A. R. Cahn, C. C. Davis, and E.R. Cady. The purpose of this paper is to present a compre-