

6-1-2003

Habitat Selection of the Channel Darter, *Percina (Cottogaster) copelandi*, a Surrogate for the Imperiled Pearl Darter, *Percina aurora*

Pamela J. Schofield
University of Southern Mississippi, pschofield@usgs.gov

Stephen T. Ross
University of Southern Mississippi, stephen.ross@usm.edu

Follow this and additional works at: https://aquila.usm.edu/fac_pubs



Part of the [Ecology and Evolutionary Biology Commons](#)

Recommended Citation

Schofield, P. J., Ross, S. T. (2003). Habitat Selection of the Channel Darter, *Percina (Cottogaster) copelandi*, a Surrogate for the Imperiled Pearl Darter, *Percina aurora*. *Journal of Freshwater Ecology*, 18(2), 249-257.

Available at: https://aquila.usm.edu/fac_pubs/8619

This Article is brought to you for free and open access by The Aquila Digital Community. It has been accepted for inclusion in Faculty Publications by an authorized administrator of The Aquila Digital Community. For more information, please contact Joshua.Cromwell@usm.edu.

Habitat Selection of the Channel Darter, *Percina (Cottogaster) copelandi*, a Surrogate for the Imperiled Pearl Darter, *Percina aurora*

Pamela J. Schofield^a and Stephen T. Ross

University of Southern Mississippi

Department of Biological Sciences

Hattiesburg, MS 39406-5018 USA

ABSTRACT

Percina (Cottogaster) aurora is an imperiled species under consideration for listing by the U.S. Fish and Wildlife Service. To better understand habitat use of *P. aurora*, we studied a related and more abundant *Cottogaster* species, *Percina copelandi*, from the Ouachita River, Arkansas. We used a laboratory stream system to examine mesohabitat selection (pools versus riffles) and microhabitat selection (substratum particle size) of *P. copelandi* over three temperature regimes (summer, spring, and winter). *Percina copelandi* selected pool habitats over riffles and selected pools with coarse substrata (e.g., cobble) over fine substrata (e.g., gravel). In riffles, *P. copelandi* selected large substrata during winter and spring but did not show particle size selection during summer. These data, and various published and unpublished field data for *P. aurora*, suggest that habitat use of *P. aurora* is also centered around deep runs and pools, with large substrata likely being more important at low water temperatures.

INTRODUCTION

The pearl darter, *Percina aurora* Suttkus and Thompson 1994, is an imperiled species under consideration for listing by the U. S. Fish and Wildlife Service (D. Drennan, USFWS, Jackson, MS, *pers. comm.*). The pearl darter historically occurred in the Chickasawhay River, Leaf River, and Pascagoula River systems of the Pascagoula River drainage of Mississippi and in the Pearl River and Strong River of the Pearl River drainage of Mississippi and Louisiana (Suttkus et al. 1994). The last collections of pearl darters from the Pearl River were from the early 1970s, and it now appears that populations in the Pearl River drainage may be extirpated (Bart 2000). Possible loss of this species from the Pearl River is attributed to habitat alteration caused by removal of riparian vegetation and extensive cultivation near the river's edge, both resulting in increased sedimentation, and from construction of a series of impoundments (Suttkus et al. 1994, Bart 2000). Populations of the pearl darter still exist in the Pascagoula River drainage (Ross 2001), characterized as the last large (>350 m³/s virgin mean discharge) river in the contiguous United States that does not have an impoundment on its main channel or is otherwise not strongly impacted (Dynesius and Nilsson 1994).

There is a heightened interest in preserving the remaining populations of *P. aurora* due to its imperiled status. However, very little is known about the biology, life history, or habitat use of this species. Because of the rarity of *P. aurora*, we studied habitat selection of a closely related surrogate to delineate potential critical habitats and document the dynamics of habitat use on a

^a Current address: U. S. Geological Survey, 7920 NW 71st Street, Gainesville, FL 32653, U.S.A. E-mail: Pam_Schofield@usgs.gov

seasonal basis. Although the various roles of surrogate species have recently been reviewed (Caro and O'Doherty 1999), we use the term here in the sense of taxonomically-related taxa that likely share similar ecological requirements (Brooks et al. 1992, Mayden and Wood 1995) and where a more common species is used to infer biological information about a less common species (Armstrong 2002).

The subgenus *Cottogaster* includes *Percina aurora*, *P. copelandi*, and *P. brevicauda*. Although populations of all three *Cottogaster* species are experiencing some degree of population decline (Suttkus et al. 1994), *P. aurora* and *P. brevicauda* are the most severely impacted (Warren et al. 1997, 2000). *Percina brevicauda*, the coal darter, is confined to the eastern part of the Mobile basin, Alabama (Suttkus et al. 1994, Mettee et al. 1996). Because of the restricted distribution and limited abundance of coal darters, we were hesitant to make collections of this species for use in the laboratory as a surrogate for the pearl darter. The channel darter, *P. copelandi*, has the widest distribution of all *Cottogaster* species, occurring west of the Mississippi River in the Red River and Arkansas River drainages of Oklahoma, Arkansas, northern Louisiana, south-eastern Kansas, and south-western Missouri. East of the Mississippi River, *P. copelandi* is found in the lower Tennessee River drainage of Kentucky (possibly extirpated) and the upper Tennessee River drainage in Tennessee and Virginia. *Percina copelandi* is also found in the Ohio River drainage, the southern part of the Great Lakes drainage and the lower St. Lawrence River drainage (Gilbert and Burgess 1980, Suttkus et al. 1994). Because it is more widely distributed and has larger population sizes (R. Mayden *pers. comm.*, H. Robison *pers. comm.*), we chose to use *P. copelandi* as a surrogate species for *P. aurora* in our study.

Percina aurora occurs in riffles, runs, and pools over gravel or bedrock substrata in slow to moderate currents. Spawning occurs from late February or March to May (Suttkus et al. 1994, Bart 2000) and during this time pearl darters become more closely associated with riffle habitats. Egress from riffles occurs after spawning. The closely related channel darter spawns in fast-flowing areas of streams over gravel substrata or along shoals in lakes. The channel darter spawns from April to late June in the southern part of its range (Hubbs 1985). Fish leave the margins of streams or shallows of lakes and move into deep water after spawning (Winn 1953, 1958). Although both species appear to move seasonally from deep pools or runs to shallow riffles during spawning, very little is known about habitat selection in either *P. copelandi* or *P. aurora*. We were particularly interested in discovering which habitat attributes are important in selection by these *Cottogaster* species and how these criteria may change on a seasonal basis. Thus, the objectives of this study were to document seasonal variation in mesohabitat (riffles versus pools) and microhabitat (particle size) selection of *P. copelandi*.

METHODS

Field collections and laboratory conditions

We captured *P. copelandi* using seines, rather than electrofishing, to reduce risk of injury or stress. Fish were collected on three occasions (April 1998, March 1999, and June 1999) in the Ouachita River above Lake Ouachita, Montgomery and Pike counties, Arkansas. Fish were transported to the laboratory in Styrofoam coolers with no mortality. In the laboratory, fish

were held in 75-151 l aquaria in an environmental chamber. Water temperature and photoperiod were adjusted to simulate summer, winter, and spring seasons from the collection site in the Ouachita River (summer: 14L:10D, 20-24 °C; winter: 10L:14D, 4-8 °C; spring: 12L:12D, 14-18 °C). We programmed the environmental chamber so that temperature increased from dawn until noon, then decreased until the lights dimmed ("sunset"), with the lowest temperature when all lights were out ("night"). Light and temperature cycles were held constant within each seasonal treatment. Between seasonal treatments, the photoperiod was slowly shifted in 15 min increments every one-two days and temperature was shifted 0.5 °C or less each day. Thus, it took approximately three weeks to complete most seasonal shifts. Fish were fed ad lib., with increased food in the warmer months, and were maintained on a diet of enriched brine shrimp, blood-worms and glass-worms. We used clay pot fragments to provide fish with a substratum in the holding tanks. We suggest that this substratum reduced stress by allowing fish to congregate below or behind pot fragments (versus flat glass bottoms of aquaria) without predisposing them to select any of the substrata used in the habitat selection experiments. We divided fish into groups of 10 for use in both the meso- and microhabitat experiments. Fish averaged 40.8 mm standard length (range = 33 - 52 mm; SD = 3.7). A small group of randomly sampled individuals reflected a roughly equivalent gender ratio (11 females, 7 males).

Particle sizes used in the experiments were based on the Wentworth series as modified by Ross et al. (1990) and included: #6, coarse sand - fine gravel (2-4 mm); #7, medium-coarse gravel (4-8 mm); #8 large gravel (8-16 mm); #9 very large gravel (16-32 mm); #10 pebbles (32-64 mm); and #11 cobble (64-256 mm).

Mesohabitat selection

We used a replicated laboratory stream system modified from Gelwick and Matthews (1993) to determine the effects of season on mesohabitat selection (i.e., riffles versus pools). Three streams were constructed of U. S. Food and Drug Administration approved resins and gelcoats. Temperature was controlled in each stream by a 1 hp Frigid-Unit) chiller placed in the headbox and recorded at the beginning and end of each trial, then averaged. Water flow was provided by 0.25 hp Little Giant) submersible pumps located in the sump. Each stream was configured with three riffles interspersed with three pools. Three particle sizes (#'s 6, 8, and 11) were randomly allocated to each of the three pools and riffles. For each trial, 10 fish were randomly distributed in the stream in the morning, and locations of the fish were recorded at the completion of the trial 8 h later. We terminated each experimental run by shutting off the pumps and quickly dropping plexiglass panels into place at the head and foot of each riffle so that fish would not move between mesohabitats as they were counted.

Before each experimental run, water velocity was tested in each riffle and pool near the water surface with a flow meter (Swoffer Instruments model 2100) and averaged for each trial. We used three sets of current speeds for both meso- and microhabitat experiments (slow, medium, and fast) that were presented in random order. Within each seasonal treatment, each group of fish was tested once at each current speed. However, because fish could not swim against faster speeds under winter conditions, winter treatments only included slow and medium speeds.

Microhabitat selection

We used a flume described by Ross et al. (1992) to test for particle size selection in riffles. The flume was subdivided into six sub-plots. For each experimental trial, plots of six substratum sizes (#'s 6 – 11) were randomly assigned to the flume. Temperature was controlled in the flume by a 1 hp Frigid-Unit) chiller placed in the headbox and recorded at the beginning and end of each trial, then averaged. The experimental design used the same water temperatures (winter, spring, and summer) as mesohabitat experiments. Water flow was provided by 0.25 hp Little Giant) submersible pumps located in the sump. Water temperature was recorded at the beginning and end of each trial and then averaged. Water velocity was recorded before each trial in each experimental plot with a velocity meter (Swoffer Instruments model 2100) and averaged across plots. We used three current speeds (slow, medium and fast) that were presented in random order within each season. These current speeds were the same as the ones used in the mesohabitat experiments. Our goal was to test each group of fish once at each current speed. However, because fish could not swim against the medium and fast speeds under winter conditions, winter treatments only included the slow speed.

For each trial, 10 fish were randomly distributed in the stream in the morning and locations of the fish were recorded at the completion of the trial 8 h later by turning off the flow and dropping plexiglass panels to isolate each of the six substrata.

Statistical design and analysis

In both meso- and microhabitat experiments we felt it was important not to randomize the “season” treatment and thus conducted each season’s round of experiments sequentially. In addition, our data represent two separate years, with different fish used in each year. However, by conducting the experiment in this fashion and by re-testing the same groups of fish several times, we were statistically constrained with respect to inferential statistics. In essence, we have potentially confounded the seasonal effect with the effect of length of time in captivity, and thus our samples across seasons were not independent (Hurlbert 1984). Because of this we refrained from making statistical comparisons across seasons.

Table 1. Experimental groups (each of 10 *Percina copelandi*) and the number of times each group was tested under the three temperature regimes in the mesohabitat and microhabitat streams.

Group	Summer		Winter		Spring		Total
	Mesohabitat	Microhabitat	Mesohabitat	Microhabitat	Mesohabitat	Microhabitat	
A	3	1	2				
B	1	1		1			
C	2	1					
D	2	1					
E			2		1		
F			2	1	3	1	
G		1	2	1	3	1	
H	3		2	1	3	3	
I			2	1	3	2	
J				1		3	
Total	11	5	12	6	13	10	57

One-way analysis of variance (ANOVA) was used to test for differences in temperatures and flow rates of the laboratory stream systems across seasons. Before using ANOVA, we insured that all distributions satisfied the parametric assumptions of homogeneity of variances and normality. When ANOVA was significant, we used the Student-Newman-Keuls post-hoc test when variances were homogeneous and the Dunnett's T3 test when variances did not meet the assumption of homogeneity. Data were analyzed with SPSS) for Windows, version 10.0. Frequency distributions of fish across substrata within seasons were tested against the null hypothesis that fish were distributed independently of substratum type using a χ^2 test (Brower et al. 1998).

RESULTS

Mesohabitat selection

We completed 36 experimental trials in the laboratory stream system (Table 1). Mean water depths (cm) were 10.4 ± 1.10 SD for riffles and 48.4 ± 2.70 SD for pools (all trials combined). Mean water temperatures ($^{\circ}$ C) were: summer 22.4 ± 1.11 SD; winter 9.2 ± 1.91 SD; spring 15.1 ± 2.51 SD. Temperatures differed significantly across the seasonal treatments (one-way ANOVA, $F = 129.1$, $df = 2$, $P < 0.001$), and post-hoc analysis with Student-Newman-Keuls test revealed significant differences ($P < 0.05$) for all comparisons. Henceforth, seasonal treatments are referred to simply as summer, winter, or spring.

Averages of the three current speeds were as follows: slow = 5.3 ± 1.1 SD, medium = 17.4 ± 2.9 SD, and fast = 29.9 ± 2.8 SD cm/s. Current speeds (cm/s) used in seasonal treatments were: summer 16.1 ± 11.0 SD, spring 19.5 ± 11.0 SD, and winter 11.1 ± 6.8 SD (the fast current speed was omitted). However, even with this reduction in winter current speeds, flow rates did not differ significantly by season (ANOVA, $F = 2.1$, $df = 2$, $P = 0.133$). Preliminary analysis showed no effect of current speed on meso- or microhabitat selection (Schofield and Ross, unpublished); consequently, data from all current speeds were combined for seasonal analysis.

Fish selected pools over riffles within each season (Figure 1). *Percina copelandi* selected coarse substrata (i.e., cobble) more often than fine substrata (Figure 2; summer $\chi^2 = 6.7$, $P < 0.05$; winter $\chi^2 = 14.0$, $P < 0.01$; spring $\chi^2 = 24.7$, $P < 0.01$).

Microhabitat selection

We completed 21 experimental trials in the riffle-like flume (Table 1). Mean water depth (cm) was 5.4 ± 1.03 SD for the flume (all trials combined). Mean water temperatures ($^{\circ}$ C) were: summer 21.5 ± 0.31 SD; winter 8.0 ± 1.02 SD; spring 14.5 ± 0.82 SD. Temperatures differed significantly across seasons (ANOVA, $F = 385.4$, $df = 2$, $P < 0.001$) and post-hoc analysis with Dunnett's T3 test revealed significant differences ($P < 0.0001$) for all comparisons. Mean current speeds (cm/s) were: summer 15.2 ± 5.7 SD; spring 20.1 ± 11.2 SD; winter 6.5 ± 1.8 SD and current speeds differed among seasons (ANOVA, $F = 5.7$, $df = 2$, $P < 0.05$).

Percina copelandi used the two largest substrata (sizes 10 and 11) in spring and winter (Figure 3; winter $\chi^2 = 61.2$, $df = 5$, $P < 0.01$; spring $\chi^2 = 37.5$, $df = 5$, $P < 0.01$). In summer, fish showed increased use of smaller substrata (sizes 6 through 9) and their distribution in the stream was independent of substratum size ($\chi^2 = 7.6$, $df = 5$, $P > 0.05$).

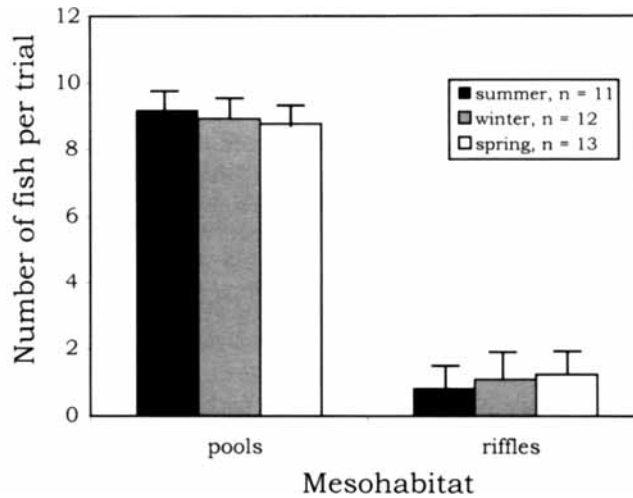


Figure 1. Mean (\pm 95% CI) number of *Percina copelandi* per trial that selected pools or riffles in three seasons (summer, winter, spring).

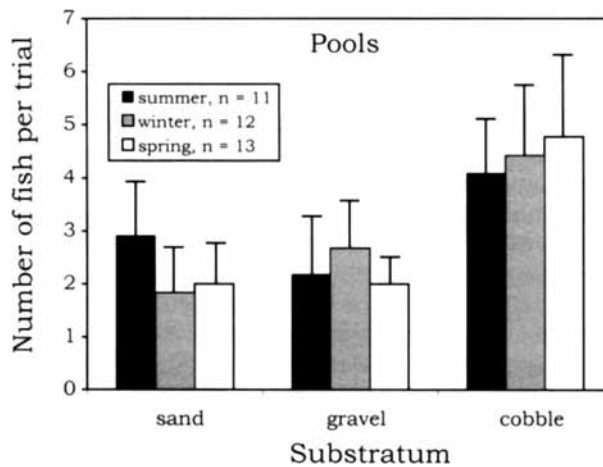


Figure 2. Mean (\pm 95% CI) number of *Percina copelandi* per trial that selected sand, gravel, or cobble in pool habitats.

DISCUSSION

The mesohabitat experiments showed that *P. copelandi* selected pools in all three seasons. Although *P. copelandi* is known to spawn in riffle habitats in the spring (Winn 1953,1958, Suttkus et al. 1994), we were unable to detect a spring shift to riffle habitats. However, we did observe that fish in our mesohabitat stream system often perched along riffle edges adjacent to the drop-off near a pool and that this behavior seemed more prevalent in the spring. The lack of a spring shift to riffles could have been due to an artifact of our experimental system (i.e., the fish may have moved from riffles to pools as the plexiglass partitions were being lowered to isolate them in specific mesohabitats), or because the fish were not in suitable spawning condition due to being held under laboratory conditions.

In the microhabitat experiments, the distribution of *Percina copelandi* was independent of substratum size in the summer but not in winter or spring when larger sizes were selected. We suggest that a threshold particle size exists that offers an adequate bioenergetic refuge for *P. copelandi*. During warmer temperatures, the fish are apparently capable of swimming fast enough to compensate for current speed without relying on large particles as refugia. However, in cold water, their swimming efficiency may be reduced and they may become dependent on large particles as refuge from the current flow. Ross et al. (1992) reached a similar conclusion for *Etheostoma rubrum*.

Based on our work with *P. copelandi*, combined with unpublished and published field observations for *P. aurora* (summarized in Suttkus et al. 1994), we infer that habitat use of *P. aurora* is also centered around deep runs and pools, with large substrata being more important at low water temperatures. Although cobble is not common in the Pascagoula River drainage, other large substrata such as woody debris and large gravel may provide winter refugia. This pattern of habitat use by *P. aurora* is further supported by ongoing field studies (Slack et al. 2002).

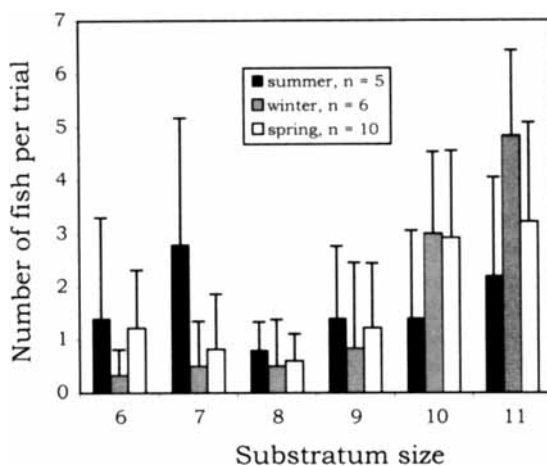


Figure 3. Mean (\pm 95% CI) number of *Percina copelandi* per trial that selected each substratum size (6 through 11) in the microhabitat flume in summer, spring, and winter.

ACKNOWLEDGEMENTS

We thank Nick Ansay, Ryan J. Heise, W. Todd Slack and Austin Trousdale for assistance in the field. Tommy Rauch and Martin T. O'Connell assisted in the laboratory. Steve Walsh kindly reviewed an earlier version of the manuscript. Field work in Arkansas was authorized under permit #1364 and #13645 issued by the Arkansas Game and Fish Commission and field work in Mississippi was authorized by a freshwater collecting permit issued by the Mississippi Department of Wildlife, Fisheries, and Parks. Experimental protocols were approved by the University of Southern Mississippi Institutional Animal Care and Use Committee, protocol approval number 150-097.

LITERATURE CITED

- Armstrong, D. 2002. Focal and surrogate species: getting the language right. *Cons. Biol.* 16:285-286.
- Bart, H. L. 2000. Anatomy of an extinction: extirpation of the pearl darter *Percina aurora* from the Pearl River system. *Assoc. Southeast. Biol. Bull.* 47:218.
- Brooks, D. R., R. L. Mayden, and D. A. McLennan. 1992. Phylogeny and biodiversity: conserving our evolutionary legacy. *Trends Ecol. Evol.* 7:55-59.
- Brower, J. E., J. H. Zar, and C. N. von Ende. 1998. Field and laboratory methods for general ecology, 4th edition. McGraw—Hill, Boston, MA. 273 p.
- Caro, T. M. and G. O'Doherty. 1999. On the use of surrogate species in conservation biology. *Cons. Biol.* 13:805-814.
- Dynesius, M. and C. Nilsson. 1994. Fragmentation and flow regulation of river systems in the northern third of the world. *Science* 266:753-762.
- Gelwick, F. P. and W. J. Matthews. 1993. Artificial streams for studies of fish ecology. *J. North Amer. Benthol. Soc.* 12:343-347.
- Gilbert, C. R. and G. H. Burgess. 1980. *Percina copelandi* (Jordan), channel darter. p. 721. *In: Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister and J.R. Stauffer, Jr. 1980. et seq. Atlas of North American Freshwater Fishes.* North Carolina State Museum of Natural History, Raleigh, NC.
- Hubbs, C. 1985. Darter reproductive seasons. *Copeia* 1985:56-68.
- Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecol. Mono.* 54:187-211.
- Mayden, R. L. and R. M. Wood. 1995. Systematics, species concepts, and the evolutionary significant unit in biodiversity and conservation biology. *Amer. Fish. Soc. Symp.* 17:58-113.
- Mettee, M. F., P. E. O'Neil, and J. M. Pierson. 1996. Fishes of Alabama and the Mobile Basin. Oxmoor House, Birmingham, AL. 870 p.
- Ross, S. T. 2001. Inland fishes of Mississippi. Univ. Press of Mississippi, Jackson. 624 p.
- Ross, S. T., J. G. Knight, and S. D. Wilkins. 1990. Longitudinal occurrence of the bayou darter (Percidae: *Etheostoma rubrum*) in Bayou Pierre – a response to stream order or habitat availability? *Pol. Arch. Hydrobiol.* 37:221-233.
- Ross, S. T., J. G. Knight, and S.D. Wilkins. 1992. Distribution and microhabitat dynamics of the threatened Bayou Darter, *Etheostoma rubrum*. *Copeia* 1992:658-671.
- Slack, W. T., R. J. Heise, M. A. Dugo, M. F. Cashner, and S. T. Ross. 2002. Status of the Pearl darter (Percidae: *Percina aurora*) in the Pascagoula drainage, Mississippi, p. 276. *In: Program book and abstracts, Joint meeting of ichthyologists and herpetologists, July 3—8, 2002.* Kansas City, MO.
- Suttkus, R. D., B. A. Thompson, and H. L. Bart. 1994. Two new darters, *Percina (Cottogaster)*, from the southeastern United States, with a review of the subgenus. *Occas. Pap. Tulane Mus. Nat. Hist.* 4:1-46.
- Warren, M. L., Jr., P. L. Angermeier, B. M. Burr, and W. R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in

- the Southeastern United States, p. 105-164. *In*: G.W. Benz and D.E. Collins (eds.). Aquatic fauna in peril: the southeastern perspective. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, GA.
- Warren, M. L., Jr., B. M. Burr, S. J. Walsh, H. L. Bart, Jr., R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross, and W. C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. *Fisheries* 25:7-31.
- Winn, H. E. 1953. Breeding habits of the percid fish *Hadropterus copelandi* in Michigan. *Copeia* 1953:26-30.
- Winn, H. E. 1958. Comparative reproductive behavior and ecology of fourteen species of darters (Pisces – Percidae). *Ecol. Mono.* 28:155-191.