Volume 1
Number 37 *Number 37 (July 1998)*

Article 1

7-1-1998

# Number 37 (July 1998)

Southern Fishes Council

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### Abstract

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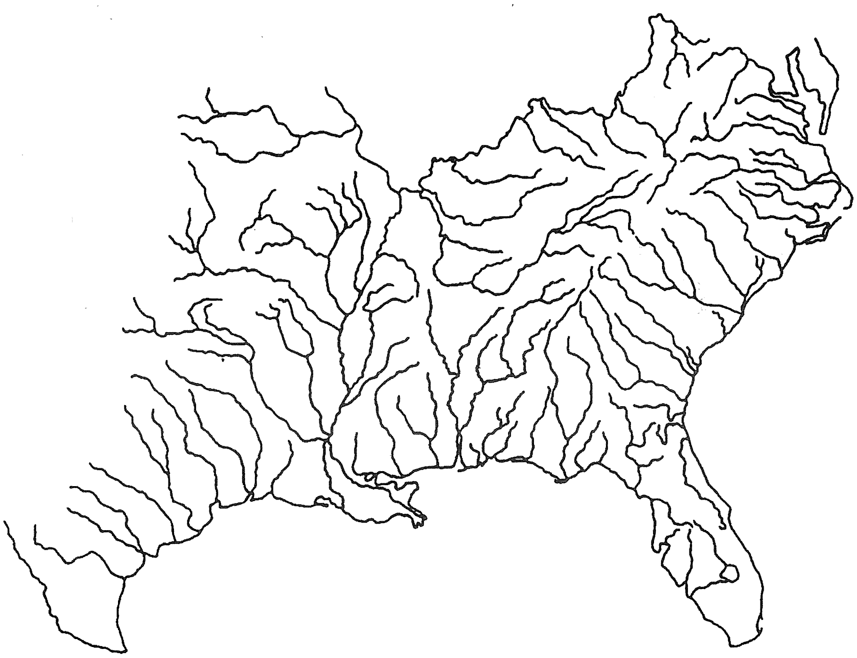
### Keywords

ironcolor shiner, notropis chalybaeus, menidia beryllina, m. peninsulae, perdido bay

Number 37 July 1998

# Southeastern Fishes Council Proceedings

DEDICATED TO THE CONSERVATION OF SOUTHEASTERN FISHES



## Contents

# Status of the Ironcolor Shiner, *Notropis chalybaeus*, in Mississippi

BRETT ALBANESE[1] AND WILLIAM T. SLACK
*University of Southern Mississippi*
*Department of Biological Sciences*
*Southern Station Box 5018*
*Hattiesburg, Mississippi 39406-5018*

## ABSTRACT

*Notropis chalybaeus* in Mississippi is known from only 20 collections taken from 15 different localities. Prior to the onset of this study, *N. chalybaeus* had not been collected in the state since 1984. During 1995-1996, we sampled 11 of the 14 historic sites and an additional 13 localities in close proximity to historic sites. Overall, we collected 5503 fishes comprising 62 taxa and 14 families. *Notropis chalybaeus* was not taken at any of these sites. However, three specimens of *N. chalybaeus* were collected from a new locality in the Escatawpa River in June 1996 (Ross and Rauch, 1996). A variety of factors may account for the rarity of *N. chalybaeus* in Mississippi. This species may be naturally uncommon in Mississippi and habitat degradation may be driving these small populations to extinction. We recommend a more thorough survey of *N. chalybaeus* be undertaken. Conservation efforts should target the Wolf and Escatawpa River systems because of the potential for multiple extant populations and relatively high habitat quality.

## INTRODUCTION

The ironcolor shiner, *Notropis chalybaeus,* occurs in low gradient coastal streams along the Atlantic Coast from the Hudson Drainage, New York, to tributaries of Lake Okeechobee, Florida; and along the Gulf Coast from the Chipola River, Florida, to the Sabine River Drainage, Texas. In addition, it occurs in Mississippi River tributaries in Texas, Oklahoma, Louisiana, Arkansas, Iowa and Indiana. Disjunct populations are reported from the San Marcos River, Texas and in Great Lakes drainages of Indiana, Michigan and Wisconsin (Fig. 1; Lee et al., 1980). *Notropis chalybaeus* has been taken from a wide variety of habitats, but most studies cite typical habitat as being small to moderate sized, sluggish, tea-stained streams with aquatic vegetation and heavily wooded riparian areas (Marshall, 1947; Robison, 1977; Jenkins and Burkhead, 1993). Considering its broad distribution, the biology of this species is poorly understood. The most detailed study found that *N. chalybaeus* in central Florida usually occupied pools, probably bred from April to September, and fed on aquatic insects, algae and detritus (Marshall, 1947). *Notropis chalybaeus* lives approximately two years (Jenkins and Burkhead, 1993; Becker, 1983).

The status of *N. chalybaeus* varies widely across its range. While common in certain parts of New York (Smith, 1985), it is apparently extirpated from Pennsylvania (Cooper, 1983). Jenkins and Burkhead (1993) described *N. chalybaeus* as generally rare and uncommon in Virginia. In North Carolina, *N. chalybaeus* is uncommon (pers. comm., F. Rhode, North Carolina Department of Environment, Health, and Natural Resources; W. Palmer, North Carolina Museum of Natural Sciences) and has been recognized by the North Carolina Department of Environmental Management as intolerant to stream degradation (Eagelson, 1995). However, this species appears to be relatively common in South Carolina, Georgia and Florida (pers. comm., J. Crane, South Carolina Department of Natural Resources; L. Hartle, University of Georgia Museum of Natural History; C. Gilbert, Florida Museum of Natural History). Robison (1977) regarded *N. chalybaeus* as uncommon in Arkansas and endangered in Oklahoma (Robison, 1974). *Notropis chalybaeus* was locally abundant, but geographically restricted in Missouri (Pflieger, 1975). Becker (1983) described *N. chalybaeus* as rare in Michigan and probably extirpated from Iowa and Wisconsin. Smith (1979) placed Illinois populations of *N. chalybaeus* in a category of "rare" or "extremely restricted" species. Ironcolor shiners are very rare in Alabama and Louisiana (pers. comm., S. Mettee, Alabama Geological Survey; N. Douglas, Northeast Louisiana University Museum of Ichthyology). Of the 296 specimens documented from Alabama, only one has been collected within this decade and the majority of collections predate 1980. Neil Douglas (pers. comm.) reports that *N. chalybaeus* is infrequently collected and never taken in great numbers within Louisiana.

In Mississippi, *N. chalybaeus* is known from only 20 collections taken from 15 different localities (Ross and Brenneman, 1991; Ross, in press.). Prior to the onset of this study, ironcolor shiners had not been collected in the state since 1984. Despite its apparent rarity in Mississippi, it is not listed as a threatened or endangered taxon (Mississippi Department of Wildlife, Fisheries, and Parks, 1994), nor has it been targeted as a species meriting distributional research. To better understand the conservation status of this species, we conducted a survey of historic localities in Mississippi. Herein we present information on the status of *N. chalybaeus* and make recommendations for future management.

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[1]Present address: Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, Virginia 24061-0321.
email: albanese@vt.edu

## METHODS

We identified historic localities of *N. chalybaeus* in Mississippi by searching the Fishes of Mississippi database (> 90,000 records). This database contains records from numerous regional ichthyological collections dating back to the mid 1800's (Ross and Brenneman, 1991; Ross, in press), but contains relatively few records from these institutions made beyond the late 1980's. We contacted the following museum curators and regional ichthyologists to make sure there were no recent records of *N. chalybaeus* from Mississippi: H. Bart (Tulane), S. Mettee, C. Knight (Mississippi Museum of Natural Sciences), L. Hartle and N. Douglas.

Surveying of historic sites began in March, 1995 and continued until August, 1996. In some cases, we made collections up and downstream of historic sites and in nearby streams that might have contained unknown populations of *N. chalybaeus*. Several sites were sampled more than once, usually when we felt that seasonal influences may have biased our initial efforts. Collections were typically made with a 1.8 x 3.1 m x 3.2 mm Ace mesh seine, but we also used a 1.8 x 6.2 m x 3.2 mm Ace mesh bag seine and a dipnet where appropriate. Our goal at each site was to collect as many species as possible. Accordingly, we sampled all available microhabitats until no new taxa were collected with additional effort. The active time spent seining was recorded for each site. We also documented any noticeable signs of habitat degradation. All specimens were anesthetized in MS-222, fixed in 10% formalin, identified, preserved in 45% isopropyl, and curated into the USM Museum.

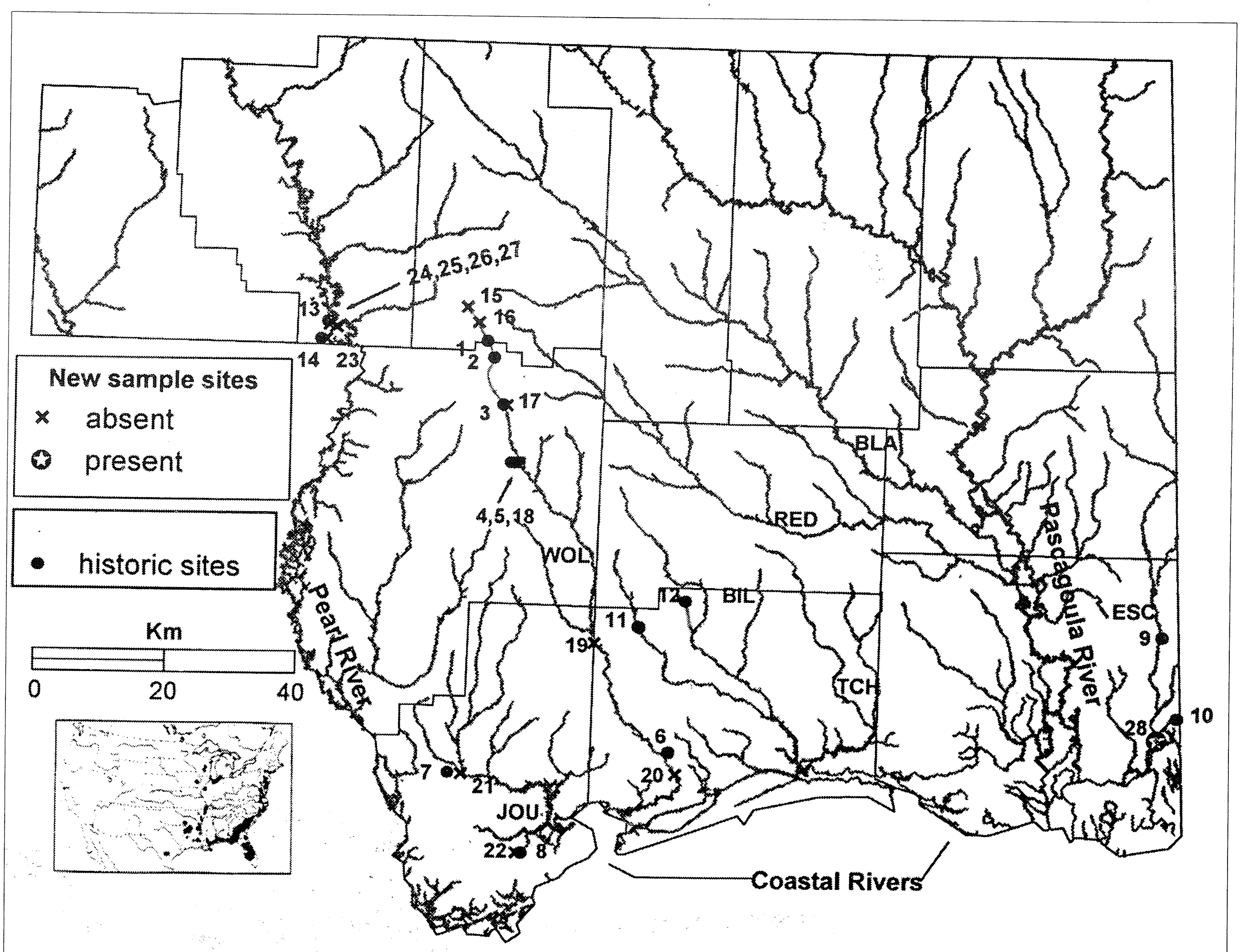


**Figure 1.** Historic (Sites 1-14) and new (Sites 15-28) collection sites for *Notropis chalybaeus* in Mississippi and the overall distribution of this species in North America (inset). Historic sites were identified by searching the Fishes of Mississippi database (Ross and Brenneman, 1991; Ross, in press) and represent collections made between 1950 and 1984. Most historic and all new sites were sampled during 1995-1996. Major drainages are labeled. Systems are abbreviated as follows: JOU = Jourdan River, WOL = Wolf River, BIL = Biloxi River, TCH = Tchoutacabouffa River, ESC = Escatawpa River, RED = Red Creek, and BLA = Black Creek. Inset adopted from Jenkins and Burkhead (1993).

**Table 1.** Historic collection records for *Notropis chalybaeus* in Mississippi. Data are from the Fishes of Mississippi database (Ross and Brenneman, 1991; Ross, in press.). Localities marked with an asterisk are uncertain and have been approximated from field notes. Abbreviations are as follows: TU=Tulane, UAIC=University of Alabama Ichthyology Collection, MMNS=Mississippi Museum of Natural Sciences and UFSU=Florida State University. See text for details.

| Site | System | Waterbody | Exact Locality | Date | Number Collected | Museum Number |
|---|---|---|---|---|---|---|
| 1 | Wolf River | Wolf Creek | at Olive Branch Rd. | 7/1/1984 | 7 | TU 136637 |
| 2 | Wolf River | Wolf Creek | at Bass Rd. | 7/1/1984 | 7 | TU 136623 |
| 3 | Wolf River | Wolf Creek | at Hillsdale Rd. | 7/1/1984 | 1 | TU 136598 |
| 4 | Wolf River | Wolf River | at Hwy. 59 | 4/18/1970 | 2 | TU 65644 |
| 4 | Wolf River | Wolf River | at Hwy. 59 | 7/3/1980 | 9 | TU 129713 |
| 5 | Wolf River | Wolf River | at Hwy 26 Crossing* | 10/24/1969 | 1 | TU 59469 |
| 6 | Wolf River | Big Creek | at Wolf River Rd. | 7/1/1965 | 4 | UAIC 1722.02 |
| 7 | Jourdan River | Wolf Branch | 4.5 mi. E. of Santa Rosa* | 5/31/1952 | 45 | TU 4852 |
| 8 | Jourdan River | Bayou Philip | at Hwy. 90 | 2/22/1952 | 41 | TU 8007 |
| 8 | Jourdan River | Bayou Philip | at Hwy. 90 | 3/9/1953 | 15 | TU 7660 |
| 8 | Jourdan River | Bayou Philip | at Hwy. 90 | 11/8/1951 | 64 | TU 4760 |
| 8 | Jourdan River | Bayou Philip | at Hwy. 90 | 5/18/1952 | 90 | TU 4524 |
| 9 | Escatawpa River | Escatawpa River | at Hwy. 614. | 5/11/1983 | 8 | MMNS 11902 |
| 10 | Escatawpa River | Jackson Creek | at Forts Lake Rd. | 4/28/1966 | 3 | UFSU 13356 |
| 11 | Biloxi River | Little Biloxi River | at McHenry Rd. | 7/1/1965 | 8 | UAIC 1720.01 |
| 11 | Biloxi River | Little Biloxi River | at McHenry Rd. | 10/26/1984 | 5 | TU 138336 |
| 12 | Biloxi River | Hickory Creek | at McHenry Rd. | 7/21/1965 | 2 | UAIC 1736.01 |
| 13 | Pearl River | Harts Swamp, unnamed tributary | at Hart's Rd * | 5/14/1962 | 48 | TU 25786 |
| 14 | Pearl River | Rankin Creek, unnamed tributary | at Hwy. 35 | 10/28/1950 | 1 | TU 70 |
| | | | | TOTAL: | 361 | |

**Table 2.** Summary of *Notropis chalybaeus* collections and recent sampling effort by river system. The number of recent sites sampled exceeds the number of historical sites because we sampled additional localities near historical sites. Several sites were sampled more than once. Effort represents the amount of time spent seining with a 1.8m x 3.1m x 3.2mm Ace mesh seine.

| System | Number Collected | Historical Sites | Recent Sites | Recent Samples | Effort (min) |
|---|---|---|---|---|---|
| Wolf | 31 | 6 | 11 | 15 | 1010 |
| Jourdan | 255 | 2 | 3 | 4 | 375 |
| Escatawpa | 11 | 2 | 2 | 4 | 415 |
| Biloxi | 15 | 2 | 2 | 3 | 300 |
| Pearl | 49 | 2 | 6 | 6 | 500 |
| TOTALS | 361 | 14 | 24 | 32 | 2600 |

## RESULTS

Historic collection records of *N. chalybaeus* in Mississippi are confined to blackwater streams of the southeastern part of the state (Fig. 1). The majority of collections and specimens are from small river systems within the Coastal Rivers Drainage (Table 1). Specific localities are not characterized by one particular habitat type. For example, only three of the localities (Sites 12, 13 and 14) are currently characterized by abundant aquatic vegetation. Some of the sites occur within or are surrounded by open swamp habitat (Sites 3, 8, 9, 13), while others drain densely canopied woodlands. *Notropis chalybaeus* is not specific to a particular stream size, having been collected in first, second, third, fourth and fifth order streams.

Thirteen of the 19 historic collections predate 1980. The Jourdan River System is notable for the great number of *N. chalybaeus* collected there during the 1950's (Table 2). Most of these specimens were collected from one site on Bayou Philip. The greatest number of collection sites occurs within the Wolf River System; however, these collections represent very few specimens. Until the onset of this study, the most recent collection of *N. chalybaeus* was made in the Biloxi River

System.

We sampled 11 of the 14 original historic sites. We could not get permission to sample Site 6 (Big Creek), and could not precisely locate Site 7 (Wolf Branch) or Site 13 (unnamed). An additional 13 sites in close proximity to historic sites were also sampled. A total of 32 collections were made and over 43 hours were spent actively seining (Table 2).

We collected 5503 fishes comprising 62 taxa and 14 families[2]. No *N. chalybaeus* were taken at any of the sites. Considering all sites, *Lythrurus roseipinnis*, *Cyprinella venusta*, *Labidesthes sicculus*, *Pteronotropis signipinnis*, *Percina nigrofasciata* and *Fundulus olivaceus* were numerically dominant. Including only the historic sites, *L. roseipinnis*, *C. venusta*, *F. olivaceus*, *L. sicculus*, *P. nigrofasciata* and *Notropis texanus* were numerically dominant. The most diverse assemblages were taken in the Wolf River System at Sites 4 (26 species), 5 (23 species), and 3 (21 species).

Deteriorating habitat quality was apparent at four of the historic sites. Site 8 (Bayou Philip) appears to have been channelized downstream of the bridge over Hwy 90. Its channel was straight with very little variation in depth and practically no instream habitat structure (i.e., snags). The Army Corps of Engineers has no documentation of a channel modification project within Bayou Philip, so we cannot be certain when this disturbance occurred (pers. comm., Doug Nestor, Mobile District). We also observed the construction of a new drainage ditch that was being linked to the main channel approximately 200 m upstream of the bridge on Hwy 90. Little erosion control had been taken and this may account for the high turbidity we observed (relative to other historic sites). *Notemigonus crysoleucas* was the only cyprinid collected at this site. Site 6 (Big Creek) was also severely degraded. Upstream of the historic locality, many of the headwater tributaries had been ditched and flow was frequently diverted to fill a series of impoundments. Riparian areas both upstream and at the historic site consisted primarily of pasture land. Compared to other low order streams in the Wolf River System, Big Creek was excessively turbid. Unfortunately, we have no recent data on the fish fauna for this site. Sites 1 and 2 on Wolf Creek were dry or drying up two of the three times we observed them. We are uncertain whether this desiccation is related to changes in landuse or part of the natural variation in stream discharge. Considering the highly diverse assemblage of fishes downstream of this site, we feel that drought conditions accounted for the low diversity of fishes collected at these sites.

*Notropis chalybaeus* was collected from a new locality in Mississippi on June 27, 1996 (Ross and Rauch, 1996). Three specimens were taken in a backwater area off the mainstem of the Escatawpa River. The habitat was characterized by dense aquatic vegetation, low flow and moderate depth (about 1m). This locality represents the first reported collection of *N. chalybaeus* in Mississippi from a sixth order stream.

## DISCUSSION

Rarity

Because the apparent decline of *N. chalybaeus* in Mississippi has largely gone undocumented, it is difficult to understand the causes of its rarity. Herein we speculate on what factors may be responsible. This species may be naturally uncommon in Mississippi and habitat degradation may be driving local populations to extinction. Some evidence suggests that interactions with *N. texanus* may be an additional factor.

Rarity is a natural feature of stream fish assemblages (Sheldon, 1987). Most communities are characterized by a few extremely abundant species, many species intermediate in number, and a few rare species (Brower et al., 1989). Meffe and Carroll (1994) delineated types of rarity based upon geographic range, habitat specificity and local population size. Obviously, *N. chalybaeus* is not geographically rare. It may exist as a rare species in Mississippi because of the rarity of some particular habitat type, but this cannot be the only factor given the variety of habitats it has been taken from in the state.

Rarity in *N. chalybaeus* may be related to inherent features of its population structure. In other words, this species may be adapted to persist at relatively low population densities. Indirect evidence for this type of rarity comes from the small sample sizes of *N. chalybaeus* taken from Mississippi and other states and the testimonials from many aquatic biologists that *N. chalybaeus* is usually not taken in large numbers (but see Introduction for exceptions). If this is an accurate assessment of the population structure of this species, then there are important implications for conservation. When species exist at low densities, extinction can only be prevented when sufficient recruitment from other areas is possible (Sheldon, 1987). Thus, populations of *N. chalybaeus* may be especially vulnerable in fragmented river networks or systems containing a small number of populations. In accordance with this idea, the Wolf River population (if it still exists) of *N. chalybaeus* should be least vulnerable to extinction because of the relatively large number of collection sites within this system. Individuals at any one site could be an important source of colonists for areas where *N. chalybaeus* has been locally extirpated. If undiscovered populations exist in the Escatawpa River, then this system could also provide a stronghold for *N. chalybaeus* in Mississippi.

In addition to its natural rarity, *N. chalybaeus* is intolerant of habitat degradation (Eagelson, 1995; Cooper, 1983). Small population sizes undoubtedly predispose *N. chalybaeus* to extirpation when habitat is degraded, but other ecological characteristics of this species may also make it vulnerable. Angermeier (1995) compared the characteristics of Virginia's extirpated and non-extirpated species, and predicted that *N. chalybaeus* is especially vulnerable to imperilment because of the characteristics it shares with extirpated species. The

[2]Appendices containing detailed locality information and species abundance at historical and recent sites are available by request from Brett Albanese.

absence of *N. chalybaeus* from Bayou Philip may be related to its intolerance of habitat degradation. Although less extreme, poor land management practices near other localities may have also played a role in declines or extirpations.

Robison and Buchanan (1988) described the distribution of *N. chalybaeus* in Arkansas as complementary to the weed shiner, *N. texanus*. They suggested that competition or differences in tolerance to degradation may account for this peculiar distribution. In Mississippi, *N. texanus* ranked sixth in abundance and was found at 9 of the 11 historic sites sampled. Is it possible that *N. texanus* has replaced *N. chalybaeus* at some of these sites? The fact that *N. texanus* and *N. chalybaeus* are closely related species (Amemiya et al., 1992) raises the plausibility of strong competitive effects. It is also possible that the existence of *N. texanus* at historic localities reflects differences in the tolerances of these two species to stream degradation, further supporting the idea that *N. chalybaeus* is an intolerant species. Unfortunately, we know very little about the interactions between these species, and these ideas remain untested. It is also intriguing that some authors report *N. chalybaeus* and *N. texanus* as commonly co-occurring species (Smith, 1979; Page and Burr, 1991).

Conservation

While the future of *Notropis chalybaeus* in Mississippi appears bleak, there are many things that can be done to improve its chances for persistence. We give the following recommendations:

1. *Notropis chalybaeus* should be listed by the Department of Wildlife, Fisheries, and Parks as an imperiled species (S2). This status should provide the impetus to conduct further research on this species.
2. A more thorough survey of *N. chalybaeus* should be completed. In the interest of limited conservation resources, the next survey should focus on, but not be limited to, the Escatawpa and Wolf River systems. This survey should attempt to identify new localities and prioritize them for further conservation.
3. The only known extant population of *N. chalybaeus* in Mississippi should be protected from habitat degradation in the Escatawpa river, floodplain, and local watershed. Establishing a riparian buffer zone will protect instream habitat and water quality. New development in the local watershed should follow best management practices.
4. The status of *N. chalybaeus* in other states, particularly Alabama and Louisiana, should be investigated.

## ACKNOWLEDGMENTS

We appreciate the efforts of all those who assisted with the project. Steve Ross and Martin O'Connell provided meaningful suggestions for improving this manuscript. Steve Ross also assisted with the production of the distribution map and provided access to the Fishes of Mississippi database. Hank Bart verified the *N. chalybaeus* deposited at Tulane. Rick Mayden verified the *N. chalybaeus* deposited at the University of Alabama. John Crane, Neil Douglas, Carter Gilbert, Lee Hartle, Bob Jenkins, Scott Mettee, Bill Palmer, Fred Rhode, Royal Suttkus and Wayne Starnes shared information on the distribution and abundance of *N. chalybaeus* throughout the Southeast.

## LITERATURE CITED

Amemiya, C.T., P.K. Powers and J.R. Gold. 1992. Chromosomal evolution in North American cyprinids, p. 515-533. *In*: Systematics, historical ecology, and North American freshwater fishes, R.L. Mayden (ed.). Stanford University Press, Stanford, California.

Angermeier, P.L. 1995. Ecological attributes of extinction prone species: loss of freshwater fishes of Virginia. Conservation Biology 9:143-158.

Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison, Wisconsin. 1052 pp.

Brower, J.E., J.H. Zar and C.N. von Ende. 1989. Field and laboratory methods for general ecology. 3rd. ed. Wm. C. Brown Publishers. Dubuque, Indiana. 237 pp.

Cooper, E.L. 1983. Fishes of Pennsylvania and the Northeastern United States. The Pennsylvania State University Press, University Park, Pennsylvania. 243 pp.

Eagleson, K.W. 1995. Standard operating procedures for biological monitoring. Biological Assessment Group, North Carolina Department of Environmental Management.

Jenkins, R.E. and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland. 1079 pp.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister and J.R. Stauffer. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, N.C. 867 pp.

Marshall, N. 1947. Studies on the life history and ecology of *Notropis chalybaeus* (Cope). Journal of Florida Academy of Sciences 9:163-188.

Meffe, G.K. and C.R. Carroll. 1994. Principles of conservation biology. Sinauer Associates, Inc., Sunderland, Massachusetts. 600 pp.

Mississippi Department of Wildlife, Fisheries, and Parks. 1994. Official state list of endangered species. Public notice 3357.

Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Co., Boston, Massachusetts. 432 pp.

Pflieger, W.L. 1975. The Fishes of Missouri. Missouri Department of Conservation. 343 pp.

Robison, H.W. 1974. Threatened fishes of Arkansas. Proceedings of the Arkansas Academy of Science 28:59-63.

Robison, H.W. 1977. Distribution, habitat notes, and status of the ironcolor shiner, *Notropis chalybaeus* Cope, in Arkansas. Proceedings of the Arkansas Academy of Science 31:92-94.

Robison, H.W. and T.M. Buchanan. 1988. Fishes of Arkansas. The University of Arkansas Press, Fayetteville, Arkansas. 536 pp.

Ross, S.T. In press: The Inland Fishes of Mississippi. University Press of Mississippi, Jackson.

Ross, S.T. and W.M. Brenneman. 1991. Distribution of freshwater fishes in Mississippi, Completion Report Project F-69. U.S. Fish and Wildlife Service and Mississippi Department of Wildlife, Fisheries, and Parks.

Ross, S.T. and T. Rauch. 1996. Survey for the pygmy killifish, *Leptolucania ommata* (Jordan) (Teleostei: Fundulidae). Final report submitted to Mississippi Wildlife Heritage Fund, Research Grant Program, Miss. Mus. Nat. Sci., Jackson.

Sheldon, A.L. 1987. Rarity: Patterns and consequences for stream fishes, p. 203-209. *In*: W.J. Matthews and D.C. Heins, eds. Community and Evolutionary Ecology of North American Stream Fishes. University of Oklahoma Press, Norman, Oklahoma.

Smith, C.L. 1985. The Inland Fishes of New York State. New York State Department of Environmental Conservation, Albany, New York.

Smith, P.W. 1979. The Fishes of Illinois. University of Illinois Press, Chicago. 314 pp.

# Morphometric, Meristic, and Natural History Notes on *Menidia beryllina* and *M. peninsulae* in a Marginal Sympatric Area in Perdido Bay, Alabama and Florida

ROYAL D. SUTTKUS
*P.O. Box 1560*
*Ocean Springs, MS 39566-1560*

MAURICE F. METTEE
*Geological Survey of Alabama*
*Tuscaloosa, AL 35486*

## INTRODUCTION

During a 1973-89 biological, water-quality study of the Perdido Bay drainage in Alabama and Florida, the senior author (RDS) collected large numbers of silversides which were initially identified as *Menidia beryllina*. However in April 1985, he collected many *Menidia* that exhibited two distinctive patterns of nuptial coloration. Closer examination of these individuals in the laboratory revealed that the samples contained two *Menidia* species. *Menidia beryllina* was consistently collected from lower salinity waters at two sample sites in upper Perdido Bay; *M. peninsulae* was consistently collected from higher salinity water at two sites in lower Perdido Bay. The goals of this paper are to: present morphological and meristic features used to distinguish *M. beryllina* from *M. peninsulae* in Perdido Bay; discuss population structure and apparent habitat preferences of each species; and finally, to compare and contrast results of this study with two other studies of *Menidia* (Middaugh and Hemmer, 1987, 1992) completed in the Pensacola Bay drainage, which lies a short distance eastward of the Perdido Bay drainage in northwest Florida.

The systematics, ecology, and habitats of *Menidia* have been studied in great detail by numerous workers, including Kendall (1902), Jordan and Hubbs (1919), Hubbs and Raney (1946), Gosline (1948), Schultz (1948), Rubinoff and Shaw (1960), Robbins (1969), Johnson (1973), Johnson (1975), Chernoff et al. (1981), Lucas (1982), and Duggins et al. (1986). Although these resources provide a wealth of information for a comprehensive summary, we only extracted limited material to support our findings in Perdido Bay.

In our perusal of the literature, we noted that Kendall (1902) and Chernoff et al. (1981) stated that Goode and Bean's (1879) original description was based on specimens from Pensacola, Florida (= *peninsulae*) and Lake Monroe, Florida (= *beryllina*). Although Goode and Bean mentioned they had numerous specimens, [USNM] No. 21,870, from Lake Monroe, FL (page 148) a comparison of the Diagnosis, which immediately followed, matches very closely the data presented in tabular form on page 150, where only two specimens from Pensacola Bay were cited. Therefore, we conclude that the original description was based primarily, if not exclusively, on the two type specimens that Goode and Bean designated as [USNM] Nos. 21, 481a and 21,481b.

## METHODS

In July 1973, RDS initiated a sampling program to examine the effects of discharge from the Perdido River, Elevenmile Creek, Bayou Marcos, an unnamed bayou, and Herrion Bayou (Bridge Creek) on water quality and aquatic life in upper and lower sections of Perdido Bay. Two sampling sites were established in upper Perdido Bay in Escambia County, Florida. One site was located at the mouth of an unnamed bayou (sec. 14, T. 2 S., R. 31 W.) where Florida Hwy 298 closely parallels the shore line, and the other at the boat ramp on Herrion Bayou (sec. 25, T. 2 S., R. 31 W.) at U.S. Hwy 98 crossing (Fig. 1). Two additional sites were established in lower Perdido Bay area. The first site was located on the south side of Du Pont Point (sec. 3, T. 3 S., R. 32 W) in Escambia County, Florida. The other site located in Baldwin County, Alabama, approximately 800 m north of Red Bluff (sec. 16, T. 8 S., R. 6 E.)

A total of 31 samples was collected at each of the four (two upper and two lower) study sites from July 1973 through July 1988. Eleven samples of each 31-sample set were collected in January; 14 were collected in July; and lesser numbers were taken in April (3), August (1), and October (2). Five additional fish samples were obtained in January 1989. Three were obtained from upper Perdido Bay area: near the mouth of Elevenmile Creek, from Grassy Point, and from Double Point. Two samples were obtained from near the mouth of Perdido Bay: one at Bear Point and the other at Inerarity Point. One additional sample was used that had been collected from along the Alabama side of lower Perdido Bay on 7 May 1965.

Samples were collected with a 16-ft (4.87 m) shrimp trawl at two stations in upper Perdido Bay. One station was located approximately 800 m north of the mouth of Herrion Bayou; the other was midway between Grassy and Double Point. One trawl station was located in lower Perdido Bay, midway in the bay west of Du Pont Point. No further details of trawling stations is pertinent to the discussion in this paper.

Most samples at seine stations were collected with a nylon seine that was 10 ft (3.05 m) long, 6 ft (1.82 m) high (or deep), and had 3/16 in (0.48 cm) ace mesh. A few samples were collected with bag seines. One bag seine was 40 ft (12.19 m) long and had 1/4 inch (0.64 cm) mesh in the bag and 3/8 inch (0.95 cm) mesh in the wings. The other was 100 ft (30.48 m)

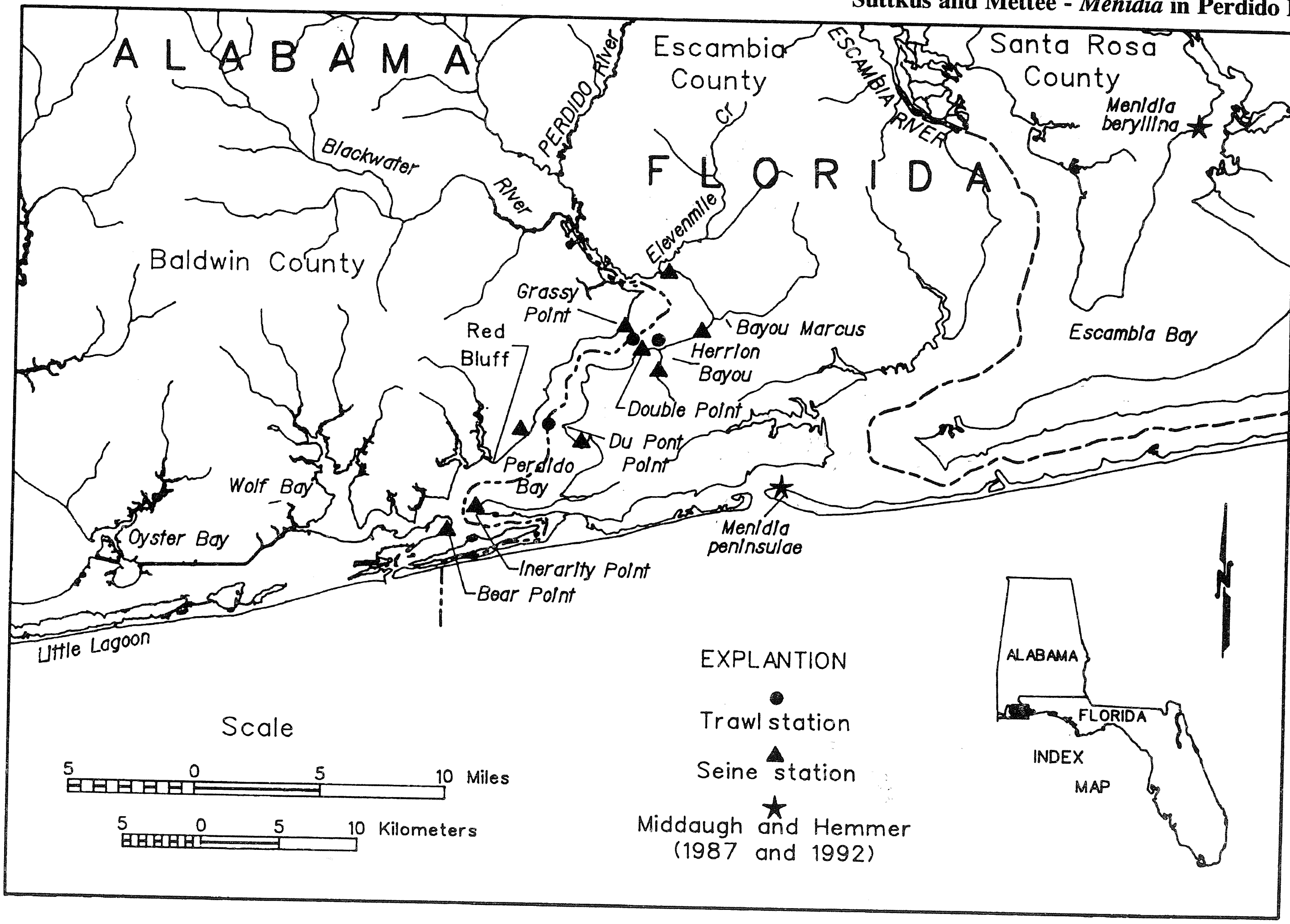


**Figure 1.** *Menidia* collecting localities used in this study.

long and had 3/8 inch (0.95 cm) mesh in bag and 1/2 inch (1.27 cm) mesh in the wings. The latter seine was used only at DuPont Point and Red Bluff.

With few exceptions, entire samples were preserved in the field and transported to Tulane University Museum of Natural History for processing. A few extremely large samples taken by seine or trawl had to be subsampled in the field, but all species and specimens were recorded and tabulated before any specimens were discarded. A few larger individuals of Atlantic stingrays, *Dasyatis sabina*, and longnose gar, *Lepisosteus osseus*, were identified and subsequently released unharmed because they were too large for preservation. Some trawl samples containing many small specimens of a few species were subsampled in the laboratory; however, all species and specimens were recorded before they were discarded.

Of the 130 seine samples from Perdido Bay, 102 contained specimens of either *M. beryllina* or *M. peninsulae*. All specimens of *Menidia* used for this report were preserved and accessioned into the Tulane University Museum of Natural History (TU). Accession numbers and inclusive numbers of specimens used for the present paper are as follows: *Menidia beryllina*, TU 82865 (452), TU 88990 (2), TU 89028 (400), TU 92118 (53), TU 94829 (323), TU 96879 (22), TU 98660 (99), TU 100809 (1), TU 102998 (15), TU 103006 (364), TU 105486 (17), TU 108613 (176), TU 111472 (106), TU 113906 (1962), TU 116055 (74), TU 117533 (167), TU 117631 (631), TU 120092 (8), TU 122285 (22), TU 122292 (30), TU 124341 (146), TU 124362 (9), TU 131506 (18), TU 133765 (135), TU 136060 (238), TU 136071 (78), TU 140173 (3), TU 140180 (4), TU 141899 (1), TU 141907 (679), TU 145947 (310), TU 145952 (181), TU 146990 (135), TU 147352 (100), TU 148357 (17), TU 149188 (351), TU 150272 (202), TU 151908 (2), TU 151917 (53), TU 152756 (173), TU 152765 (242), TU 154237 (84), TU 154256 (25), and TU 154266 (47) (total = 8,157 specimens). *Menidia peninsulae*: TU 71826 (89), TU 82880 (16), TU 82888 (287), TU 89002 (27), TU 89014 (842), TU 92141 (14), TU 92150 (114), TU 94982 (39), TU 94996 (323), TU 96886 (17), TU 98687 (222), TU 98698 (9), TU 100826 (33), TU 100829 (103), TU 102974 (41), TU 102989 (235), TU 105501, TU 105507 (11), TU 108682 (6), TU 108692 (139), TU 111498 (12), TU 111501 (18), TU 113934 (2), TU 113948 (3121), TU 116092 (151), TU 116094 (77), TU 117623 (1), TU 122331 (179), TU 122341 (137), TU 124365 (499), TU 131484 (31), TU 131493 (2), TU 133205 (2), TU 136137

(20), TU 136146 (16), TU 140229 (1), TU 140237 (20), TU 141935 (13), TU 141948 (81), TU 145999 (3), TU 147030 (169), TU 147038 (35), TU 147689 (275), TU 147694 (141), TU 148384 (53), TU 148388 (44), TU 149218 (187), TU 149229 (26), TU 150313 (23), TU 150331 (107), TU 151328 (77), TU 151335 (23), TU 151983 (6), TU 151989 (2), TU 152804 (16), TU 152811 (30), TU 154216 (243) and TU 154227 (129) (total = 8,682).

Eleven proportional measurements were taken to the nearest 0.1 mm with dial calipers and were expressed in thousandths of standard length (SL). Morphometrics were taken on 100 specimens each of *M. beryllina* and *M. peninsulae;* each species set included specimens in nuptial condition. Pectoral and anal fin ray counts and predorsal scale counts were made on 200 specimens of *M. beryllina* and 400 specimens of *M. peninsulae* following methods in Hubbs and Lagler (1958). Gill raker counts were made on the first, left gill arch (total count) of 250 specimens each of *M. beryllina* and *M. peninsulae*.

Standard analytical equipment was used to determine several different water-quality parameters. A hand-held Taylor Instrument Company Centigrade pocket thermometer was used to measure water temperature (C). Chlorides were determined to the nearest mg/l in freshwater using the standard Hach Chemical Company procedure which involved premeasured chemicals in powder pillows in titration with standard mercuric nitrate solution. Salinity as parts per thousand (ppt) was determined in brackish water using a Yellow Springs Instrument (YSI) Company Model 33S-C-T salinometer.

## RESULTS AND DISCUSSION

All *Menidia* collected during the early years of this survey were initially identified as *M. beryllina*. However In April 1985, several series of *Menidia* were collected that exhibited two distinctly different patterns of nuptial coloration. On 5 April 1985, ripe males and females were collected at both upper Perdido Bay sites that were heavily pigmented on the fins and body with a rather uniform overlay of brassy-olive and had no bright yellow or orange anywhere on the fins or body. These were determined to be *Menidia beryllina*. The water temperature was 22 C and the salinity 2.29 ppt at the unnamed bayou and the water temperature was 21 C at Herrion Bayou.

On 6 April 1985, ripe males and females were collected at Du Pont Point in lower Perdido Bay. *Menidia* collected at these sites had a lighter and more silvery appearance than individuals from the upper bay sites and they had bright orange coloration at the base of the pectoral fins and in the axil of the same fin. Also, the caudal fin was a bright lemon yellow, especially the base. These were determined to be *Menidia peninsulae*. A review of our field notes revealed that in some cases the coloration of the pectoral fin base was noted but not of the caudal fin and so we do not know the consistency of the dual coloration of both fins. The water temperature at DuPont Point was 20 C and salinity was 7.0 ppt.

Similarly, on 16 April 1987, ripe males and females of *M. beryllina* were taken at the unnamed bayou and Herrion Bayou in upper Perdido Bay. Water temperature was 23 C at both sites; salinity was 2.0 ppt at the unnamed bayou site. On 17 April 1987, nuptial (squeeze ripe) individuals of *M. peninsulae* were obtained at the two lower bay sites. Water temperature was 22 C at both Du Pont Point and Red Bluff, but salinity varied from 7.2 ppt at Du Pont Point to 8.0 ppt at Red Bluff. Nuptial coloration patterns on *Menidia* collected in upper and lower Perdido Bay in mid-April were consistent with those collected at the upper and lower sites in early April.

All individuals of *Menidia* collected from Perdido Bay during the survey were reexamined to determine if the distinctive color patterns noted in April collections were habitat influenced or they actually reflected discrete, previously observed, differences in species identity. Although laboratory work produced moderate (depth of body and caudal peduncle) to slight differences in morphometrics (Table 1), pectoral and anal fin ray counts and predorsal scale counts (Table 2), considerable overlap of these parameters provided little information for reliable separation of these two *Menidia* species in our samples. The same was not true, however, with regard to gill raker counts (Table 3). Although some overlap was observed, modal gill raker counts ranged from 22-23 (mean = 22.2) for *M. beryllina* and from 25-26 (mean = 25.6) for *M. peninsulae* and no single sample exhibited bimodality in gill raker counts.

Thus, the distinctive color pattern and salinity relationships of *Menidia* in the April collections, did indeed, coincide with the identification of two species. All 102 Perdido Bay (upper and lower) samples were checked for gill raker counts. All samples from upper Perdido Bay contained only individuals of *M. beryllina*, whereas those samples, with two exceptions, from lower Perdido Bay contained only *M. peninsulae*. The aforementioned two exceptions were as follows: On 17 July 1980, 631 *M. beryllina* were taken at Du Pont Point. No *M. peninsulae* were identifiable in the samples. The water temperature was 32.5 C at the time of collection and the surface salinity a short distance out in the bay was 3.6 ppt which was the lowest salinity of the 31 corresponding measurements recorded between July 1973 and July 1988 at the DuPont Point site. On 9 January 1982 when the water temperature was 13.5 C, nine specimens of *M. beryllina* were taken at the Red Bluff site. No other atherinids were taken with the *M. beryllina* at the site on that date. On that date, the surface salinity a short distance out in the bay was 3.9 ppt. These data, although few, indicate that the two species, *M. beryllina* and *M. peninsulae*, in Perdido Bay area, do segregate on the basis of salinity.

**Table 1.** Measurements in thousandths of standard length for *Menidia beryllina* and *M. peninsulae*.

| Measurements | *Menidia beryllina* (N= 100) | | | *Menidia peninsulae* (N= 100) | | |
|---|---|---|---|---|---|---|
| | Range | Mean | S.D. | Range | Mean | S.D. |
| Standard length (mm) | 52.9 - 83.0 | 66.2 | 7.6 | 48.5 - 110.2 | 72.7 | 15.7 |
| First dorsal origin to snout tip | 484 - 544 | 515 | 11.4 | 485 - 554 | 519 | 13.7 |
| Second dorsal origin to snout tip | 639 - 683 | 660 | 9.5 | 640 - 702 | 675 | 11.8 |
| Anal origin to snout tip | 541 - 600 | 573 | 12.3 | 582 - 630 | 604 | 10.5 |
| Pelvic insertion to snout tip | 369 - 417 | 392 | 9.1 | 389 - 454 | 409 | 11.7 |
| Anal origin to caudal base | 399 - 463 | 439 | 12.5 | 390 - 437 | 416 | 10.4 |
| Head length | 227 - 258 | 240 | 6.0 | 225 - 274 | 248 | 13.3 |
| Head depth | 114 - 134 | 125 | 3.9 | 125 - 156 | 138 | 8.7 |
| Orbit length | 63 - 81 | 72 | 3.7 | 58 - 89 | 72 | 7.6 |
| Snout length | 69 - 96 | 77 | 4.0 | 71 - 90 | 80 | 4.0 |
| Body depth | 141 - 175 | 160 | 8.1 | 162 - 209 | 192 | 8.8 |
| Caudal peduncle depth | 67 - 84 | 76 | 3.7 | 76 - 101 | 87 | 5.8 |

**Table 2.** Frequency distributions for pectoral and anal fin ray and predorsal scale counts in *Menidia beryllina* and *M. peninsulae* from Perdido Bay, Florida and Alabama.

| Species | Meristic Character | | | | | | N | Mean | S.D. |
|---|---|---|---|---|---|---|---|---|---|
| | Pectoral Fin Rays | | | | | | | | |
| | 12 | 13 | 14 | 15 | 16 | | | | |
| *M. beryllina* | 1 | 50 | 126 | 23 | | | 200 | 13.8 | 1.02 |
| *M. peninsulae* | | 62 | 213 | 115 | 10 | | 400 | 14.2 | 0.71 |
| | Anal Fin Rays | | | | | | | | |
| | 14 | 15 | 16 | 17 | 18 | 19 | | | |
| *M. beryllina* | 1 | 27 | 65 | 78 | 23 | 6 | 200 | 16.5 | 1.31 |
| *M. peninsulae* | 19 | 115 | 176 | 73 | 15 | 2 | 400 | 15.9 | 1.09 |
| | Predorsal Scales | | | | | | | | |
| | 14 | 15 | 16 | 17 | 18 | | | | |
| *M. beryllina* | 1 | 44 | 110 | 42 | 3 | | 200 | 16.0 | 0.71 |
| *M. peninsulae* | 28 | 135 | 181 | 49 | 7 | | 400 | 15.6 | 1.02 |

**Table 3.** Frequency distribution for gill rakers in *Menidia beryllina* and *M. peninsulae* from Perdido Bay, Florida and Alabama.

| Species | Gill Rakers | | | | | | | | | | N | Mean | S.D. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | |
| *M. beryllina* | 9 | 62 | 82 | 72 | 23 | 2 | | | | | 250 | 22.2 | 1.04 |
| *M. peninsulae* | | | | 8 | 40 | 65 | 76 | 42 | 17 | 2 | 250 | 25.6 | 1.25 |

Repeated sampling at the two upper (unnamed and Herrion) and two lower (DuPont Point and Red Bluff) sites in Perdido Bay revealed some interesting species associations and habitat relationships. A total of 68 *Membras martinica* was taken in five of 31 collections at the unnamed bayou site while a total of 6,654 *Menidia beryllina* was taken in 28 of 31 collections. Both species were taken in four of the 31 collections. Four collections containing *Membras martinica* were obtained during July surveys and the remainder (a single specimen) was taken on 21 April. A total of 601 brook silverside, *Labidesthes sicculus*, was taken in eight of the 31 collections at Herrion Bayou while a total of 707 *Menidia beryllina* was taken in ten of the 31 collections. Both species were taken together only once (11 July 1984) when the water temperature was 31 C. This sample contained 29 *L. sicculus* and 78 *M. beryllina*.

Three species of atherinids were obtained in 31 collections from the Du Pont Point site in lower Perdido Bay. A total of 250 *Membras martinica* was taken in 13 of the 31 samples while 6,594 *Menidia peninsulae* was taken in 28 of the 31 collections. On 17 July 1980, 631 *Menidia beryllina* were taken at Du Pont Point.

Three species of atherinids were obtained in the 31 collections from the Red Bluff site. A total of 110 *Membras martinica* was taken in seven collections and 1,608 *Menidia peninsulae* was taken in 27 collections. On 9 January 1982, nine specimens of *M. beryllina* were taken at the Red Bluff site as stated above when the water temperature was 13.5 C and the surface salinity a short distance out in Perdido Bay was 3.9 ppt.

The separate January 1989 survey resulted in the collection of 156 *Menidia beryllina* from three sites along the shore of upper Perdido Bay and 372 *Menidia peninsulae* from two sites near the outlet of lower Perdido Bay.

Allopatric distributions of *M. beryllina* in upper Perdido Bay and *M. peninsulae* in lower Perdido Bay appear strongly influenced by a north to south salinity gradient which may, in turn, be affected by the unique shape of Perdido Bay itself. In January, salinities in the upper bay area ranged from 0.3 to 10.5 ppt while in the lower bay area, they ranged from 3.5 to 17.0 ppt. Correspondingly in July, salinities ranged from 0.1 to 9.8 ppt in the upper bay and from 2.0 to 21.5 ppt in the lower bay. April, August and October salinities varied from station to station, but in general, they were lower in the upper bay than in the lower bay. A description of surface and bottom current patterns in Perdido Bay, particularly in the constricted area of Perdido Bay near Chagrin and Cummings Points, are detailed in a 1970 study by the Federal Water Pollution Control Administration.

Results of our morphological examinations and our observation of an apparent allopatric distribution of *M. beryllina* and *M. peninsulae* along a salinity gradient in Perdido Bay are, at least in part, substantiated by reports on *Menidia* species completed by earlier workers in other areas. Kendall (1902) noted that "Although the different forms [of *Menidia*] when mixed together are readily distinguishable by the eye, it is difficult to represent their differences by measurements or figures." Johnson (1975) stated, "Differences between *M. peninsulae* and *M. beryllina* are statistically clear, but difficult to express in terms of individuals." He also said, "Although *M. beryllina* is broadly sympatric with both *M. peninsulae* and *M. menidia*, it is usually not taken with these species, due to differences in distribution with respect to salinity." The fact that we never took both *Menidia beryllina* and *M. peninsulae* in the same seine haul nor at the same sampling site during the same sampling period seems to substantiate Johnson's foregoing statement.

In referring to *Menidia menidia*, Kendall (1902) wrote, "They swim in immense schools, fish of about the same size generally being found together." We observed that most individuals in schools of *Menidia peninsulae* were also rather uniform in size. Most *Menidia beryllina* taken in our April samples were also of a uniform size. However, by 1 July 1988, we collected several schools of *Menidia beryllina* that contained juvenile individuals in addition to ripe males and females.

Our findings, that allopatric distribution of *M. beryllina* and *M. peninsulae* in our samples appeared related to north to south salinity gradients in Perdido Bay, differed considerably from two other studies completed by Middaugh and Hemmer (1987 and 1992) in the Pensacola Bay drainage, which lies immediately east of Perdido Bay. Middaugh and Hemmer (1987) reported they collected both *M. beryllina* and *M. peninsulae* at Santa Rosa Island. Ninety-nine specimens (presumably of *M. beryllina*) were eliminated from the study because the ratio of the horizontal distance from the origin of the first dorsal and anal fins in millimeters (herein called HD) to standard length in millimeters (SL) was $<0.7$ (Chernoff, et al. 1981). Middaugh and Hemmer (1992) also eliminated a small percentage of *Menidia* specimens (presumably *M. peninsulae)* from their study sample of *M. beryllina* in Blackwater Bay because the HD/SL was equal to or $> 0.7$ (Chernoff, et al. (1981). A second feature used to separate the two species concerned gas bladder structure. Echelle and Mosier (1982) found that the gas bladder in *M. beryllina* is long and translucent; in *M. peninsulae*, it is truncated and opaque.

In contrast to Chernoff, et al. (1981) and Middaugh and Hemmer (1987 and 1992), the HD/SL ratio did not appear to be a reliable character to separate *M. beryllina* and *M. peninsulae* on individuals collected from Perdido Bay. The first dorsal and second dorsal fin origins, the anal fin origin, and the pelvic fin insertion all appeared farther posterior on *M. peninsulae* than in *M. beryllina* but again as with all other proportions cited above, there was considerable overlap between the two species with respect to each proportion (Table 1). We support the view of Edwards, et al. (1978) that the position of the extension of the air bladder is not an absolute reliable feature for distinguishing between *M. beryllina* and *M. peninsulae*.

Several workers have commented on male to female ratios within various *Menidia* species, including *beryllina* and

*peninsulae*. Hildebrand (1922) made observations on living and fresh material in the vicinity of the biological station at Beaufort, North Carolina, from April 1914 into August 1916. With special reference to *Menidia menidia*, he stated that, "It was learned from the examination of large collections that the ratio of males to females is about equal." He followed this with a profound statement: "It so happens, however, for unknown reasons, that at times a school which consists almost wholly of females is taken, and again the reverse is true." Could Echelle and Mosier (1982) have observed this same phenomenon 60 years after Hildebrand (1922)? Kendall (1902) examined 250 specimens of a sample of 380 *M. menidia* and identified 204 females versus 146 males. Rubinoff and Shaw (1960) found only 12 males in a sample of more than 200 adult *M. beryllina*.

Conover and Heins (1987) presented data that sex determination in progeny of *Menidia menidia* is temperature-dependent and that at low temperatures (15 C), three distinct modes result: 50/50 male and female; all female; or nearly all male. Further, they went on to say that significant fluctuations in sex ratio had been observed in field populations, but they postulated that fluctuations would cancel out because the adults breed en masse. We believe that *M. peninsulae* may follow a similar behavioral and developmental pattern as described for *M. menidia*.

Middaugh and Hemmer (1987) stated that the gonado-somatic indices of *M. peninsulae* at the Santa Rosa site were highest at increasing water temperatures from 16.7 to 30.8 C, mean = 25.9 C. We observed *M. peninsulae* spawning or determined individuals to be in nuptial condition at three different times in April with water temperatures of 20 to 22 C. One additional observation of *M. peninsulae* in nuptial condition was made on 12 January 1989 at Inerarity Point, Lower Perdido Bay, when water temperature was 20 C. The observations and water temperature coincide with those stated by Middaugh and Hemmer (1987) with regards to *M. peninsulae*. Spawning of *M. beryllina* in upper Perdido Bay was observed four different times in April with water temperatures that ranged from 21 to 23 C. An additional observation on 1 July 1988, a few large *M. beryllina* in a large school were determined to be ripe. Water temperature was 29.5 C about a mile out in the bay at the time of the observation and thus spawning activity of *M. beryllina* in Perdido Bay were similar to those reported by Middaugh and Hemmer (1992) for Blackwater Bay. We have included these few data to help document some of our following statements.

Conover and Heins (1987) demonstrated that the sex ratio in *Menidia menidia* was primarily temperature dependent and little affected or unaffected by photoperiod and salinity. We believe temperature, salinity, perhaps photoperiod, and additional factors play an important role in the development and hatching success of spawned *Menidia* eggs. Both *M. beryllina* and *M. peninsulae* spawn in the intertidal zone where there are plants for attachment of the eggs. The upper tidal zone is perhaps the optimum subzone (Middaugh, 1981) because of the strength and duration of tidal currents and the lapping of wind-generated waves that continually move or agitate the vegetation with the attached eggs. Moreover, surface diffusion of oxygen is greatest in this shallow, often turbulent zone. Certainly developing embryos are subjected to numerous ebb and flood tides, on and offshore wind turbulence, and diurnal changes in temperature and salinities. All of these variables interacting with different intensities on spawned masses at different sites along the shoreline would obviously result in variation in development and hatching time. Thus, with an environmentally plastic form, the end result is a highly variable morphology.

We have a strong belief that the two species (*M. beryllina* and *M. peninsulae*) do not occur together in the same school or aggregation in Perdido Bay. One would have expected, if co-occurrence was typical, occasional, or even a rare event, that in more than 100 samples taken in a period of 16 years, we would have taken both species in a least one sample, however this was not the case. The primary factor of separation seems to be salinity.

Our conclusion with regard to identification of the two species, *beryllina and peninsulae*, is that the overall appearance (color, body depth, caudal peduncle depth, and so forth) should be sufficient to allow experienced workers to identify the species of *Menidia* when schools of individuals are sampled. Size, spawning colors, and color pattern are additional features for identification of spawning adults and gill raker counts of a sub-sample of any large sample should be sufficient to verify identification based on general appearance.

## ACKNOWLEDGMENTS

We thank the late Gerald E. Gunning and his various students for the use of the water-quality data. The following individuals helped collect the many fish samples from the Perdido Bay area: Daniel L. Adkinson, James M. Barkuloo, Gerry Bresnick, John H. Caruso, Phil Dinette, Keith G. Goodfellow, Gerald E. Gunning, Steve Herbert, Gail Kohl, Rudolph Meier, John Odenkirk, Johnnie Pike, Steven O. Rohmann, the late Alfred E. Smalley, Patrick Sorensen, Bruce A. Thompson, Veronica C. Trau, Mark A. Warren, and David A. White. We owe a debt of gratitude to James M. Barkuloo for the use of his personal boat on a number of surveys. His expertise in trawling and seining were much appreciated. Also, we wish to extend our thanks to Henry L. Bart, Jr. and his staff for their continued care of the collections at Tulane University and the many courtesies extended to facilitate study of the material.

## LITERATURE CITED

Chernoff, B., J.V. Conner and C.F. Bryan. 1981. Systematics of the *Menidia beryllina* complex (Pisces: Atherinidae) from the Gulf of Mexico and its tributaries. Copeia 1981(2):319-336.

Conover, D.O. and S.W. Heins. 1987. The environmental and genetic components of sex ratio in *Menidia menidia* (Pisces: Atherinidae). Copeia 1987(3):732-743.

Duggins, C.F., A.A. Karlin, K. Relyea and R.W. Yerger. 1986. Systematics of the Key silverside, *Menidia conchorum*, with comments on other *Menidia* species (Pisces: Atherinidae). Tulane Stud. Zool. Bot. 25(2): 133-150.

Echelle, A.A. and D.T. Mosier. 1982. *Menidia clarkhubbsi* n. sp. (Pisces: Atherinidae), an all female species. Copeia 1982(3):533-540.

Edwards, R.J., E. Marsh and F.B. Stevens, Jr. 1978. The utility of the air bladder in determining specific relationships in the atherinid genus *Menidia*. Contrib. Mar. Sci. Univ. Tex. 21:1-7.

Federal Water Pollution Control Administration. 1970. Conference in the matter of pollution of the interstate waters of Perdido Bay and its tributaries, Florida and Alabama. United States Federal Water Pollution Control Administration Proceedings. 283 pp.

Goode, G.B. and T.H. Bean. 1879. Catalogue of a collection of fishes sent from Pensacola, Florida, and vicinity, by M. Silas Stearns, with descriptions of six new species. Proc. U.S. Nat. Mus. 2:121-156.

Gosline, W.A. 1948. Speciation in the fishes of the genus *Menidia*. Evolution 2(4):306-313.

Hildebrand, S.F. 1922. Notes on habitats and development of eggs and larvae of the silversides *Menidia menidia* and *Menidia beryllina*. Bull. U.S. Bur. Fish. 38(1921-22): 113-120.

Hubbs, C.L. and K.F. Lagler. 1958. Fishes of the Great Lakes region. Cranbrook Inst. Bull. 26:1-213.

Hubbs, C.L. and E.C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. Misc. Publ. Mus. Zool., Univ. Mich. 65. 30pp.

Johnson, M.S. 1973. An electrophoretic study of enzyme variation in fishes of the genus *Menidia* (Teleostei, Atherinidae). Ph.D. thesis, Yale University.

Johnson, M.S., 1975. Biochemical systematics of the atherinid genus *Menidia*. Copeia 1975(4):662-691.

Jordan, D.S. and C.L. Hubbs. 1919. Studies in ichthyology. A monographic review of the family Atherinidae or silversides. Stanford Univ. Publ. Biol. Sci. 87 pp.

Kendall, W.C. 1902. Notes on the silversides of the genus *Menidia* of the east coast of the United States, with descriptions of two new sub-species. Rept. U.S. Fish Comm. 1901:241-267.

Lucas, J.R. 1982. Feeding ecology of the gulf silverside, *Menidia peninsulae*, near Crystal River, Florida, with notes on its life history. Estuaries 5(2):138-144.

Middaugh, D.P. 1981. Reproductive ecology and spawning periodicity of the Atlantic silverside *Menidia menidia* (Pisces: Atherinidae). Copeia 1981(4): 766-776.

Middaugh, D.P. and M.J. Hemmer. 1987. Reproductive ecology of the tidewater silverside, *Menidia peninsulae* (Pisces: Atherinidae) from Santa Rosa Island, Florida. Copeia 1987(3):727-732.

Middaugh, D.P. and M.J. Hemmer. 1992. Reproductive ecology of the inland silverside, *Menidia beryllina*, (Pisces: Atherinidae) from Blackwater Bay, Florida. Copeia 1992(1):53-61.

Robbins, T.W. 1969. A systematic study of the silversides *Membras* and *Menidia* (Atherinidae, Teleostei). Ph.D. thesis, Cornell University.

Rubinoff, I. and E. Shaw. 1960. Hybridization in two sympatric species of the atherinid fishes, *Menidia menidia* (Linnaeus) and *Menidia beryllina* (Cope). American Mus. Nov. No. 1999:1-13.

Schultz, L.P. 1948. A revision of six subfamilies of atherine fishes, with descriptions of new genera and species. Proc. U.S. Nat. Mus. 98:1-48.

## ERRATUM

In the article "Distribution and habitat affinities of the blackmouth shiner (*Notropis melanostomus*) in Mississippi, including eight newly discovered localities in the Upper Pascagoula River Drainage" that appeared in *Southeastern Fishes Council Proceedings 36* (March, 1998), the second sentence of the abstract incorrectly referred to the species as being "federally listed as threatened". The sentence should read as follows:

"Because of its limited distribution, the species is listed as imperilled by the Mississippi Natural Heritage Program and as threatened by the American Fisheries Society (Williams et al. 1989)."

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Michael M. Stevenson
Department of Biological Sciences, University of New Orleans, Lakefront
New Orleans, LA 70148
(504) 280-6783

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*Proceedings* is a publication of the Southeastern Fishes Council, Inc, and is published in Charleston, South Carolina. Officers are Stephen T. Ross, Chair; Gerald Dinkins, Secretary; and Mary Freeman, Treasurer. Editor for the *Proceedings* is Michael M. Stevenson, Biological Sciences, University of New Orleans, LA 70148, (504)280-6783, MMSBS@jazz.ucc.uno.edu; Associate Editor is George R. Sedberry, Marine Resources Research Institute, P.O. Box 12559, Charleston, SC 29422-2559, (843)762-5045, sedberryg@mrd.dnr.state.sc.us. *Proceedings* is printed on recycled paper.