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Abstract

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Keywords

fishes, calhoun county, pebble-nests, smotilus, walleye, tombigbee river

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FISHES OF SPRINGS AND SPRING-FED CREEKS OF CALHOUN COUNTY, ALABAMA

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Abstract – A survey of the fish fauna inhabiting the springs and spring-fed creeks of Calhoun County, Alabama, was conducted between May, 1986 and February, 1987. Additional data were obtained from collections made prior to this study on the Fort McClellan Military Reservation, a limited access area. Forty-five species and two hybrids representing 24 genera and 11 families were collected from 83 stations.

New populations of *Hemitremia flammea* and *Etheostoma ditrema* were discovered. Range extensions were documented for *Notropis texanus*, *Lepomis humilis*, and the undescribed "upland snubnose" darter, *Etheostoma sp*.

INTRODUCTION

Calhoun County, Alabama, possesses an abundant supply of ground water much of which surfaces in the form of springs. These springs range in size from small seepage areas to large thrust fault springs. The largest spring in the county is Coldwater Spring, with a minimum daily discharge of 32 million gallons (Warman and Causey, 1962). Ichthyologists from various universities and government agencies have made relatively few collections of the spring ichthyofauna within Calhoun County; however, some important discoveries have been made within the area. The pygmy sculpin, *Cottus pygmaeus* (Williams, 1968), and a rare darter *Etheostoma ditrema* (Ramsey and Suttkus, 1965), were discovered in Coldwater Spring near Anniston, AL. And, in nearby Talladega County, specimens of the flame chub, *Hemitremia flammea*, were discovered in a spring tributary of Kelley Creek (Smith-Vaniz, 1968). These important ichthyological findings, coupled with the fact that springs throughout much of north Alabama serve as habitats for spring restricted fishes, have led us to conduct a comprehensive ichthyofaunal survey within Calhoun County. Due to population growth and environmental pressures facing the numerous unique spring ecosystems within Calhoun County, we felt that an ichthyological survey was needed immediately. The purpose of this study is to document the diversity and distribution of the ichthyofauna of springs and spring-fed creeks of Calhoun County, AL, prior to any further environmental degradation.

The majority of Calhoun County is located within the Valley and Ridge Physiographic Province of northeastern Alabama. That portion of the county lying outside the Valley and Ridge Province parallels the Calhoun-Cleburne county line. This narrow strip of land is situated within the Ashland Plateau of the Piedmont Province. Topography is generally mountainous since the county is located within the foothills of the Appalachian Mountains. The Coosa River and its tributaries drain the county.

MATERIALS AND METHODS

Seventy-one collections of springs and spring distributaries were made from 20 May 1986 through 7 February 1987. All collections during this period were made by the authors. Additional data were obtained from 12 collections made by M.F. Mettee and P.E. O'Neil between 24 May 1979 and 11 October 1979. Data from these collections were utilized because the samples were made on the Fort McClellan Military Reservation, a restricted public access area.

All collections were made using either 4 or 6 foot minnow seines. All specimens were immediately preserved in 10% formalin and returned to the laboratory for identification.

Collecting stations are plotted on a dot distribution map of Calhoun County (Fig. 1). The collecting stations are in no particular order throughout the county. Two springs just outside Calhoun County were included since they were less than 100 meters from the county line.

The List of Species is presented below. Species are arranged alphabetically within a family. The families are arranged in the sequence proposed by Greenwood *et al.* (1966). The Collecting Stations section contains information concerning the location of each collecting station as well as the species collected at each station.

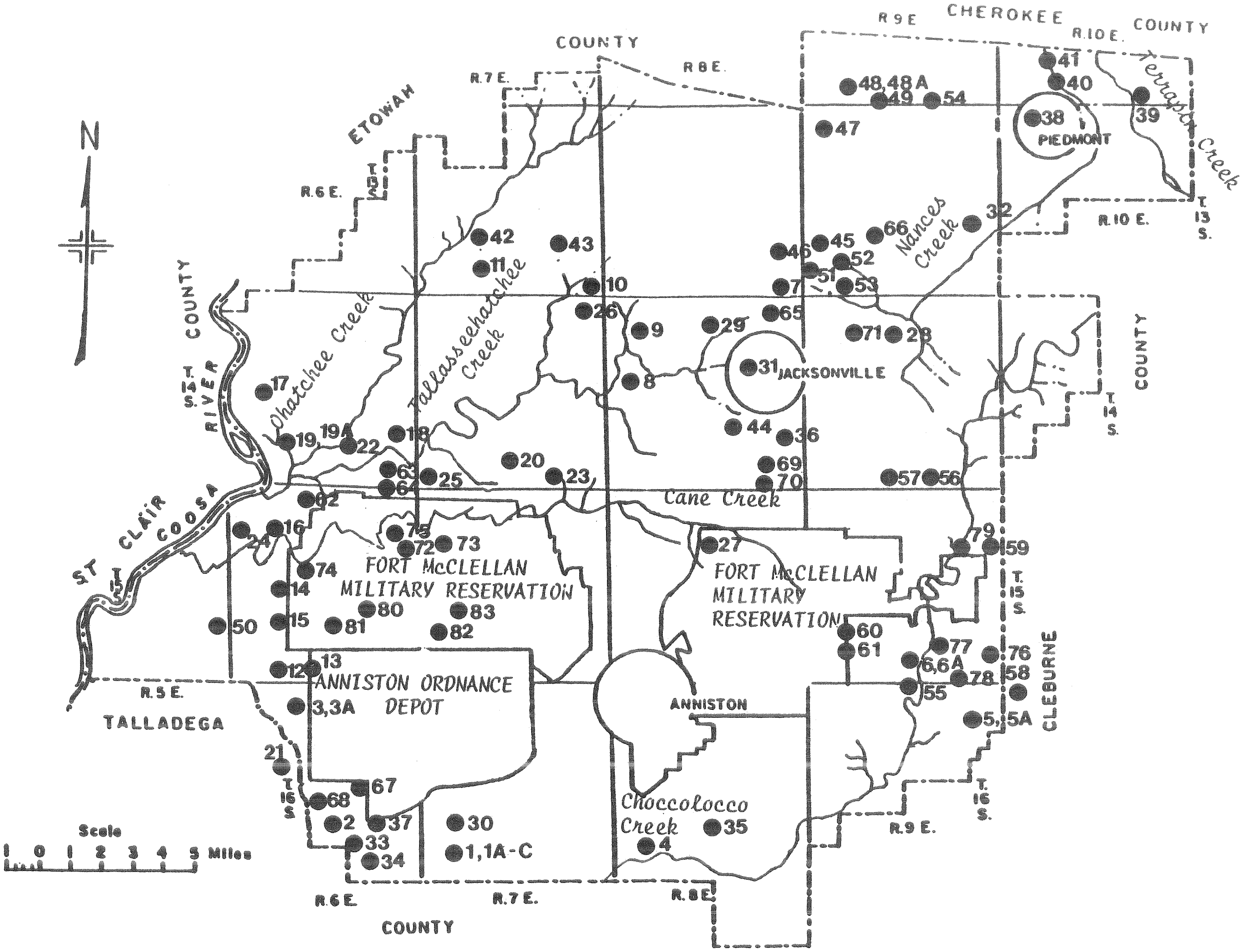

Figure 1. Map depicting collection stations within Calhoun County, AL. Base map from Warman and Causey, 1962

LIST OF SPECIES

CLUPEIDAE – HERRINGS

1. *Dorosoma petenense* (Gunther). Threadfin shad.
Station: 18

SALMONIDAE – TROUT

2. *Salmo gairdneri* Richardson. Rainbow trout.
Rainbow trout were introduced into Willett Spring for angling purposes. Station: 72.

ESOCIDAE – PIKES

3. *Esox americanus* Gmelin. Redfin pickerel.
Station: 1A.
4. *Esox niger* Lesueur. Chain pickerel.
Stations: 25, 72, 73, 76, 80.

CYPRINIDAE – MINNOWS

5. *Campostoma oligolepis* Hubbs and Green. Large scale stoneroller. Stations: 1, 1A, 3, 3A, 8 19A, 23, 24, 27, 30, 31, 34, 38, 39, 41, 42, 50, 55, 64, 69, 72 -82.
6. *Campostoma oligolepis* x *Luxilus chrysocephalus*.
This single specimen apparently represents a natural intergeneric hybrid minnow. Although the hybrid was intermediate in some characteristics that differentiate the presumed parental species, it was closer morphologically to *Luxilus chrysocephalus* (Sizemore and Howell, 1987). Station: 1.
7. *Cyprinella trichroistius* (Jordan and Gilbert). Tricolored shiner. Stations: 34, 55, 56, 58, 76-78.
8. *Cyprinella venustus* (Girard). Blacktail shiner.
Stations: 41, 55, 64.
9. *Cyprinus carpio* Linnaeus. Carp.
Stations: 25, 64.
10. *Hemitremia flammea* (Jordan and Gilbert). Flame chub.
Previous collections by many ichthyologists have revealed *H. flammea* at only one locality within the Mobile Basin – an

unnamed spring tributary to Kelly Creek, 4.5 miles northeast of Talladega along Hwy 21, Talladega County, AL (Smith-Vaniz, 1969). Two heretofore unknown populations of the flame chub were discovered within the study area. These populations are separated by approximately 24 miles. Blue Eye Spring, Station 3A, supported a healthy population of flame chubs. Joseph Spring, Station 6, produced only one specimen. Stations: 3A, 6.

11. *Luxilus chrysocephalus* (Rafinesque). Striped shiner. Stations: 1, 1A, 1B, 72, 73, 80.
12. *Lythrurus lirus* (Jordan). Mountain shiner. Stations: 55, 73, 74, 80.
13. *Notemigonus crysoleucas* (Mitchill). Golden shiner. Stations: 16, 17, 19A,22, 72.
14. *Notropis asperifrons* Suttkus and Ramsey. Burrhead shiner. Stations: 6, 34, 42, 43, 55, 57.
15. *Notropis chrosomus* (Jordan). Rainbow shiner. Stations: 6, 49, 53, 54, 56, 59, 63-65, 72-75, 78-82.
16. *Notropis stilbius* (Jordan). Silverstripe shiner. Stations: 1, 74, 75.
17. *Notropis texanus* (Girard). Weed shiner. The weed shiner is rare above the Fall Line (Swift, 1979). This record of *N. texanus* is a significant range extension above the Fall Line well into the upper Coosa River system. Station: 50.
18. *Notropis xaenocephalus* (Jordan). Coosa shiner. Stations: 27, 58, 73, 76.
19. *Rhinichthys atratulus* (Hermann). Blacknose dace. Stations: 7, 31, 32, 47, 49, 53, 54, 60, 61, 64, 65, 81.
20. *Semotilus atromaculatus* (Mitchill). Creek chub. Stations: 1A, 3, 6, 6A, 7, 8, 16, 22-24, 29, 30, 33, 36, 39, 41, 43, 44, 47, 49, 53, 54, 56, 57, 59, 60-65, 70-72, 74-81, 83.

CATOSTOMIDAE – SUCKERS

21. *Hypentelium etowanum* (Jordan). Alabama hog sucker. Stations: 1, 8, 23, 30, 38, 52,55, 65, 72-75, 77, 78, 80-82.
22. *Moxostoma duquesnei* (Lesueur). Black redhorse. Station: 78.
23. *Moxostoma erythrurum* (Rafinesque). Golden redhorse. Station: 75.

ICTALURIDAE – CATFISHES

24. *Ameiurus melas* (Rafinesque). Black bullhead. Stations: 2, 34, 72.
25. *Ameiurus natalis* (Lesueur). Yellow bullhead. Stations: 19A, 80.

FUNDULIDAE – KILLIFISHES

26. *Fundulus stellifer* (Jordan). Southern studfish. Stations: 78.

POECILIIDAE – LIVERBEARERS

27. *Gambusia affinis* (Baird and Girard). Mosquitofish. Stations: 2-5A, 8, 12-14, 17-24, 27, 32-34, 37-41, 46, 48, 48A, 50, 53, 56, 67, 69, 72, 76, 79.

CENTRARCHIDAE – SUNFISHES

28. *Lepomis auritus*(Linnaeus). Redbreast sunfish. Station: 41.
29. *Lepomis cyanellus* (Rafinesque). Green sunfish. Stations: 1, 2, 3A, 5A, 6, 12-14, 17, 18A, 19A, 21, 23, 25, 29, 47, 48, 59, 62, 63, 67, 71, 73, 75, 76, 79, 80, 81.
30. *Lepomis cyanellus* x *Lepomis megalotis*. This was the only hybrid sunfish collected during the survey. Station: 23.
31. *Lepomis gulosus* (Cuvier). Warmouth. Stations: 72, 73.
32. *Lepomis humilis* (Girard). Orangespotted sunfish. This species does not occur naturally within the Coosa River system (Lee, 1978; Smith-Vaniz, 1968). The specimen collected here most likely resulted from pond-stocking or other accidental or purposed introduction by humans. Station: 22.
33. *Lepomis macrochirus* (Rafinesque). Bluegill. Stations: 12, 15, 17, 18, 18A, 21, 23, 24, 27, 30, 34, 39, 42, 50, 52, 57, 63, 66, 67, 72-76, 79, 81.
34. *Lepomis megalotis* (Rafinesque). Longear sunfish. Stations: 4, 6, 9, 25, 32, 34, 40, 41, 50, 64, 68, 71, 73, 74, 78.
35. *Lepomis microlophus* (Gunther). Redear sunfish. Stations: 25, 74.
36. *Lepomis punctatus* (Valenciennes). Spotted sunfish. Stations: 26, 48A, 49, 73, 75.
37. *Micropterus coosae* (Hubbs and Bailey). Redeye bass. Stations: 6, 58, 59, 75, 77, 78, 80, 83.
38. *Micropterus punctulatus* (Rafinesque). Spotted bass. Station: 1.
39. *Micropterus salmoides* (Lacepede). Largemouth bass. Stations: 4, 11, 19A, 21, 25, 27, 29, 33, 34, 68, 73, 74.
40. *Pomoxis nigromaculatus* (Lesueur). Black crappie. Station: 72.

PERCIDAE – PERCHES

41. *Etheostoma coosae* (Fowler). Coosa darter. Stations: 6, 8, 10, 17, 19, 19A, 23, 26, 32, 42, 43, 47, 63, 73, 74, 76, 77, 78, 80, 81.
42. *Etheostoma ditrema* (Ramsey and Suttkus). Coldwater darter. This uncommon darter was collected at two new localities during the study. Stations: 1C, 30, 40, 41.
43. *Etheostoma stigmaeum* (Jordan). Speckled darter. Station: 55.
44. *Etheostoma* sp. "Upland snubnose" darter. Stations: 55, 58, 59.
45. *Percina nigrofasciata* (Agassiz). Blackbanded darter. Stations: 32, 55, 73, 75, 78.

COTTIDAE – SCULPINS

46. *Cottus carolinae* (Gill). Banded sculpin. Stations: 2, 3, 3A, 7, 8, 10, 19, 20, 23, 26, 32, 38-44, 46, 48, 49, 51, 53, 65, 72-77, 81, 82, 83.
47. *Cottus pygmaeus* (Williams). Pygmy sculpin. Approximately 30 specimens of the pygmy sculpin were captured and released at Coldwater Spring, the type-locality for this species. Several springs which appeared physically similar to Coldwater Spring were collected but no pygmy sculpins were found. Station: 30.

COLLECTING STATIONS

1. Coldwater Creek, sec 32, T 16S, R 7E, approximately 150 meters up-stream from U.S. Hwy 78 bridge. Species: 5, 6, 11, 16, 21, 29, 38.

1A. Coldwater Creek, sec 32, T 16S, R 7E, approximately 300 meters up-stream from U.S. Hwy 78 bridge. Species: 3, 5, 11, 20.
1B. Coldwater Creek, sec 32, T 16S, R 7E, approximately 400 meters up-stream from U.S. Hwy 78 bridge. Species: 11.
1C. Coldwater Creek, sec 32, T 16S, R 7E, approximately 500 meters up-stream from U.S. Hwy 78 bridge. Species: 42.
2. Everett's Spring, NW 1/4 of sec 21, T 16S, R 6E. Species: 24, 27, 29, 46.
3. Blue Eye Spring, sec 6, T 16S, R 6E. Species: 5, 20, 27, 46.
3A. Blue Eye Spring, sec 6, T 16S, R 6E. Species: 5, 10, 27, 29, 46.
4. Oxford Spring Lake and runoff, sec 29, T 16S, R 8E. Species: 27, 34, 39.
5. Talley Spring, sec 11, T 16S, R 9E. Species: 27.
5A. Talley Spring, sec 11, T 16S, R 9E. Species: 27, 29.
6. Joseph Spring, sec 27, T 15S, R 9E. Species: 10, 14, 15, 20, 29, 34, 37, 41.
6A. Joseph Spring, sec 27, T 15S, R 9E. Species: 20.
7. Germania Spring, sec 36, T 13S, R 8E. Species: 19, 20, 46.
8. Cedar Spring, sec 18, T 14S, R 8E. Species 5, 20, 21, 27, 41, 46.
9. Angle Spring, NW 1/4, sec 8, T 14S, R 8E. Species: 34.
10. Seven Springs, sec 36, T 13S, R 7E. Species: 41, 46.
11. Crystal Springs, sec 33, T 13S, R 7E. Species: 39.
12. Unnamed spring-fed pond, sec 31, T 15S, R 6E. Species: 27, 29, 33.
13. Unnamed spring-fed pond, sec 32, T 15S, R 6E. Species: 27, 29.
14. Unnamed spring, sec 18, T 15S, R 6E. Species: 27, 29.
15. Sulphur Spring, sec 30, T 15S, R 6E. Species: 33.
16. Boling Spring, sec 8, T 15S, R 6E. Species: 13, 20.
17. Winn Spring, sec 20, T 14S, R 6E. Species: 13, 27, 29, 33, 41.
18. T.T. McCullars' Spring distributary, sec 25, T 14S, R 6E. Species: 1, 27, 29, 33.
18A. T. T. McCullars' Spring distributary, sec 25, T 14S, R 6E. Species: 27, 29, 33.
19. Guthrie Spring, sec 29, T 14S, R 6E. Species: 27, 41, 46.
19A. Guthrie Spring, sec 29, T 14S, R 6E. Species: 5, 13, 25, 27, 29, 39, 41.
20. Unnamed springs, sec 28, T 14S, R 7E. Species: 27, 46.
21. Plumb Spring, sec 20, T 16S, R 6E. Species: 27, 29, 33, 39.
22. Unnamed spring distributary, sec 27, T 14S, R 6E. Species: 13, 20, 27, 32.
23. Alexandria Spring, sec 34, T 14S, R 7E. Species: 5, 20, 21, 27, 29, 30, 33, 41, 46.
24. Unnamed spring distributary, sec 7, T 15S, R 6E. Species: 5, 20, 27, 33.
25. H.T. McCullars' Spring, sec 31, T 14S, R 7E. Species: 4, 9, 29, 34, 35, 39.
26. Unnamed spring distributary, sec 1, T 14S, R 7E. Species: 36, 41, 46.
27. Blue Spring, sec 15, T 15S, R 8E. Species 5, 18, 27, 33, 39.
28. Whites Gap Spring, sec 9, T 14S, R 9E. Species: None collected.
29. Unnamed spring distributary, sec 9, T 14S, R 8E. Species: 20, 29, 39.
30. Coldwater Spring, sec 29, T 16S, R 7E. Species: 5, 20, 21, 33, 42, 47.
31. Big Spring, sec 14, T 14S, R 8E. Species: 5, 19.
32. Maxwellborn Spring, sec 24, T 13S, R 9E. Species: 19, 27, 34, 41, 45, 46.
33. Jack Dunn Spring, sec 27, T 16S, R 6E. Species: 20, 27, 39.
34. Unnamed spring distributary, sec 27, T 16S, R 6E. Species: 5, 7, 14, 24, 27, 33, 34, 39.
35. Boiling Springs, sec 27, T 16S, R 8E. Species: none collected.
36. Unnamed spring distributary, sec 24, T 14S, R 8E. Species: 20.
37. Unnamed spring at distributary, sec 27, T 16, T 6E. Species: 27.
38. Unnamed spring at Piedmont City Park, sec 5, T 13S, R 10E. Species 5, 21, 27, 46.
39. Smith Spring, sec 35, T 12S, R 10E. Species: 5, 20, 27, 33, 46.
40. Smart Spring, sec 33, T 12S, R 10E, 1.3 miles N U.S. 278, near Northside Baptist Church. Species: 27, 34, 42, 46.
41. Todd Spring, S1/2 sec 28, T 12S, R 10E, 1.3 miles N U.S. 278 past Northside Baptist Church. Species: 5, 8, 20, 27, 28, 34, 42, 46.
42. Read's Spring, sec 27, T 13S, R 7E. Species: 5, 14, 33, 41, 46.
43. Blue Pond Spring, sec 26, T 13S, R 7E. Species: 14, 20, 41, 46.
44. Tolbert Spring, SW 1/4, sec 22, T 14S, R 8E. Species: 20, 46.
45. Unnamed spring distributary, sec 19, T 13S, R 9E. Species: none collected.
46. Holders Spring, sec 25, T 13S, R 8E. Species: 27, 46.
47. Unnamed spring, sec 6, T 13S, R 9E. Species: 19, 20, 29, 41.
48. Bennefield Spring, sec 32, T 12S, R 9E. Species: 27, 29, 46.
48A. Bennefield Spring, sec 32, T 12S, R 9E. Species: 27, 36.
49. Unnamed spring, sec 33, T 12S, R 9E. Species: 15, 19, 20, 36, 46.
50. Nance Spring, sec 25, T 15S, R 5E. Species: 5, 17, 27, 33, 34.
51. Unnamed spring distributary, sec 30, T 13S, R 9E. Species: 46.
52. Unnamed spring distributary, sec 30, T 13S, R 9E. Species: 21, 33.
53. Unnamed spring, sec 30, T 13S, R 9E. Species: 15, 19, 20, 27, 46.
54. Unnamed spring distributary, sec 33, T 12S, R 9E. Species: 15, 19, 20.
55. Unnamed spring distributary, W 1/2, sec 3, T 16S, R 9E. Species: 5, 7, 8, 12, 14, 21, 43, 44, 45.
56. Unnamed spring tributary, sec 34, T 14S, R 9E. Species: 7, 15, 20, 27.
57. Cheatwood Spring, sec 33, T 14S, R 9E. Species: 14, 20, 33.
58. Unnamed spring distributary, sec 6, T 16S, R 10E. Species: 7, 18, 37, 44.
59. Unnamed spring distributary, sec 24, T 15S, R 9E. Species: 20, 29, 37, 44.
60. Unnamed spring distributary, sec 30, T 15S, R 9E. Species: 19, 20.
61. Unnamed spring distributary, W 1/2, sec 30, T 15S, R 9E. Species: 19, 20.
62. Braswell Spring, sec 4, T 15S, R 6E. Species: 20, 29.
63. Unnamed spring, sec 35, T 14S, R 6E. Species: 15, 20, 29, 33, 41.
64. Unnamed spring distributary, sec 35, T 14S, R 6E. Species: 5, 8, 9, 15, 19, 20, 34.
65. Williams Spring, sec 2, T 14S, R 8E. Species: 15, 19, 20, 21, 46.
66. Hoague Spring, sec 21, T 13S, R 9E. Species: 33.
67. Miller's Spring, sec 22, T 16S, R 6E. Species: 27, 29, 33.
68. Russ Spring, sec 28, T 16S, R 6E. Species: 34, 39.
69. Sloup Spring, sec 35, T 14S, R 8E. Species: 5, 27.
70. Fourmile Spring, S 1/2, sec 35, T 14S, R 8E. Species 20.
71. Unnamed spring distributary, sec 9, T 14S, R 9E. Species: 20, 29, 34.

The following stations were collected by M.F. Mettee and P.E. O'Neil from 24 May 1979 to 11 October 1979 on the Fort McClellen Military Reservation.

72. Willett Spring, sec 13, T 15S, R 6E. Species: 2, 4, 5, 11, 13, 15, 20, 21, 24, 27, 31, 33, 40, 46.
73. Unnamed spring distributary, sec 18, T 15S, R 7E. Species: 4, 5, 11, 12, 15, 18, 21, 29, 31, 33, 34, 36, 39, 41, 45, 46.
74. Unnamed spring distributary, sec 18, T 15S, R 6E. Species: 5,

12, 15, 16, 20, 21, 33, 34, 35, 39, 41, 46.

75. Willett Spring, sec 13, T 15S, R 6E. Species: 5, 15, 16, 20, 21, 23, 27, 29, 33, 36, 37, 45, 46.
76. Unnamed spring distributary, sec 36, T 15S, R 9E. Species: 4, 5, 7, 18, 20, 29, 33, 41, 46.
77. Unnamed spring distributary, sec 27, T 15S, R 9E. Species: 5, 7, 20, 21, 37, 41, 46.
78. Unnamed spring distributary, sec 35, T 15S, R 9E. Species: 5, 7, 15, 20,21, 22, 26, 34, 37, 41, 45.
79. Tributary from Willis Spring, sec 23, T 15S, R 9E. Species: 5, 15, 20, 27, 29, 33.
80. Unnamed spring distributary, sec 22, T 15S, R 6E. Species: 4, 5, 11, 12, 15, 20, 21, 25, 29, 37, 41.
81. Unnamed spring distributary, sec 28, T 15S, R 6E. Species: 5, 15, 19, 20, 21, 29, 33, 41, 46.
82. Unnamed spring distributary, sec 30, T 15S, R 7E. Species: 5, 15, 21, 46.
83. Unnamed spring distributary, sec 20, T 15S, R 7E. Species: 20, 37, 46.

DISCUSSION

Eighty-three springs or spring distributaries in Calhoun County, Alabama, were surveyed to determine the diversity and distribution of the ichthyofauna. Forty-five species and two hybrids belonging to twenty-four genera and eleven families were collected. An average of 5.3 species were taken from each station. Three springs, however, yielded no fishes (Stations: 28, 35, 45). The modal number of species collected per station was 3, and one spring harbored 16 species (Station: 73). Considering all species collected, the following were the most commonly taken: *Semotilus atromaculatus* (43 stations), *Gambusia affinis* (38 stations), *Cottus carolinae* (33 stations), *Campostoma oligolepis* (31 stations), and *Lepomis macrochirus* (26 stations). Ten of the species collected were present at fifteen or more stations.

Many of the fishes are known to inhabit rivers, creeks and lakes as well as springs. Four species, however, seem to be restricted to springs or spring tributaries within the study area: *Cottus pygmaeus, Hemitremia flammea, Etheostoma ditrema* and *Rhinichthys atratulus*. *Rhinichthys atratulus* is not, however, restricted to springs in its range north of the study area. In terms of frequency of collection, the spring restricted species rank as follows: *R. atratulus* (12 stations); *E. ditrema* (4 stations); *H. flammea* (2 stations); and *C. pygmaeus* (1 station).

Cottus pygmaeus has the most geographically limited distribution of the spring restricted species. The pygmy sculpin was taken only at Station 30, Coldwater Spring, the type locality. Aside from this survey, several workers have made numerous collections within the Valley and Ridge Province in unsuccessful efforts to locate additional populations of *C. pygmaeus*.

The pygmy sculpin is relatively abundant in Coldwater Spring and in the effluent spring-creek immediately below the spring basin. On 26 September 1986,30 specimens were collected in the spring run and others were observed in the spring basin. Mature individuals were collected in the spring run for approximately 100 meters downstream. At this point, the effluent run of the spring confluences with an unnamed creek. Formerly this creek was visibly polluted (per. comm. R.A. Stiles); however, now the creek appears to be pollution free. Almost certainly this creek checked the downstream advancement of *C. pygmaeus* with its warmer water and pollutants. Sampling continued for approximately 50 meters beyond the point of confluence and no specimens of *C. pygmaeus* were collected.

As a result of this study, range extensions for the following species were noted: *H. flammea, E. ditrema, Lepomis humilis* and *Notropis texanus*. Prior to this study the range of *H. flammea* in Alabama was thought to be limited to springs and clear tributaries in the Tennessee River system, plus the previously mentioned spring tributary to Kelly Creek near Talladega, AL. This survey revealed the presence of two populations of *H. flammea* within the study area: Blue Eye Spring (Station 3A) and Joseph Spring (Station 6).

Within the study area *Etheostoma ditrema* was historically present in Martin Spring (now inundated by Weiss Lake) and Coldwater Spring. Thorough sampling of the immediate effluent run of Coldwater Spring revealed the presence of only three specimens of *E. ditrema*. Later collections of Coldwater Creek approximately 400 meters downstream from the spring basin fortuitously produced one specimen of the coldwater darter.

Two new populations of *E. ditrema* were located in Calhoun County: Smart Spring (Station 40) and Todd Spring (Station 41). The new localities for the coldwater darter increase the number of known populations of this species in Alabama to only five (Glencoe Spring and Waxahatchee Creek being additional populations, Ramsey et al, 1986). However, considering the status of this fish, any range extension of *E. ditrema* is significant since this darter has been classified as threatened by Deacon et al. (1979). A more recent treatment of threatened vertebrates in Alabama place *E. ditrema* in a category of special concern (Ramsey et al. 1986).

Lepomis humilis was not previously known from the Coosa River drainage; the most probable explanation for the occurrence of this species in the Coosa River drainage is pond stocking.

Notropis texanus is exceedingly rare above the Fall Line (Smith-Vaniz, 1968). Only one specimen of the weed shiner was collected, from a large sandy bottomed spring run. This represents a new record for the species above the Fall Line.

Only one undescribed species was collected during this study– the "upland snubnose" darter, *Etheostoma* sp. A total of 13 specimens were taken from three large spring tributaries in the mountains of the Talladega National Forest (Stations: 55,58,59).

In summary, Calhoun County appears to support a diverse assemblage of spring dwelling fishes, some of which occur in relative abundance. The forty-five species reported in this study represents a thorough sampling of the ichthyofauna of the spring habitat of the area. While it is assuring to see the diversity of species within the study area and to locate undiscovered populations, it must be noted that many species (such as *Etheostoma trisella* and *Cottus pygmaeus*) possibly have been exterminated in the county, or reduced in numbers, due to human activities. It has, therefore, become important to protect the natural spring habitat and the associated species that remain within Calhoun County. Consequently, a practical plan of protection and conservation should be initiated to protect the fragile spring ecosystem and the inhabitants it supports.

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NEWS NOTE

VIDEO DOCUMENTARIES of reproductive behaviors of North American cyprinids are now available through the University of Richmond.

1. *Reproductive Behaviors of the Creek Chub,* 13-min
2. *Spawning Nests of the Bluehead Chub,* 14-min
3. *Nocomis – The Spawning Fish* 13-min
4. *Were They Accurate? Comparison Between Journal Accounts and Video Recordings of Reproductive Behaviors of Selected Cyprinids*

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PEBBLE-NESTS OF FOUR *SEMOTILUS* SPECIES

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Abstract – The pebble-nest microhabitats of four species of *Semotilus* were compared. Pit/mound nests of *Semotilus corporalis* were significantly larger than the pit/ridge nest of *Semotilus atromaculatus*, *Semotilus lumbee*, and *Semotilus* sp. Nests of *S. corporalis* were in wider and deeper streams. Pits of *S. lumbee* nests were longest of the four species; those of *S. corporalis* were widest and deepest. There was no significant difference by weight in the electivity index (percentage of nest pebble sizes versus those of the substrate) among the species for the three largest stone sizes (6.0, 11.3, and 23.0 mm). Although the greatest percentage of stones in the nests of *S. corporalis* were 23 mm, they did not represent the greatest electivity index as that stone size had a high percentage in the substrate. Mounds and ridges of pebble nests served as breakwaters, reducing the flow to near zero in the downstream spawning pit below the ridge or mound of the nest.

INTRODUCTION

Males of four species of *Semotilus* (Cyprinidae) build spawning nests by placing pebbles in mounds or ridges at the head of riffles in clear montane, Piedmont or upper Coastal Plain streams. *Semotilus corporalis* (fallfish) has been considered a pit/mound nest builder. The other three species, *Semotilus atromaculatus* (creek chub), *Semotilus lumbee* (Sandhills chub), and *Semotilus* sp. (= *Semotilus thoreauianus* of Woolcott and Maurakis, 1988), are closely related pit/ridge nest builders. The latter, a diminutive form (adult males approximately one-half the length of adult male *S. atromaculatus*) collected and studied primarily in northeastern Georgia, is tentatively identified as *Semotilus* sp. until its systematics can be reconciled.

Prior to spawning, mounds of *S. corporalis* nests are built by a breeding adult male that excavates an area and later fills it with stones (Raney, 1969). Although this species has not been observed constructing nests following the spawning act as is characteristic of the creek chubs, we have found fallfish eggs covered by pebbles immediately upstream of the pit of a mature nest under construction by the male. Male creek chubs begin a nest by digging a pit and placing the pebbles from it at the pit's upstream margin. Following spawning, the male moves pebbles from the downstream end of the pit and puts them over the eggs deposited in the upstream end of the pit. Thus, as spawning continues, the ridge increases in length and the pit is displaced downstream (Woolcott and Maurakis, 1988).

As most studies of nest construction have been limited to generalized descriptions of nests (e.g. overall dimensions), an objective of this study was to compare the materials and construction of the nests among four species of *Semotilus*. A second objective was to examine the effects of the physical characteristics of pebble-nests on water currents in spawning pits.

MATERIALS EXAMINED

The collection number, number of nests (in parentheses), drainage, locality, and date for *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. are:

Semotilus atromaculatus. Virginia: EGM-VA-106 (1), Rappahannock, Fauquier Co., unnamed tributary of Thumb Run at Co. Rt. 688, 300 yds. upstream from bridge, 7 May 1983. EGM-VA-107 (2), Rappahannock, Fauquier Co., Carter Run at Co. Rt. 688 bridge, 7 May 1983. EGM-VA-115 (1), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd., 0.75 mi. E of I-395, 21 April 1984. EGM-VA-116 (3), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd. 0.75 mi. E of I-395, 21 April 1984. EGM-VA-117.1 (1), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd. 0.75 mi. E of I-395, 21 April 1984. EGM-VA-117.3 (1), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd. 0.75 mi. E of I-395, 21 April 1984. EGM-VA-209 (2), Potomac, Fairfax Co., unnamed tributary of Indian Run, 0.5 mi. E of I-395 jct. with Edsal Rd., 23 April 1988. WSW-VA-365 (1), James, Appomattox Co., small drainage near jct. St. Rt. 24 and Co. Rt. 627 opposite Appomattox National Park, 15 May 1987. WSW-VA-369 (1), York, Hanover Co., tributary of Falling Cr. at Co. Rt. 667 approximately 2 mi. N of Ashland, 23 May 1987. Maryland: EGM-MD-121 (1), Potomac, Montgomery Co., unnamed creek of Monocacy R. on Rt. 28, 0.5 mi. from turnoff to PEPCO Dickerson Plant, 13 May 1984.

Semotilus corporalis. Virginia: EGM-VA-54 (2), Rappahannock, Madison/Green Co. line, Conway R. at Co. Rt. 667 and Rt. 613 bridge, 16 May 1982. EGM-VA-108 (2), Rappahannock, Fauguier Co., Great Run at St. Rt. 211 bridge, 4 mi. W of Warrenton, 7 May 1982. WSW-VA-381 (2), James, Campbell Co., Opossum Cr. at bridge on Co. Rt. 669, 1 mi. S of Co. Rt. 664, 9 May 1988.

Semotilus lumbee. North Carolina: EGM-NC-104.1 (1), EGM-NC-105 (1), EGM-NC-208 (3), Peedee, Moore Co., tributary of Drowning Cr. on Co. Rt. 1122, 2.3 mi. W of jct. with Co. Rt. 1004 at Foxfire, 25 April 1982, 16 April 1983, 16 April 1988, respectively.

Semotilus sp. Georgia: EGM-GA-199 (1), Savannah, Stephens Co., Gibson Branch on Ray Rice's farm St. Rt. 124, 13 April 1986. EGM-GA-204 (1), Altamaha, Barrow Co., tributary of Mulberry Cr. on W. C. Wade's farm on St. Rt. 211, 3 mi. W of Winder, 11 April 1987. EGM-GA-207 (3), Altamaha, Barrow Co., tributary of Mulberry Cr. on W. C. Wade's farm on St. Rt. 211, 3 mi W of Winder, 10 April 1988. EGM-GA-208 (1), Savannah, Stephens Co., Zebulon Branch, tributary of N. Fork Broad R. on Ray Rice's property, approximately 1.5 mi. from jct. Rt. 124, N of Toccoa, 11 April 1988.

METHODS

Morphological and meristic characteristics of *Semotilus* sp. are compared with those described for *Semotilus thoreauianus* by Jordan (1877) (Table 1).

Pebble nests were collected from streams in Georgia, North Carolina, and Virginia in April, May, and June from 1982 through

1988. The total number of nests were: *S. atromaculatus*, 14; *S. corporalis*, 6; *S. lumbee*, 5; and *Semotilus* sp., 6.

Table 1. Characteristics of 10 specimens of *Semotilus* sp. compared with *Semotilus thoreauianus* of Jordan (1877).

Character	sp.	*thoreauianus*
Body	robust, short	robust, short
Head	short, round	short, round
Tubercles	8 (anterior bilobed)	8 (anterior bilobed)
Fin rays		
Dorsal	8	8
Anal	8	7
Dorsal position	behind pelvic origin	behind pelvic origin
Pelvic length	reaches vent	short of vent
Pectoral	short	short
Scales		
LL	49.3 (48-51)	48
Above LL	9.2 (9-10)	9
Below LL	6	5

Pebble samples from nests were collected from the upstream, middle, and downstream portions of ridges and mounds. Substrate samples were restricted to the area adjacent to ridges except for those for *S. corporalis* where additional random samples of the substrate were collected as far as 20 m from the nest. Nest and substrate samples were stored in tagged plastic bags and returned to the laboratory for analysis. Pebbles were air-dried and sifted through five custom-built wire sieves. Mesh sizes, restricted to commercially available prefabricated screen sizes were 23.0 mm, 11.3 mm, 6.0 mm, 2.5 mm, and 0.8 mm. Material that sifted through the smallest size mesh was collected in a pan. The weight of material in each sieve was used to calculate the percentage of material per mesh size. Hereafter, all references to percentage of mesh size classes are based on weights.

Fishes over nests were collected with a pulsed DC electroshocker, preserved in 10 percent formalin, measured to SL, and stored at the University of Richmond.

Stream depth (cm), width (m), and temperature (C) were recorded. The velocity of water currents (1 cm above nests and 1 cm above substrates) measured with a Marsh-McBirney current meter were recorded 0.5 m upstream of the ridge, 0.5 m downstream of the ridge, above the ridge, and in the spawning pit. Ridge length, height, and width; and pit depth, length, and width of each nest were measured and used to calculate mean values for each parameter. The Froude number (Davis and Barmuta, 1989) was used for the classification of mean stream flows. The equation, Froude no. $= S\frac{U}{gD}$ [where U = water velocity, g= acceleration due to gravity (9.8 m/ sec^2), and D = depth] was calculated for flows before the nest, above the ridge or mound, and in the pit. Near stream bed flow, expressed as ratios k/L, D/k, and D/j (where k = ridge height, D = water depth, L = ridge length + pit length, and j = pit length) were calculated following Davis and Barmuta (1989).

An electivity index (Ivlev, 1961) was calculated for each pebble size class per nest of each species.

The equation $E = \frac{(r_1 - p_1)}{(r_1 + p_1)}$ (where E = pebble size selection, r = percentage of a particular pebble size in the nest, and p = the percentage of a particular pebble size in the substrate of the stream) was used to determine if selection of pebble size from the substrate was nonrandom. Electivity index values range from 1 to – 1. Values closer to 1 indicate a greater selection of a particular pebble size. Percentages and electivity index values were transformed to arcsin equivalents. Average values of electivities, percent pebble composition of nests, and stream dimensions, derived from analysis of variance (ANOVA), were compared between and within species with Duncan's Multiple Range Test (alpha = 0.05; Steel and Torrie, 1980). Backward stepwise regression (SAS, 1985) was used to examine relationships of water current in pits to physical dimensions of the nests and streams.

RESULTS

Nests of *S. corporalis* were in significantly deeper ($\bar{x}$, 52.7 cm) and wider ($\bar{x}$, 5.7 m) streams than were those of other *Semotilus* species (Table 2). Water temperature at active nests for all species ranged from a mean of 13.2 C (*S. atromaculatus*) to 15.0 C (*Semotilus* sp.). Differences were not significant (Table 2). The nonadhesive, demersal eggs were found in nests of all species.

Table 2. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for stream characteristics among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA	
Stream depth					df	F
Species	sp.	*atromaculatus*	*lumbee*	*corporalis*		
Mean (cm)	12.5	15.5	20.7	52.7	26	7.87
Stream Width						
Species	sp.	*lumbee*	*atromaculatus*	*corporalis*		
Mean (m)	1.7	1.9	2.7	5.7	30	24.2
Water Temp.						
Species	*atromaculatus*	*lumbee*	*corporalis*	sp.		
Mean (C)	13.2	13.3	14.7	15.0	30	1.11
Range (C)	11.1-16.7	12.5-16.1	13-15.6	10-17		

Approximately 83% of the pebbles in nests of *S. corporalis* were in size class 23.0 mm. (49.3%) or 11.3 mm (33.6%) (Table 3). Average percentage of pebbles in the 11.3 mm size class followed by those of the 6.0 mm size class were high in nests of *S. atromaculatus* (38.5% and 23.0%, respectively), *S. lumbee* (48.7% and 33.5%, respectively), and *Semotilus* sp. (31.2% and 25.1%, respectively) (Table 3).

Nests of the largest of the four species, *S. corporalis* (♂ 128.9-265.7 mm), had a significantly greater number of 23.0 mm pebbles than those of the other species. Mean percentage of 11.3 mm pebbles in nests of intermediate sized *S. lumbee* (♂ 129.1-185 mm) were significantly greater than those of *S. corporalis* and the smallest species, *Semotilus* sp. (♂ 67.1-67.5 mm). *Semotilus lumbee* nests also had the greatest percentage of 6.0 mm pebbles but differed significantly only form those of *S. corporalis*. *Semo-*

Table 3. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average percentage of nest material according to size class (mm) within *Semotilus atromaculatus, Semotilus corporalis, Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

							ANOVA df	ANOVA F
S. corporalis								
Stone size	<0.8	0.8	2.5	6.0	11.3	23.0		
Mean	0.20	0.60	4.6	11.8	33.6	49.3	6	15.57
S. atromaculatus								
Stone size	<0.8	0.8	2.5	23.0	6.0	11.3		
Mean	2.6	5.1	15.3	15.7	23.0	38.5	6	28.99
S. lumbee								
Stone size	<0.8	0.8	23.0	2.5	6.0	11.3		
Mean	0.70	1.7	6.8	8.6	33.5	48.7	12	52.42
Semotilus sp.								
Stone size	<0.8	0.8	23.0	2.5	6.0	11.3		
Mean	6.3	7.2	10.1	14.0	25.1	31.2	18	12.44

tilus atromaculatus (♂ 130-145.2 mm) and *Semotilus* sp. nests had similar high percentages of 2.5 mm pebbles and were significantly different from those of *S. corporalis*. Percentages of 0.8 mm pebbles in the nests of *Semotilus* sp. and *S. atromaculatus* were significantly greater than those for the other two species. The average percentage of particles less than 0.8 mm in nests of *Semotilus* sp. was greater than those for other species (Table 4).

Table 4. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average percentage of nest material according to size class (mm) among *Semotilus atromaculatus, Semotilus corporalis, Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differe significantly (alpha = 0.05).

					ANOVA df	ANOVA F
23.0						
Species	*lumbee*	sp.	*atromaculatus*	*corporalis*		
Mean	6.8	10.0	15.7	49.3	7	11.8
11.3						
Species	sp.	*corporalis*	*atromaculatus*	*lumbee*		
Mean	31.2	33.6	38.5	48.7	7	4.1
6.0						
Species	*corporalis*	*atromaculatus*	sp.	*lumbee*		
Mean	11.8	23.0	25.0	33.5	7	4.1
2.5						
Species	*corporalis*	*lumbee*	sp.	*atromaculatus*		
Mean	4.6	8.6	14.0	15.3	7	5.1
0.8						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	0.6	1.7	5.1	7.2	7	14.7
<0.8						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	0.2	0.7	2.6	6.3	7	19.1

Substrate material at nests of *S. corporalis* was comprised of 61.1% of the 23.0 mm size class pebbles. In all other size classes, the percentage of substrate material at *S. corporalis* nests was lowest of the four species (Table 5).

Table 5. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average percentage of substrate material according to size class (mm) among *Semotilus atromaculatus, Semotilus corporalis, Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
23.0						
Species	*lumbee*	*atromaculatus*	sp.	*corporalis*		
Mean	2.5	6.8	8.9	61.1	7	13.3
11.3						
Species	*corporalis*	*atromaculatus*	sp.	*lumbee*		
Mean	19.8	24.9	25.7	33.6	7	1.6
6.0						
Species	*corporalis*	sp.	*atromaculatus*	*lumbee*		
Mean	10.9	15.7	17.7	25.1	7	4.1
2.5						
Species	*corporalis*	sp.	*lumbee*	*atromaculatus*		
Mean	4.8	10.4	13.2	14.8	7	5.6
0.8						
Species	*corporalis*	sp.	*lumbee*	*atromaculatus*		
Mean	1.5	7.3	8.9	9.8	7	9.6
<0.8						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	1.8	16.7	26.0	32.0	7	13.4

Electivity indices were highest for pebbles in size classes 11.3 and 6.0 mm in all four species (Tables 6 and 7). *Semotilus atromaculatus* selected significantly more 23.0 mm pebbles than pebbles 2.5 mm and smaller. Although 23.0 mm size pebbles were most abundant in *S. corporalis* nests (Table 3), they did not have a high electivity index as they also were most abundant in the substrate. Numbers of pebble sizes (6.0, 11.3, and 23.0 mm) selected by *S. lumbee* were similar. There were no significant differences among the size classes 0.8 to 23.0 mm selected by *Semotilus* sp. (Table 6).

Mean electivity indices among species did not differ significantly for nest pebbles in the 23.0, 11.3, and 6.0 mm size classes. Except for *Semotilus* sp., no species selected stones less than 2.5 mm (Table 7).

Mean ridge length of *S. lumbee* nests was greatest but differed significantly only from that of *Semotilus* sp. nests. Average mound width and height of *S. corporalis* nests were significantly greater than the ridges of nests of the other three species (Table 8).

Average pit depths and widths of *S. corporalis* nests were significantly greater than those of nests of *S. atromaculatus* and *Semotilus* sp. Mean pit length of *S. lumbee* nests was significantly greater than that of the nest of S. *atromaculatus* (Table 8).

Table 6. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average electivity according to size class (mm) within *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

							ANOVA df	ANOVA F
S. atromaculatus								
Size Class	<0.8	0.8	2.5	6.0	11.3	23.0		
Mean	–0.90	–0.30	0.0	0.10	0.20	0.50	6	14.7
S. corporalis								
Size Class	<0.8	0.8	23.0	2.5	6.0	11.3		
Mean	–0.80	–0.50	–0.10	–0.02	0.03	0.30	6	9.9
S. lumbee								
Size Class	<0.8	0.8	2.5	6.0	11.3	23.0		
Mean	–0.90	–0.70	–0.20	0.20	0.20	0.30	12	25.5
Semotilus sp.								
Size Class	<0.8	0.8	11.3	2.5	6.0	23.0		
Mean	–0.70	0.07	0.10	0.10	0.20	0.50	18	4.0

Table 7. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average electivity according to size class (mm) among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
23.0						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	–0.10	0.30	0.50	0.50	7	0.44
11.3						
Species	sp.	*lumbee*	*atromaculatus*	*corporalis*		
Mean	0.10	0.20	0.20	0.30	7	0.67
6.0						
Species	*corporalis*	*atromaculatus*	*lumbee*	sp.		
Mean	0.03	0.10	0.20	0.20	7	1.63
2.5						
Species	*lumbee*	*corporalis*	*atromaculatus*	sp.		
Mean	–0.20	–0.02	0.00	0.10	7	3.66
0.8						
Species	*lumbee*	*corporalis*	*atromaculatus*	sp.		
Mean	–0.70	–0.50	–0.30	0.07	7	12.71
<0.8						
Species	*lumbee*	*atromaculatus*	*corporalis*	sp.		
Mean	–0.90	–0.90	–0.80	–0.70	7	4.71

Table 8. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for nest characteristics (cm) among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
Ridge length						
Species	sp.	*atromaculatus*	*corporalis*	*lumbee*		
Mean	35.2	68.6	81.6	96.2	28	2.6
Ridge width						
Species	sp.	*atromaculatus*	*lumbee*	*corporalis*		
Mean	18.2	21.6	28.0	60.9	28	26.8
Ridge height						
Species	sp.	*atromaculatus*	*lumbee*	*corporalis*		
Mean	4.0	4.2	6.9	38.1	27	8.3
Pit depth						
Species	*atromaculatus*	sp.	*lumbee*	*corporalis*		
Mean	6.7	7.6	9.4	14.5	25	1.8
Pit length						
Species	*atromaculatus*	*corporalis*	sp.	*lumbee*		
Mean	21.3	32.0	32.1	36.3	25	4.0
Pit width						
Species	*atromaculatus*	sp.	*lumbee*	*corporalis*		
Mean	16.2	25.5	29.6	39.0	24	6.1

Average velocity of water current over and near nests of all four species was similar with two exceptions: current velocity over the crest of the mounds of *S. corporalis* nests was significantly greater than that over the crest of ridges of *S. atromaculatus* nests; and average current downstream of *S. lumbee* nests was significantly greater than those of *S. atromaculatus* and *Semotilus* sp. (Table 9). In nests of all species, average current velocity in the pit was significantly less than average current velocity at other points on or near nests (Table 10). Ridge length and height, and water depth were the three physical factors associated with reduced water currents in the pit (Table 11). Froude number($\bar{x}$ range = 0.015 – 0.035) in the pit was lower than values in the stream ($\bar{x}$ range = 0.074 – 0.111) or over the ridge or mound ($\bar{x}$ range = 0.120 – 0.394) (Table 12). The ratios k/L and D/j never exceeded 1.0 for nests of all species. The mean D/k ration (0.610) for *S. corporalis* nests was lower than that (4.334 – 5.595) for nests of other *Semotilus* species.

DISCUSSION

Our study is the first to quantitatively analyze the construction and composition of spawning nests of nest-building species of *Semotilus*. Previously, investigators have given limited measurements and descriptions of the physical characteristics and composition of nests (Reighard, 1910; Moshenko and Gee, 1973; Ross, 1983; and Copes, 1978).

Southeastern Fishes Council

PROCEEDINGS

DEDICATED TO THE PRESERVATION OF SOUTHEASTERN FISHES

Number 22 October 1990

FISHES OF SPRINGS AND SPRING-FED CREEKS OF CALHOUN COUNTY, ALABAMA

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Abstract – A survey of the fish fauna inhabiting the springs and spring-fed creeks of Calhoun County, Alabama, was conducted between May, 1986 and February, 1987. Additional data were obtained from collections made prior to this study on the Fort McClellan Military Reservation, a limited access area. Forty-five species and two hybrids representing 24 genera and 11 families were collected from 83 stations.

New populations of *Hemitremia flammea* and *Etheostoma ditrema* were discovered. Range extensions were documented for *Notropis texanus*,*Lepomis humilis,* and the undescribed "upland snubnose" darter, *Etheostoma sp*.

INTRODUCTION

Calhoun County, Alabama, possesses an abundant supply of ground water much of which surfaces in the form of springs. These springs range in size from small seepage areas to large thrust fault springs. The largest spring in the county is Coldwater Spring, with a minimum daily discharge of 32 million gallons (Warman and Causey, 1962). Ichthyologists from various universities and government agencies have made relatively few collections of the spring ichthyofauna within Calhoun County; however, some important discoveries have been made within the area. The pygmy sculpin, *Cottus pygmaeus* (Williams, 1968), and a rare darter *Etheostoma ditrema* (Ramsey and Suttkus, 1965), were discovered in Coldwater Spring near Anniston, AL. And, in nearby Talladega County, specimens of the flame chub, *Hemitremia flammea*, were discovered in a spring tributary of Kelley Creek (Smith-Vaniz, 1968). These important ichthyological findings, coupled with the fact that springs throughout much of north Alabama serve as habitats for spring restricted fishes, have led us to conduct a comprehensive ichthyofaunal survey within Calhoun County. Due to population growth and environmental pressures facing the numerous unique spring ecosystems within Calhoun County, we felt that an ichthyological survey was needed immediately. The purpose of this study is to document the diversity and distribution of the ichthyofauna of springs and spring-fed creeks of Calhoun County, AL, prior to any further environmental degradation.

The majority of Calhoun County is located within the Valley and Ridge Physiographic Province of northeastern Alabama. That portion of the county lying outside the Valley and Ridge Province parallels the Calhoun-Cleburne county line. This narrow strip of land is situated within the Ashland Plateau of the Piedmont Province. Topography is generally mountainous since the county is located within the foothills of the Appalachian Mountains. The Coosa River and its tributaries drain the county.

MATERIALS AND METHODS

Seventy-one collections of springs and spring distributaries were made from 20 May 1986 through 7 February 1987. All collections during this period were made by the authors. Additional data were obtained from 12 collections made by M.F. Mettee and P.E. O'Neil between 24 May 1979 and 11 October 1979. Data from these collections were utilized because the samples were made on the Fort McClellen Military Reservation, a restricted public access area.

All collections were made using either 4 or 6 foot minnow seines. All specimens were immediately preserved in 10% formalin and returned to the laboratory for identification.

Collecting stations are plotted on a dot distribution map of Calhoun County (Fig. 1). The collecting stations are in no particular order throughout the county. Two springs just outside Calhoun County were included since they were less than 100 meters from the county line.

The List of Species is presented below. Species are arranged alphabetically within a family. The families are arranged in the sequence proposed by Greenwood *et al.* (1966). The Collecting Stations section contains information concerning the location of each collecting station as well as the species collected at each station.

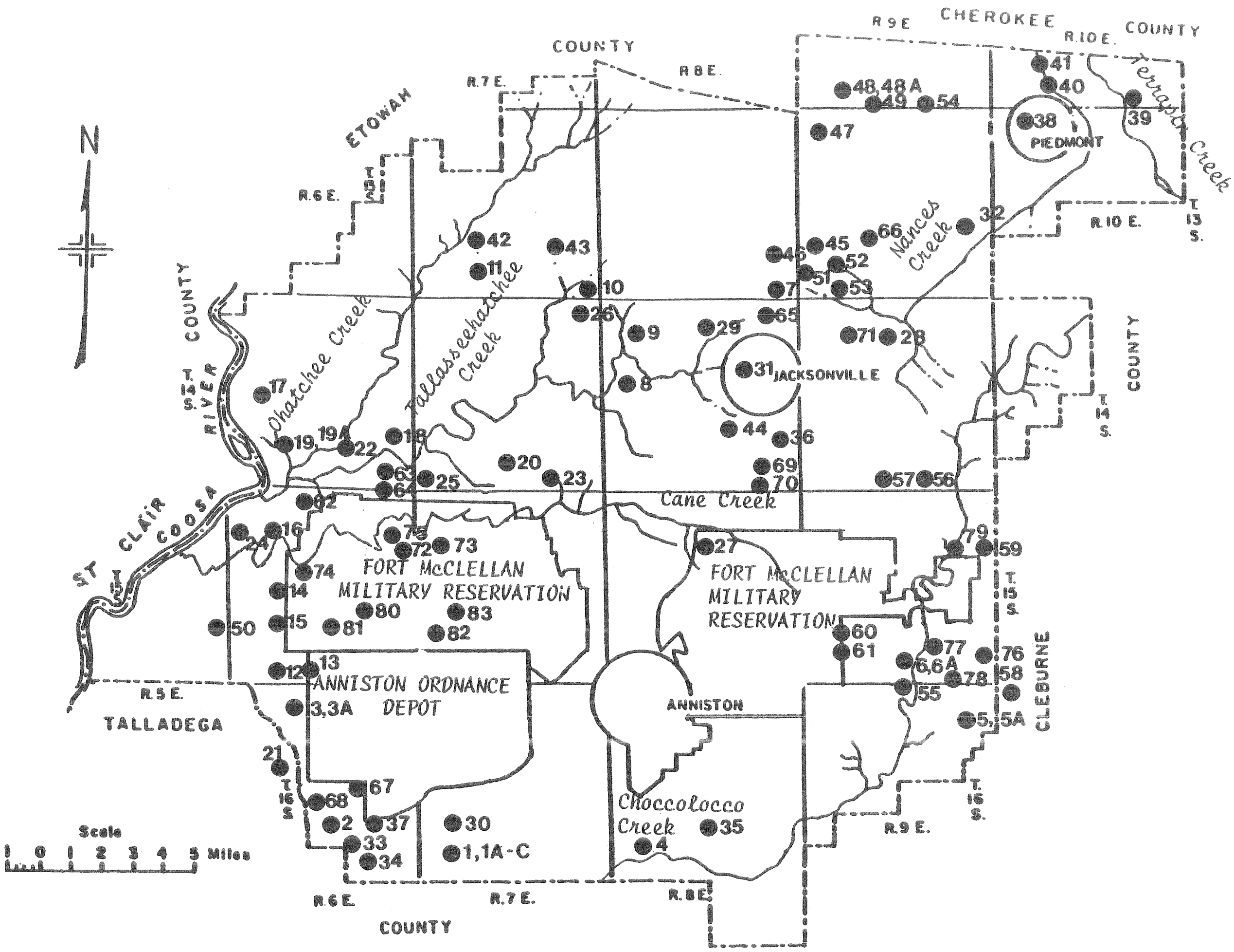

Figure 1. Map depicting collection stations within Calhoun County, AL. Base map from Warman and Causey, 1962

LIST OF SPECIES

CLUPEIDAE – HERRINGS

1. *Dorosoma petenense* (Gunther). Threadfin shad.
   Station: 18

SALMONIDAE – TROUT

2. *Salmo gairdneri* Richardson. Rainbow trout.
   Rainbow trout were introduced into Willett Spring for angling purposes. Station: 72.

ESOCIDAE – PIKES

3. *Esox americanus* Gmelin. Redfin pickerel.
   Station: 1A.
4. *Esox niger* Lesueur. Chain pickerel.
   Stations: 25, 72, 73, 76, 80.

CYPRINIDAE – MINNOWS

5. *Campostoma oligolepis* Hubbs and Green. Large scale stoneroller. Stations: 1, 1A, 3, 3A, 8 19A, 23, 24, 27, 30, 31, 34, 38, 39, 41, 42, 50, 55, 64, 69, 72 -82.
6. *Campostoma oligolepis* x *Luxilus chrysocephalus*.
   This single specimen apparently represents a natural intergeneric hybrid minnow. Although the hybrid was intermediate in some characteristics that differentiate the presumed parental species, it was closer morphologically to *Luxilus chrysocephalus* (Sizemore and Howell, 1987). Station: 1.
7. *Cyprinella trichroistius* (Jordan and Gilbert). Tricolored shiner. Stations: 34, 55, 56, 58, 76-78.
8. *Cyprinella venustus* (Girard). Blacktail shiner.
   Stations: 41, 55, 64.
9. *Cyprinus carpio* Linnaeus. Carp.
   Stations: 25, 64.
10. *Hemitremia flammea* (Jordan and Gilbert). Flame chub.
    Previous collections by many ichthyologists have revealed *H. flammea* at only one locality within the Mobile Basin – an

unnamed spring tributary to Kelly Creek, 4.5 miles northeast of Talladega along Hwy 21, Talladega County, AL (Smith-Vaniz, 1969). Two heretofore unknown populations of the flame chub were discovered within the study area. These populations are separated by approximately 24 miles. Blue Eye Spring, Station 3A, supported a healthy population of flame chubs. Joseph Spring, Station 6, produced only one specimen. Stations: 3A, 6.

11. *Luxilus chrysocephalus* (Rafinesque). Striped shiner. Stations: 1, 1A, 1B, 72, 73, 80.
12. *Lythrurus lirus* (Jordan). Mountain shiner. Stations: 55, 73, 74, 80.
13. *Notemigonus crysoleucas* (Mitchill). Golden shiner. Stations: 16, 17, 19A,22, 72.
14. *Notropis asperifrons* Suttkus and Ramsey. Burrhead shiner. Stations: 6, 34, 42, 43, 55, 57.
15. *Notropis chrosomus* (Jordan). Rainbow shiner. Stations: 6, 49, 53, 54, 56, 59, 63-65, 72-75, 78-82.
16. *Notropis stilbius* (Jordan). Silverstripe shiner. Stations: 1, 74, 75.
17. *Notropis texanus* (Girard). Weed shiner. The weed shiner is rare above the Fall Line (Swift, 1979). This record of *N. texanus* is a significant range extension above the Fall Line well into the upper Coosa River system. Station: 50.
18. *Notropis xaenocephalus* (Jordan). Coosa shiner. Stations: 27, 58, 73, 76.
19. *Rhinichthys atratulus* (Hermann). Blacknose dace. Stations: 7, 31, 32, 47, 49, 53, 54, 60, 61, 64, 65, 81.
20. *Semotilus atromaculatus* (Mitchill). Creek chub. Stations: 1A, 3, 6, 6A, 7, 8, 16, 22-24, 29, 30, 33, 36, 39, 41, 43, 44, 47, 49, 53, 54, 56, 57, 59, 60-65, 70-72, 74-81, 83.

CATOSTOMIDAE – SUCKERS

21. *Hypentelium etowanum* (Jordan). Alabama hog sucker. Stations: 1, 8, 23, 30, 38, 52,55, 65, 72-75, 77, 78, 80-82.
22. *Moxostoma duquesnei* (Lesueur). Black redhorse. Station: 78.
23. *Moxostoma erythrurum* (Rafinesque). Golden redhorse. Station: 75.

ICTALURIDAE – CATFISHES

24. *Ameiurus melas* (Rafinesque). Black bullhead. Stations: 2, 34, 72.
25. *Ameiurus natalis* (Lesueur). Yellow bullhead. Stations: 19A, 80.

FUNDULIDAE – KILLIFISHES

26. *Fundulus stellifer* (Jordan). Southern studfish. Stations: 78.

POECILIIDAE – LIVERBEARERS

27. *Gambusia affinis* (Baird and Girard). Mosquitofish. Stations: 2-5A, 8, 12-14, 17-24, 27, 32-34, 37-41, 46, 48, 48A, 50, 53, 56, 67, 69, 72, 76, 79.

CENTRARCHIDAE – SUNFISHES

28. *Lepomis auritus*(Linnaeus). Redbreast sunfish. Station: 41.
29. *Lepomis cyanellus* (Rafinesque). Green sunfish. Stations: 1, 2, 3A, 5A, 6, 12-14, 17, 18A, 19A, 21, 23, 25, 29, 47, 48, 59, 62, 63, 67, 71, 73, 75, 76, 79, 80, 81.
30. *Lepomis cyanellus* x *Lepomis megalotis*. This was the only hybrid sunfish collected during the survey. Station: 23.
31. *Lepomis gulosus* (Cuvier). Warmouth. Stations: 72, 73.
32. *Lepomis humilis* (Girard). Orangespotted sunfish. This species does not occur naturally within the Coosa River system (Lee, 1978; Smith-Vaniz, 1968). The specimen collected here most likely resulted from pond-stocking or other accidental or purposed introduction by humans. Station: 22.
33. *Lepomis macrochirus* (Rafinesque). Bluegill. Stations: 12, 15, 17, 18, 18A, 21, 23, 24, 27, 30, 34, 39, 42, 50, 52, 57, 63, 66, 67, 72-76, 79, 81.
34. *Lepomis megalotis* (Rafinesque). Longear sunfish. Stations: 4, 6, 9, 25, 32, 34, 40, 41, 50, 64, 68, 71, 73, 74, 78.
35. *Lepomis microlophus* (Gunther). Redear sunfish. Stations: 25, 74.
36. *Lepomis punctatus* (Valenciennes). Spotted sunfish. Stations: 26, 48A, 49, 73, 75.
37. *Micropterus coosae* (Hubbs and Bailey). Redeye bass. Stations: 6, 58, 59, 75, 77, 78, 80, 83.
38. *Micropterus punctulatus* (Rafinesque). Spotted bass. Station: 1.
39. *Micropterus salmoides* (Lacepede). Largemouth bass. Stations: 4, 11, 19A, 21, 25, 27, 29, 33, 34, 68, 73, 74.
40. *Pomoxis nigromaculatus* (Lesueur). Black crappie. Station: 72.

PERCIDAE – PERCHES

41. *Etheostoma coosae* (Fowler). Coosa darter. Stations: 6, 8, 10, 17, 19, 19A, 23, 26, 32, 42, 43, 47, 63, 73, 74, 76, 77, 78, 80, 81.
42. *Etheostoma ditrema* (Ramsey and Suttkus). Coldwater darter. This uncommon darter was collected at two new localities during the study. Stations: 1C, 30, 40, 41.
43. *Etheostoma stigmaeum* (Jordan). Speckled darter. Station: 55.
44. *Etheostoma* sp. "Upland snubnose" darter. Stations: 55, 58, 59.
45. *Percina nigrofasciata* (Agassiz). Blackbanded darter. Stations: 32, 55, 73, 75, 78.

COTTIDAE – SCULPINS

46. *Cottus carolinae* (Gill). Banded sculpin. Stations: 2, 3, 3A, 7, 8, 10, 19, 20, 23, 26, 32, 38-44, 46, 48, 49, 51, 53, 65, 72-77, 81, 82, 83.
47. *Cottus pygmaeus* (Williams). Pygmy sculpin. Approximately 30 specimens of the pygmy sculpin were captured and released at Coldwater Spring, the type-locality for this species. Several springs which appeared physically similar to Coldwater Spring were collected but no pygmy sculpins were found. Station: 30.

COLLECTING STATIONS

1. Coldwater Creek, sec 32, T 16S, R 7E, approximately 150 meters up-stream from U.S. Hwy 78 bridge. Species: 5, 6, 11, 16, 21, 29, 38.

1A. Coldwater Creek, sec 32, T 16S, R 7E, approximately 300 meters up-stream from U.S. Hwy 78 bridge. Species: 3, 5, 11, 20.
1B. Coldwater Creek, sec 32, T 16S, R 7E, approximately 400 meters up-stream from U.S. Hwy 78 bridge. Species: 11.
1C. Coldwater Creek, sec 32, T 16S, R 7E, approximately 500 meters up-stream from U.S. Hwy 78 bridge. Species: 42.
2. Everett's Spring, NW 1/4 of sec 21, T 16S, R 6E. Species: 24, 27, 29, 46.
3. Blue Eye Spring, sec 6, T 16S, R 6E. Species: 5, 20, 27, 46.
3A. Blue Eye Spring, sec 6, T 16S, R 6E. Species: 5, 10, 27, 29, 46.
4. Oxford Spring Lake and runoff, sec 29, T 16S, R 8E. Species: 27, 34, 39.
5. Talley Spring, sec 11, T 16S, R 9E. Species: 27.
5A. Talley Spring, sec 11, T 16S, R 9E. Species: 27, 29.
6. Joseph Spring, sec 27, T 15S, R 9E. Species: 10, 14, 15, 20, 29, 34, 37, 41.
6A. Joseph Spring, sec 27, T 15S, R 9E. Species: 20.
7. Germania Spring, sec 36, T 13S, R 8E. Species: 19, 20, 46.
8. Cedar Spring, sec 18, T 14S, R 8E. Species 5, 20, 21, 27, 41, 46.
9. Angle Spring, NW 1/4, sec 8, T 14S, R 8E. Species: 34.
10. Seven Springs, sec 36, T 13S, R 7E. Species: 41, 46.
11. Crystal Springs, sec 33, T 13S, R 7E. Species: 39.
12. Unnamed spring-fed pond, sec 31, T 15S, R 6E. Species: 27, 29, 33.
13. Unnamed spring-fed pond, sec 32, T 15S, R 6E. Species: 27, 29.
14. Unnamed spring, sec 18, T 15S, R 6E. Species: 27, 29.
15. Sulphur Spring, sec 30, T 15S, R 6E. Species: 33.
16. Boling Spring, sec 8, T 15S, R 6E. Species: 13, 20.
17. Winn Spring, sec 20, T 14S, R 6E. Species: 13, 27, 29, 33, 41.
18. T.T. McCullars' Spring distributary, sec 25, T 14S, R 6E. Species: 1, 27, 29, 33.
18A. T. T. McCullars' Spring distributary, sec 25, T 14S, R 6E. Species: 27, 29, 33.
19. Guthrie Spring, sec 29, T 14S, R 6E. Species: 27, 41, 46.
19A. Guthrie Spring, sec 29, T 14S, R 6E. Species: 5, 13, 25, 27, 29, 39, 41.
20. Unnamed springs, sec 28, T 14S, R 7E. Species: 27, 46.
21. Plumb Spring, sec 20, T 16S, R 6E. Species: 27, 29, 33, 39.
22. Unnamed spring distributary, sec 27, T 14S, R 6E. Species: 13, 20, 27, 32.
23. Alexandria Spring, sec 34, T 14S, R 7E. Species: 5, 20, 21, 27, 29, 30, 33, 41, 46.
24. Unnamed spring distributary, sec 7, T 15S, R 6E. Species: 5, 20, 27, 33.
25. H.T. McCullars' Spring, sec 31, T 14S, R 7E. Species: 4, 9, 29, 34, 35, 39.
26. Unnamed spring distributary, sec 1, T 14S, R 7E. Species: 36, 41, 46.
27. Blue Spring, sec 15, T 15S, R 8E. Species 5, 18, 27, 33, 39.
28. Whites Gap Spring, sec 9, T 14S, R 9E. Species: None collected.
29. Unnamed spring distributary, sec 9, T 14S, R 8E. Species: 20, 29, 39.
30. Coldwater Spring, sec 29, T 16S, R 7E. Species: 5, 20, 21, 33, 42, 47.
31. Big Spring, sec 14, T 14S, R 8E. Species: 5, 19.
32. Maxwellborn Spring, sec 24, T 13S, R 9E. Species: 19, 27, 34, 41, 45, 46.
33. Jack Dunn Spring, sec 27, T 16S, R 6E. Species: 20, 27, 39.
34. Unnamed spring distributary, sec 27, T 16S, R 6E. Species: 5, 7, 14, 24, 27, 33, 34, 39.
35. Boiling Springs, sec 27, T 16S, R 8E. Species: none collected.
36. Unnamed spring distributary, sec 24, T 14S, R 8E. Species: 20.
37. Unnamed spring at distributary, sec 27, T 16, T 6E. Species: 27.
38. Unnamed spring at Piedmont City Park, sec 5, T 13S, R 10E. Species 5, 21, 27, 46.
39. Smith Spring, sec 35, T 12S, R 10E. Species: 5, 20, 27, 33, 46.
40. Smart Spring, sec 33, T 12S, R 10E, 1.3 miles N U.S. 278, near Northside Baptist Church. Species: 27, 34, 42, 46.
41. Todd Spring, S1/2 sec 28, T 12S, R 10E, 1.3 miles N U.S. 278 past Northside Baptist Church. Species: 5, 8, 20, 27, 28, 34, 42, 46.
42. Read's Spring, sec 27, T 13S, R 7E. Species: 5, 14, 33, 41, 46.
43. Blue Pond Spring, sec 26, T 13S, R 7E. Species: 14, 20, 41, 46.
44. Tolbert Spring, SW 1/4, sec 22, T 14S, R 8E. Species: 20, 46.
45. Unnamed spring distributary, sec 19, T 13S, R 9E. Species: none collected.
46. Holders Spring, sec 25, T 13S, R 8E. Species: 27, 46.
47. Unnamed spring, sec 6, T 13S, R 9E. Species: 19, 20, 29, 41.
48. Bennefield Spring, sec 32, T 12S, R 9E. Species: 27, 29, 46.
48A. Bennefield Spring, sec 32, T 12S, R 9E. Species: 27, 36.
49. Unnamed spring, sec 33, T 12S, R 9E. Species: 15, 19, 20, 36, 46.
50. Nance Spring, sec 25, T 15S, R 5E. Species: 5, 17, 27, 33, 34.
51. Unnamed spring distributary, sec 30, T 13S, R 9E. Species: 46.
52. Unnamed spring distributary, sec 30, T 13S, R 9E. Species: 21, 33.
53. Unnamed spring, sec 30, T 13S, R 9E. Species: 15, 19, 20, 27, 46.
54. Unnamed spring distributary, sec 33, T 12S, R 9E. Species: 15, 19, 20.
55. Unnamed spring distributary, W 1/2, sec 3, T 16S, R 9E. Species: 5, 7, 8, 12, 14, 21, 43, 44, 45.
56. Unnamed spring tributary, sec 34, T 14S, R 9E. Species: 7, 15, 20, 27.
57. Cheatwood Spring, sec 33, T 14S, R 9E. Species: 14, 20, 33.
58. Unnamed spring distributary, sec 6, T 16S, R 10E. Species: 7, 18, 37, 44.
59. Unnamed spring distributary, sec 24, T 15S, R 9E. Speci[illegible] 20, 29, 37, 44.
60. Unnamed spring distributary, sec 30, T 15S, R 9E. Species: 19, 20.
61. Unnamed spring distributary, W 1/2, sec 30, T 15S, R 9E. Species: 19, 20.
62. Braswell Spring, sec 4, T 15S, R 6E. Species: 20, 29.
63. Unnamed spring, sec 35, T 14S, R 6E. Species: 15, 20, 29, 33, 41.
64. Unnamed spring distributary, sec 35, T 14S, R 6E. Species: 5, 8, 9, 15, 19, 20, 34.
65. Williams Spring, sec 2, T 14S, R 8E. Species: 15, 19, 20, 21, 46.
66. Hoague Spring, sec 21, T 13S, R 9E. Species: 33.
67. Miller's Spring, sec 22, T 16S, R 6E. Species: 27, 29, 33.
68. Russ Spring, sec 28, T 16S, R 6E. Species: 34, 39.
69. Sloup Spring, sec 35, T 14S, R 8E. Species: 5, 27.
70. Fourmile Spring, S 1/2, sec 35, T 14S, R 8E. Species 20.
71. Unnamed spring distributary, sec 9, T 14S, R 9E. Species: 20, 29, 34.

The following stations were collected by M.F. Mettee and P.E. O'Neil from 24 May 1979 to 11 October 1979 on the Fort McClellen Military Reservation.

72. Willett Spring, sec 13, T 15S, R 6E. Species: 2, 4, 5, 11, 13, 15, 20, 21, 24, 27, 31, 33, 40, 46.
73. Unnamed spring distributary, sec 18, T 15S, R 7E. Species: 4, 5, 11, 12, 15, 18, 21, 29, 31, 33, 34, 36, 39, 41, 45, 46.
74. Unnamed spring distributary, sec 18, T 15S, R 6E. Species: 5,

12, 15, 16, 20, 21, 33, 34, 35, 39, 41, 46.

75. Willett Spring, sec 13, T 15S, R 6E. Species: 5, 15, 16, 20, 21, 23, 27, 29, 33, 36, 37, 45, 46.
76. Unnamed spring distributary, sec 36, T 15S, R 9E. Species: 4, 5, 7, 18, 20, 29, 33, 41, 46.
77. Unnamed spring distributary, sec 27, T 15S, R 9E. Species: 5, 7, 20, 21, 37, 41, 46.
78. Unnamed spring distributary, sec 35, T 15S, R 9E. Species: 5, 7, 15, 20,21, 22, 26, 34, 37, 41, 45.
79. Tributary from Willis Spring, sec 23, T 15S, R 9E. Species: 5, 15, 20, 27, 29, 33.
80. Unnamed spring distributary, sec 22, T 15S, R 6E. Species: 4, 5, 11, 12, 15, 20, 21, 25, 29, 37, 41.
81. Unnamed spring distributary, sec 28, T 15S, R 6E. Species: 5, 15, 19, 20, 21, 29, 33, 41, 46.
82. Unnamed spring distributary, sec 30, T 15S, R 7E. Species: 5, 15, 21, 46.
83. Unnamed spring distributary, sec 20, T 15S, R 7E. Species: 20, 37, 46.

DISCUSSION

Eighty-three springs or spring distributaries in Calhoun County, Alabama, were surveyed to determine the diversity and distribution of the ichthyofauna. Forty-five species and two hybrids belonging to twenty-four genera and eleven families were collected. An average of 5.3 species were taken from each station. Three springs, however, yielded no fishes (Stations: 28, 35, 45). The modal number of species collected per station was 3, and one spring harbored 16 species (Station: 73). Considering all species collected, the following were the most commonly taken: *Semotilus atromaculatus* (43 stations), *Gambusia affinis* (38 stations), *Cottus carolinae* (33 stations), *Campostoma oligolepis* (31 stations), and *Lepomis macrochirus* (26 stations). Ten of the species collected were present at fifteen or more stations.

Many of the fishes are known to inhabit rivers, creeks and lakes as well as springs. Four species, however, seem to be restricted to springs or spring tributaries within the study area: *Cottus pygmaeus, Hemitremia flammea, Etheostoma ditrema* and *Rhinichthys atratulus*. *Rhinichthys atratulus* is not, however, restricted to springs in its range north of the study area. In terms of frequency of collection, the spring restricted species rank as follows: *R. atratulus* (12 stations); *E. ditrema* (4 stations); *H. flammea* (2 stations); and *C. pygmaeus* (1 station).

Cottus pygmaeus has the most geographically limited distribution of the spring restricted species. The pygmy sculpin was taken only at Station 30, Coldwater Spring, the type locality. Aside from this survey, several workers have made numerous collections within the Valley and Ridge Province in unsuccessful efforts to locate additional populations of *C. pygmaeus*.

The pygmy sculpin is relatively abundant in Coldwater Spring and in the effluent spring-creek immediately below the spring basin. On 26 September 1986,30 specimens were collected in the spring run and others were observed in the spring basin. Mature individuals were collected in the spring run for approximately 100 meters downstream. At this point, the effluent run of the spring confluences with an unnamed creek. Formerly this creek was visibly polluted (per. comm. R.A. Stiles); however, now the creek appears to be pollution free. Almost certainly this creek checked the downstream advancement of *C. pygmaeus* with its warmer water and pollutants. Sampling continued for approximately 50 meters beyond the point of confluence and no specimens of *C. pygmaeus* were collected.

As a result of this study, range extensions for the following species were noted: *H. flammea*, *E. ditrema*, *Lepomis humilis* and *Notropis texanus*. Prior to this study the range of *H. flammea* in Alabama was thought to be limited to springs and clear tributaries in the Tennessee River system, plus the previously mentioned spring tributary to Kelly Creek near Talladega, AL. This survey revealed the presence of two populations of *H. flammea* within the study area: Blue Eye Spring (Station 3A) and Joseph Spring (Station 6).

Within the study area *Etheostoma ditrema* was historically present in Martin Spring (now inundated by Weiss Lake) and Coldwater Spring. Thorough sampling of the immediate effluent run of Coldwater Spring revealed the presence of only three specimens of *E. ditrema*. Later collections of Coldwater Creek approximately 400 meters downstream from the spring basin fortuitously produced one specimen of the coldwater darter.

Two new populations of *E. ditrema* were located in Calhoun County: Smart Spring (Station 40) and Todd Spring (Station 41). The new localities for the coldwater darter increase the number of known populations of this species in Alabama to only five (Glencoe Spring and Waxahatchee Creek being additional populations, Ramsey et al, 1986). However, considering the status of this fish, any range extension of *E. ditrema* is significant since this darter has been classified as threatened by Deacon et al. (1979). A more recent treatment of threatened vertebrates in Alabama place *E. ditrema* in a category of special concern (Ramsey et al. 1986).

Lepomis humilis was not previously known from the Coosa River drainage; the most probable explanation for the occurrence of this species in the Coosa River drainage is pond stocking.

Notropis texanus is exceedingly rare above the Fall Line (Smith-Vaniz, 1968). Only one specimen of the weed shiner was collected, from a large sandy bottomed spring run. This represents a new record for the species above the Fall Line.

Only one undescribed species was collected during this study– the "upland snubnose" darter, *Etheostoma* sp. A total of 13 specimens were taken from three large spring tributaries in the mountains of the Talladega National Forest (Stations: 55, 58,59).

In summary, Calhoun County appears to support a diverse assemblage of spring dwelling fishes, some of which occur in relative abundance. The forty-five species reported in this study represents a thorough sampling of the ichthyofauna of the spring habitat of the area. While it is assuring to see the diversity of species within the study area and to locate undiscovered populations, it must be noted that many species (such as *Etheostoma trisella* and *Cottus pygmaeus*) possibly have been exterminated in the county, or reduced in numbers, due to human activities. It has, therefore, become important to protect the natural spring habitat and the associated species that remain within Calhoun County. Consequently, a practical plan of protection and conservation should be initiated to protect the fragile spring ecosystem and the inhabitants it supports.

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NEWS NOTE

VIDEO DOCUMENTARIES of reproductive behaviors of North American cyprinids are now available through the University of Richmond.

1. *Reproductive Behaviors of the Creek Chub*, 13-min
2. *Spawning Nests of the Bluehead Chub*, 14-min
3. *Nocomis – The Spawning Fish* 13-min
4. *Were They Accurate? Comparison Between Journal Accounts and Video Recordings of Reproductive Behaviors of Selected Cyprinids*

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PEBBLE-NESTS OF FOUR *SEMOTILUS* SPECIES

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Abstract – The pebble-nest microhabitats of four species of *Semotilus* were compared. Pit/mound nests of *Semotilus corporalis* were significantly larger than the pit/ridge nest of *Semotilus atromaculatus*, *Semotilus lumbee*, and *Semotilus* sp. Nests of *S. corporalis* were in wider and deeper streams. Pits of *S. lumbee* nests were longest of the four species; those of *S. corporalis* were widest and deepest. There was no significant difference by weight in the electivity index (percentage of nest pebble sizes versus those of the substrate) among the species for the three largest stone sizes (6.0, 11.3, and 23.0 mm). Although the greatest percentage of stones in the nests of *S. corporalis* were 23 mm, they did not represent the greatest electivity index as that stone size had a high percentage in the substrate. Mounds and ridges of pebble nests served as breakwaters, reducing the flow to near zero in the downstream spawning pit below the ridge or mound of the nest.

INTRODUCTION

Males of four species of *Semotilus* (Cyprinidae) build spawning nests by placing pebbles in mounds or ridges at the head of riffles in clear montane, Piedmont or upper Coastal Plain streams. *Semotilus corporalis* (fallfish) has been considered a pit/mound nest builder. The other three species, *Semotilus atromaculatus* (creek chub), *Semotilus lumbee* (Sandhills chub), and *Semotilus* sp. (= *Semotilus thoreauianus* of Woolcott and Maurakis, 1988), are closely related pit/ridge nest builders. The latter, a diminutive form (adult males approximately one-half the length of adult male *S. atromaculatus*) collected and studied primarily in northeastern Georgia, is tentatively identified as *Semotilus* sp. until its systematics can be reconciled.

Prior to spawning, mounds of *S. corporalis* nests are built by a breeding adult male that excavates an area and later fills it with stones (Raney, 1969). Although this species has not been observed constructing nests following the spawning act as is characteristic of the creek chubs, we have found fallfish eggs covered by pebbles immediately upstream of the pit of a mature nest under construction by the male. Male creek chubs begin a nest by digging a pit and placing the pebbles from it at the pit's upstream margin. Following spawning, the male moves pebbles from the downstream end of the pit and puts them over the eggs deposited in the upstream end of the pit. Thus, as spawning continues, the ridge increases in length and the pit is displaced downstream (Woolcott and Maurakis, 1988).

As most studies of nest construction have been limited to generalized descriptions of nests (e.g. overall dimensions), an objective of this study was to compare the materials and construction of the nests among four species of *Semotilus*. A second objective was to examine the effects of the physical characteristics of pebble-nests on water currents in spawning pits.

MATERIALS EXAMINED

The collection number, number of nests (in parentheses), drainage, locality, and date for *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. are:

Semotilus atromaculatus. Virginia: EGM-VA-106 (1), Rappahannock, Fauquier Co., unnamed tributary of Thumb Run at Co. Rt. 688, 300 yds. upstream from bridge, 7 May 1983. EGM-VA-107 (2), Rappahannock, Fauquier Co., Carter Run at Co. Rt. 688 bridge, 7 May 1983. EGM-VA-115 (1), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd., 0.75 mi. E of I-395, 21 April 1984. EGM-VA-116 (3), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd. 0.75 mi. E of I-395, 21 April 1984. EGM-VA-117.1 (1), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd. 0.75 mi. E of I-395, 21 April 1984. EGM-VA-117.3 (1), Potomac, Fairfax Co., Indian Run at bridge on Edsal Rd. 0.75 mi. E of I-395, 21 April 1984. EGM-VA-209 (2), Potomac, Fairfax Co., unnamed tributary of Indian Run, 0.5 mi. E of I-395 jct. with Edsal Rd., 23 April 1988. WSW-VA-365 (1), James, Appomattox Co., small drainage near jct. St. Rt. 24 and Co. Rt. 627 opposite Appomattox National Park, 15 May 1987. WSW-VA-369 (1), York, Hanover Co., tributary of Falling Cr. at Co. Rt. 667 approximately 2 mi. N of Ashland, 23 May 1987. Maryland: EGM-MD-121 (1), Potomac, Montgomery Co., unnamed creek of Monocacy R. on Rt. 28, 0.5 mi. from turnoff to PEPCO Dickerson Plant, 13 May 1984.

Semotilus corporalis. Virginia: EGM-VA-54 (2), Rappahannock, Madison/Green Co. line, Conway R. at Co. Rt. 667 and Rt. 613 bridge, 16 May 1982. EGM-VA-108 (2), Rappahannock, Fauguier Co., Great Run at St. Rt. 211 bridge, 4 mi. W of Warrenton, 7 May 1982. WSW-VA-381 (2), James, Campbell Co., Opossum Cr. at bridge on Co. Rt. 669, 1 mi. S of Co. Rt. 664, 9 May 1988.

Semotilus lumbee. North Carolina: EGM-NC-104.1 (1), EGM-NC-105 (1), EGM-NC-208 (3), Peedee, Moore Co., tributary of Drowning Cr. on Co. Rt. 1122, 2.3 mi. W of jct. with Co. Rt. 1004 at Foxfire, 25 April 1982, 16 April 1983, 16 April 1988, respectively.

Semotilus sp. Georgia: EGM-GA-199 (1), Savannah, Stephens Co., Gibson Branch on Ray Rice's farm St. Rt. 124, 13 April 1986. EGM-GA-204 (1), Altamaha, Barrow Co., tributary of Mulberry Cr. on W. C. Wade's farm on St. Rt. 211, 3 mi. W of Winder, 11 April 1987. EGM-GA-207 (3), Altamaha, Barrow Co., tributary of Mulberry Cr. on W. C. Wade's farm on St. Rt. 211, 3 mi W of Winder, 10 April 1988. EGM-GA-208 (1), Savannah, Stephens Co., Zebulon Branch, tributary of N. Fork Broad R. on Ray Rice's property, approximately 1.5 mi. from jct. Rt. 124, N of Toccoa, 11 April 1988.

METHODS

Morphological and meristic characteristics of *Semotilus* sp. are compared with those described for *Semotilus thoreauianus* by Jordan (1877) (Table 1).

Pebble nests were collected from streams in Georgia, North Carolina, and Virginia in April, May, and June from 1982 through

1988. The total number of nests were: *S. atromaculatus*, 14; *S. corporalis*, 6; *S. lumbee*, 5; and *Semotilus* sp., 6.

Table 1. Characteristics of 10 specimens of *Semotilus* sp. compared with *Semotilus thoreauianus* of Jordan (1877).

Character	sp.	*thoreauianus*
Body	robust, short	robust, short
Head	short, round	short, round
Tubercles	8 (anterior bilobed)	8 (anterior bilobed)
Fin rays		
Dorsal	8	8
Anal	8	7
Dorsal position	behind pelvic origin	behind pelvic origin
Pelvic length	reaches vent	short of vent
Pectoral	short	short
Scales		
LL	49.3 (48-51)	48
Above LL	9.2 (9-10)	9
Below LL	6	5

Pebble samples from nests were collected from the upstream, middle, and downstream portions of ridges and mounds. Substrate samples were restricted to the area adjacent to ridges except for those for *S. corporalis* where additional random samples of the substrate were collected as far as 20 m from the nest. Nest and substrate samples were stored in tagged plastic bags and returned to the laboratory for analysis. Pebbles were air-dried and sifted through five custom-built wire sieves. Mesh sizes, restricted to commercially available prefabricated screen sizes were 23.0 mm, 11.3 mm, 6.0 mm, 2.5 mm, and 0.8 mm. Material that sifted through the smallest size mesh was collected in a pan. The weight of material in each sieve was used to calculate the percentage of material per mesh size. Hereafter, all references to percentage of mesh size classes are based on weights.

Fishes over nests were collected with a pulsed DC electroshocker, preserved in 10 percent formalin, measured to SL, and stored at the University of Richmond.

Stream depth (cm), width (m), and temperature (C) were recorded. The velocity of water currents (1 cm above nests and 1 cm above substrates) measured with a Marsh-McBirney current meter were recorded 0.5 m upstream of the ridge, 0.5 m downstream of the ridge, above the ridge, and in the spawning pit. Ridge length, height, and width; and pit depth, length, and width of each nest were measured and used to calculate mean values for each parameter. The Froude number (Davis and Barmuta, 1989) was used for the classification of mean stream flows. The equation, Froude no. $= S\frac{U}{gD}$ [where U = water velocity, g= acceleration due to gravity (9.8 m/ sec^2), and D = depth] was calculated for flows before the nest, above the ridge or mound, and in the pit. Near stream bed flow, expressed as ratios k/L, D/k, and D/j (where k = ridge height, D = water depth, L = ridge length + pit length, and j = pit length) were calculated following Davis and Barmuta (1989).

An electivity index (Ivlev, 1961) was calculated for each pebble size class per nest of each species.

The equation $E = \frac{(r_1 - p_1)}{(r_1 + p_1)}$ (where E = pebble size selection, r = percentage of a particular pebble size in the nest, and p = the percentage of a particular pebble size in the substrate of the stream) was used to determine if selection of pebble size from the substrate was nonrandom. Electivity index values range from 1 to – 1. Values closer to 1 indicate a greater selection of a particular pebble size. Percentages and electivity index values were transformed to arcsin equivalents. Average values of electivities, percent pebble composition of nests, and stream dimensions, derived from analysis of variance (ANOVA), were compared between and within species with Duncan's Multiple Range Test (alpha = 0.05; Steel and Torrie, 1980). Backward stepwise regression (SAS, 1985) was used to examine relationships of water current in pits to physical dimensions of the nests and streams.

RESULTS

Nests of *S. corporalis* were in significantly deeper ($\bar{x}$, 52.7 cm) and wider ($\bar{x}$, 5.7 m) streams than were those of other *Semotilus* species (Table 2). Water temperature at active nests for all species ranged from a mean of 13.2 C (*S. atromaculatus*) to 15.0 C (*Semotilus* sp.). Differences were not significant (Table 2). The nonadhesive, demersal eggs were found in nests of all species.

Table 2. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for stream characteristics among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
Stream depth						
Species	sp.	*atromaculatus*	*lumbee*	*corporalis*		
Mean (cm)	12.5	15.5	20.7	52.7	26	7.87
Stream Width						
Species	sp.	*lumbee*	*atromaculatus*	*corporalis*		
Mean (m)	1.7	1.9	2.7	5.7	30	24.2
Water Temp.						
Species	*atromaculatus*	*lumbee*	*corporalis*	sp.		
Mean (C)	13.2	13.3	14.7	15.0	30	1.11
Range (C)	11.1-16.7	12.5-16.1	13-15.6	10-17		

Approximately 83% of the pebbles in nests of *S. corporalis* were in size class 23.0 mm. (49.3%) or 11.3 mm (33.6%) (Table 3). Average percentage of pebbles in the 11.3 mm size class followed by those of the 6.0 mm size class were high in nests of *S. atromaculatus* (38.5% and 23.0%, respectively), *S. lumbee* (48.7% and 33.5%, respectively), and *Semotilus* sp. (31.2% and 25.1%, respectively) (Table 3).

Nests of the largest of the four species, *S. corporalis* (♂ 128.9-265.7 mm), had a significantly greater number of 23.0 mm pebbles than those of the other species. Mean percentage of 11.3 mm pebbles in nests of intermediate sized *S. lumbee* (♂ 129.1-185 mm) were significantly greater than those of *S. corporalis* and the smallest species, *Semotilus* sp. (♂ 67.1-67.5 mm). *Semotilus lumbee* nests also had the greatest percentage of 6.0 mm pebbles but differed significantly only form those of *S. corporalis*. *Semo-*

Table 3. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average percentage of nest material according to size class (mm) within *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

							ANOVA df	ANOVA F
S. corporalis								
Stone size	<0.8	0.8	2.5	6.0	11.3	23.0		
Mean	0.20	0.60	4.6	11.8	33.6	49.3	6	15.57
S. atromaculatus								
Stone size	<0.8	0.8	2.5	23.0	6.0	11.3		
Mean	2.6	5.1	15.3	15.7	23.0	38.5	6	28.99
S. lumbee								
Stone size	<0.8	0.8	23.0	2.5	6.0	11.3		
Mean	0.70	1.7	6.8	8.6	33.5	48.7	12	52.42
Semotilus sp.								
Stone size	<0.8	0.8	23.0	2.5	6.0	11.3		
Mean	6.3	7.2	10.1	14.0	25.1	31.2	18	12.44

tilus atromaculatus (♂ 130-145.2 mm) and *Semotilus* sp. nests had similar high percentages of 2.5 mm pebbles and were significantly different from those of *S. corporalis*. Percentages of 0.8 mm pebbles in the nests of *Semotilus* sp. and *S. atromaculatus* were significantly greater than those for the other two species. The average percentage of particles less than 0.8 mm in nests of *Semotilus* sp. was greater than those for other species (Table 4).

Table 4. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average percentage of nest material according to size class (mm) among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differe significantly (alpha = 0.05).

					ANOVA df	ANOVA F
23.0						
Species	*lumbee*	sp.	*atromaculatus*	*corporalis*		
Mean	6.8	10.0	15.7	49.3	7	11.8
11.3						
Species	sp.	*corporalis*	*atromaculatus*	*lumbee*		
Mean	31.2	33.6	38.5	48.7	7	4.1
6.0						
Species	*corporalis*	*atromaculatus*	sp.	*lumbee*		
Mean	11.8	23.0	25.0	33.5	7	4.1
2.5						
Species	*corporalis*	*lumbee*	sp.	*atromaculatus*		
Mean	4.6	8.6	14.0	15.3	7	5.1
0.8						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	0.6	1.7	5.1	7.2	7	14.7
<0.8						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	0.2	0.7	2.6	6.3	7	19.1

Substrate material at nests of *S. corporalis* was comprised of 61.1% of the 23.0 mm size class pebbles. In all other size classes, the percentage of substrate material at *S. corporalis* nests was lowest of the four species (Table 5).

Table 5. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average percentage of substrate material according to size class (mm) among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
23.0						
Species	*lumbee*	*atromaculatus*	sp.	*corporalis*		
Mean	2.5	6.8	8.9	61.1	7	13.3
11.3						
Species	*corporalis*	*atromaculatus*	sp.	*lumbee*		
Mean	19.8	24.9	25.7	33.6	7	1.6
6.0						
Species	*corporalis*	sp.	*atromaculatus*	*lumbee*		
Mean	10.9	15.7	17.7	25.1	7	4.1
2.5						
Species	*corporalis*	sp.	*lumbee*	*atromaculatus*		
Mean	4.8	10.4	13.2	14.8	7	5.6
0.8						
Species	*corporalis*	sp.	*lumbee*	*atromaculatus*		
Mean	1.5	7.3	8.9	9.8	7	9.6
<0.8						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	1.8	16.7	26.0	32.0	7	13.4

Electivity indices were highest for pebbles in size classes 11.3 and 6.0 mm in all four species (Tables 6 and 7). *Semotilus atromaculatus* selected significantly more 23.0 mm pebbles than pebbles 2.5 mm and smaller. Although 23.0 mm size pebbles were most abundant in *S. corporalis* nests (Table 3), they did not have a high electivity index as they also were most abundant in the substrate. Numbers of pebble sizes (6.0, 11.3, and 23.0 mm) selected by *S. lumbee* were similar. There were no significant differences among the size classes 0.8 to 23.0 mm selected by *Semotilus* sp. (Table 6).

Mean electivity indices among species did not differ significantly for nest pebbles in the 23.0, 11.3, and 6.0 mm size classes. Except for *Semotilus* sp., no species selected stones less than 2.5 mm (Table 7).

Mean ridge length of *S. lumbee* nests was greatest but differed significantly only from that of *Semotilus* sp. nests. Average mound width and height of *S. corporalis* nests were significantly greater than the ridges of nests of the other three species (Table 8).

Average pit depths and widths of *S. corporalis* nests were significantly greater than those of nests of *S. atromaculatus* and *Semotilus* sp. Mean pit length of *S. lumbee* nests was significantly greater than that of the nest of S. *atromaculatus* (Table 8).

Table 6. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average electivity according to size class (mm) within *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

							ANOVA df	ANOVA F
S. atromaculatus								
Size Class	<0.8	0.8	2.5	6.0	11.3	23.0		
Mean	–0.90	–0.30	0.0	0.10	0.20	0.50	6	14.7
S. corporalis								
Size Class	<0.8	0.8	23.0	2.5	6.0	11.3		
Mean	–0.80	–0.50	–0.10	–0.02	0.03	0.30	6	9.9
S. lumbee								
Size Class	<0.8	0.8	2.5	6.0	11.3	23.0		
Mean	–0.90	–0.70	–0.20	0.20	0.20	0.30	12	25.5
Semotilus sp.								
Size Class	<0.8	0.8	11.3	2.5	6.0	23.0		
Mean	–0.70	0.07	0.10	0.10	0.20	0.50	18	4.0

Table 7. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average electivity according to size class (mm) among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
23.0						
Species	*corporalis*	*lumbee*	*atromaculatus*	sp.		
Mean	–0.10	0.30	0.50	0.50	7	0.44
11.3						
Species	sp.	*lumbee*	*atromaculatus*	*corporalis*		
Mean	0.10	0.20	0.20	0.30	7	0.67
6.0						
Species	*corporalis*	*atromaculatus*	*lumbee*	sp.		
Mean	0.03	0.10	0.20	0.20	7	1.63
2.5						
Species	*lumbee*	*corporalis*	*atromaculatus*	sp.		
Mean	–0.20	–0.02	0.00	0.10	7	3.66
0.8						
Species	*lumbee*	*corporalis*	*atromaculatus*	sp.		
Mean	–0.70	–0.50	–0.30	0.07	7	12.71
<0.8						
Species	*lumbee*	*atromaculatus*	*corporalis*	sp.		
Mean	–0.90	–0.90	–0.80	–0.70	7	4.71

Table 8. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for nest characteristics (cm) among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
Ridge length						
Species	sp.	*atromaculatus*	*corporalis*	*lumbee*		
Mean	35.2	68.6	81.6	96.2	28	2.6
Ridge width						
Species	sp.	*atromaculatus*	*lumbee*	*corporalis*		
Mean	18.2	21.6	28.0	60.9	28	26.8
Ridge height						
Species	sp.	*atromaculatus*	*lumbee*	*corporalis*		
Mean	4.0	4.2	6.9	38.1	27	8.3
Pit depth						
Species	*atromaculatus*	sp.	*lumbee*	*corporalis*		
Mean	6.7	7.6	9.4	14.5	25	1.8
Pit length						
Species	*atromaculatus*	*corporalis*	sp.	*lumbee*		
Mean	21.3	32.0	32.1	36.3	25	4.0
Pit width						
Species	*atromaculatus*	sp.	*lumbee*	*corporalis*		
Mean	16.2	25.5	29.6	39.0	24	6.1

Average velocity of water current over and near nests of all four species was similar with two exceptions: current velocity over the crest of the mounds of *S. corporalis* nests was significantly greater than that over the crest of ridges of *S. atromaculatus* nests; and average current downstream of *S. lumbee* nests was significantly greater than those of *S. atromaculatus* and *Semotilus* sp. (Table 9). In nests of all species, average current velocity in the pit was significantly less than average current velocity at other points on or near nests (Table 10). Ridge length and height, and water depth were the three physical factors associated with reduced water currents in the pit (Table 11). Froude number ($\bar{x}$ range = 0.015 – 0.035) in the pit was lower than values in the stream ($\bar{x}$ range = 0.074 – 0.111) or over the ridge or mound ($\bar{x}$ range = 0.120 – 0.394) (Table 12). The ratios k/L and D/j never exceeded 1.0 for nests of all species. The mean D/k ration (0.610) for S. *corporalis* nests was lower than that (4.334 – 5.595) for nests of other *Semotilus* species.

DISCUSSION

Our study is the first to quantitatively analyze the construction and composition of spawning nests of nest-building species of *Semotilus*. Previously, investigators have given limited measurements and descriptions of the physical characteristics and composition of nests (Reighard, 1910; Moshenko and Gee, 1973; Ross, 1983; and Copes, 1978).

Table 9. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average current velocity (m/sec) before ridge, over ridge, in pit, and after pit among *Semotilus atromaculatus*, *Semotilus corporalis*, *Semotilus lumbee*, and *Semotilus* sp. Underscored means do not differ significantly (alpha = 0.05).

					ANOVA df	ANOVA F
Before ridge						
Species	*atromaculatus*	sp.	*corporalis*	*lumbee*		
Mean	0.05	0.13	0.16	0.16	12	1.1
Ridge						
Species	*atromaculatus*	*lumbee*	sp.	*corporalis*		
Mean	0.08	0.15	0.17	0.22	9	3.1
Pit						
Species	*atromaculatus*	*corporalis*	*lumbee*	sp.		
Mean	0.02	0.02	0.03	0.05	10	0.4
After Pit						
Species	*atromaculatus*	sp.	*corporalis*	*lumbee*		
Mean	0.13	0.17	0.28	0.37	9	4.7

Table 10. Analysis of variance (ANOVA) and Duncan's Multiple Range Test for average current velocity (m/sec) upstream of ridge, over ridge, in pit, and downstream of pit for all nest-building species of *Semotilus*. Underscored means do not differ significantly (alpha = 0.05)

Location	Pit	Upstream of ridge	Ridge	Downstream of Pit	ANOVA df	ANOVA F
Mean current	0.04	0.13	0.16	0.23	52	13.1

Table 11. Results of Backward Stepwise Regression (SAS, 1985) for effects of stream depth; ridge length, height, and width; pit depth, length, and width; stream flow; and flow over the ridge or mound on water currents in the pit of nest-building *Semotilus* species.

Parameter	B value	F value	Probability > F
Intercept	–0.05707285	999999.99	0.0001
Stream depth	0.84210059	999999.99	0.0001
Ridge length	–0.09544103	999999.99	0.0001
Ridge height	0.11541706	999999.99	0.0001
Ridge width	0.00000000	0	1.0
Pit depth	0.00000000	0	1.0
Pit length	0.00000000	0	1.0
Pit width	0.00000000	0	1.0
Stream flow	0.00000000	0	1.0
Ridge flow	0.00000000	0	1.0

Table 12. Classification parameters of average stream flow and pebble-nest microenvironments of *Semotilus* nests.

Parameter	*atromaculatus*	*corporalis*	*lumbee*	sp.
Froude no.				
Stream				
$\bar{x}$	0.106	0.111	0.074	0.108
s.d.	0.078	0.025	0.015	0.061
Nest ridge/mound				
$\bar{x}$	0.142	0.394	0.120	0.147
s.d.	0.092	0.239	0.019	0.070
Nest pit				
$\bar{x}$	0.018	0.015	0.021	0.035
s.d.	0.009	0.012	0.006	0.005
k/l $\bar{x}$	0.048	0.118	0.030	0.040
s.d. 0.020	0.001	0.017	0.018	
D/j $\bar{x}$	0.783	0.715	0.803	0.473
s.d.	0.169	0.421	0.332	0.104
D/k $\bar{x}$	4.334	0.610	5.595	5.311
s.d.	1.528	0.764	2.342	2.720

Hynes (1979) stated that larger fish occupy larger streams, and in accord, breeding males of *S. corporalis* are larger than those of *S. atromaculatus*, *S. lumbee*, and *Semotilus* sp. and are likely to live in larger streams. Stream dimensions are similar for the three smaller *Semotilus* species which are similar to each other and do not differ substantially from those reported by other investigators (Reighard, 1910; Hankinson, 1932; Sisk, 1966; Snelson and Suttkus, 1978; and Ross, 1983). According to the terminology developed by Davis and Barmuta (1989) for classifying mean stream flow, mean stream flows where we studied nests were subcritical and turbulent.

Semotilus species spawn in the spring and are the earliest spawners compared to other pebble nest-building cyprinid genera (i.e. *Exoglossum* and *Nocomis)*. Nests were found at water temperatures comparable to those given for *S. corporalis* by Richardson (1935) and Reed (1971); for *S. atromaculatus* by Reighard (1910), Hankinson (1932), Sisk (1966), Miller (1967), Raney (1969), Moshenko and Gee (1973), and Copes (1978); for *S. lumbee* and *Semotilus* sp. by Woolcott and Maurakis (1988). Conversely, Miller (1964), in a field study of cyprinids in New York, found S. *atromaculatus* spawning at temperatures as high as 23.3 C; about seven degrees higher than the highest temperature (16.7 C) in this study.

Larger pebble sizes (6.0-23.0 mm) were used more frequently in the construction of nests by all *Semotilus* species. Moshenko and Gee (1973), in the only available study that examined pebble sizes in a *S. corporalis* nest, reported fine gravel accounted for more than 50% of the ridge. As they did not provide actual pebble size, their data could not be compared to those given in this study.

We previously have observed that 90% of the pebbles in the pits and ridges of *S. lumbee* nests measured 11.3 mm or less; and 10% measured 23.0 mm.

Large pebble sizes (6.0-23.0 mm) were used in the construction of nests by all four species. Since all four species, regardless of the size of the male, showed a selective preference for these pebble size, interstices created by these sizes may provide optimal aeration of the water while providing protection for eggs and developing larvae against predation. Only *Semotilus* sp. selected pebble sizes less than 6.0 mm. It should be pointed out that even though the nests of *S. corporalis* did not reflect a high electivity index for the largest pebbles (23.0 mm), because of the large numbers of this size class in the substrate, nests were composed of almost 50% of this pebble size.

Pit-mound nests of *S. corporalis* are usually larger in all dimensions than the pit-ridge nests of the other three *Semotilus* species. Raney (1969) gave approximate values for the nests of *S. corporalis* of 180.0 cm in diameter and 60.0 cm high, which are similar to those of Wilson (1907), and Mansueti and Hardy (1967). Nest sizes in our study were within ranges reported by other investigators; however, as most *S. corporalis* nests were ridge-like (longer than wide), measurements for these dimensions could not be compared to those given by the above authors who did not specify the shape of the nests they observed. Reed (1971) suggested nest shape in *S. corporalis* nests is controlled by current. We could not confirm his statement that nests in a current have a downstream keel and those outside the current are dome shaped.

Comparison of ridge sizes within and among the other *Semotilus* species may be meaningless as ridge size is related to the length of time the male has been spawning. For example, in *S. atromaculatus* ridges there was a difference of about 200 cm (longest, 210.0 cm; shortest, 9.0 cm); in *S. lumbee*, the longest ridge was 120.0 cm and the shortest was 65.0 cm; and in *Semotilus* sp., the longest ridge was 66.0 cm and the shortest was 11.0 cm. Reighard (1910) reported ridge lengths as long as 5.5 m in *S. atromaculatus*. Woolcott and Maurakis (1988) observed ridge lengths of 4.6 m, and Moshenko and Gee (1973) noted ridges up to 2.0 m long in *S. atromaculatus* nests. Shorter ridge lengths (35.5-76.2 cm) for nests of *S. atromaculatus* were reported by Copes (1978).

All four *Semotilus* species excavate a pit at the downstream portion of the nest mound or ridge, a feature restricted to the members of this genus. Pit depths, lengths, and widths in S. *atromaculatus* nests examined in this study were comparable to those of Reighard (1910); Raney (1969); Moshenko and Gee (1973); Copes (1978); and Woolcott and Maurakis (1988). The similarity in ridge construction among the three creek chubs lends credibility to their monophyly. In S. *corporalis* nests, pebble excavation resulted in well-defined pit and a pebble ridge of deposited material from the pit during the early stages of nest construction. The concentration of large numbers of eggs in an area in the downstream base of the mound suggest that the *S. corporalis* we studied probably spawned in the early stages of nest construction. During the later stages of nest construction, time spent by *S. corporaalis* excavating the pit decreased as the frequency of pebbles collected away from the nest increased. Regardless from where the pebble was collected, the male always moved into the pit, and then moved forward to drop the stone on the ridge. This behavior resulted in the formation of a well-developed mound nest with a poorly-defined, shallow pit at the downstream edge of the mound.

Analysis of stream and nest measurements indicated that ridge/mound height and length, and water depth were the three factors associated with decreased water current velocities in the pit. According to flow microenvironment classification by Davis and Barmuta (1989), an isolated roughness flow is created when k/L is small. This related directly to the conditions created by the construction of *Semotilus* nests (i.e. ridge height and length, and pit length). Isolated roughness flows create horseshoe vortices behind the roughness element of nests. The significance of which is the slowest current was in the pit and facilitated the vertical descent of eggs and milt during the spawning act (Table 9). Because of the increased height of mounds which cause a condition comparable to a shallow riffle, microenvironment flow of mature S. *corporalis* nests may be considered as a chaotic flow (after the terminology of Davis and Barmuta, 1989). If measurements of flows had been made at the time that we postulate spawning occurred by the fallfish, flow over the smaller nest would have been like that over the nests of creek chubs. That *S. corporalis* in Virginia continues to build on the nest after spawning (evidenced by the presence of eggs covered by stones upstream of the pit) apparently is contrary to statements by Ross and Reed (1978) and Jenkins (pers. comm.) that more northern *S. corporalis* spawns communally over mounds. We have never found the eggs of *S. corporalis* randomly scattered on mounds of any of the 12 nests that were investigated. Rather, eggs were collected only in discrete areas in the downstream base of mature mounds.

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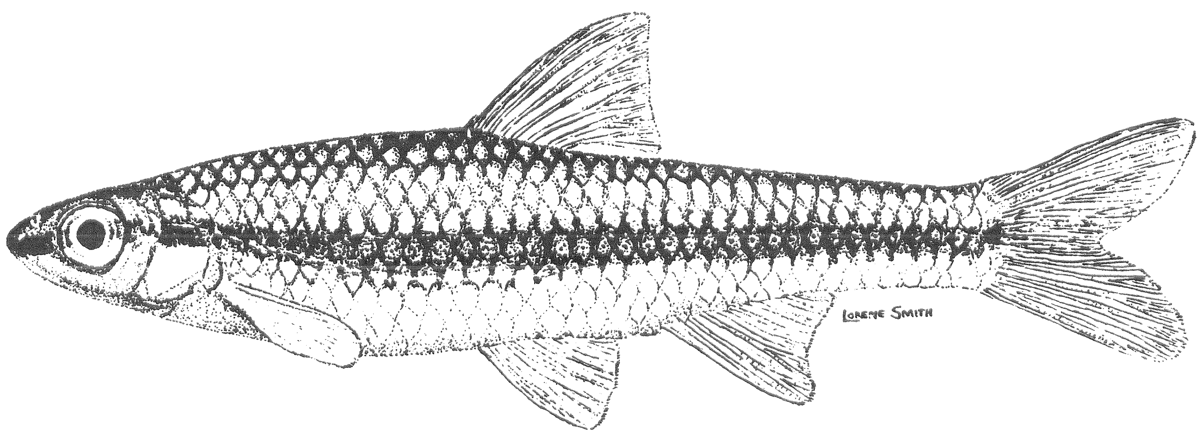

CAPE FEAR SHINER

The Southeastern Fishes Council wishes to thank Ms. Lorene Smith, of the Louisiana Marine Consortium, Chauvin, LA, who produced the above illustration that appeared on our most recent button. Ms. Smith, a member of the SFC, also provided the drawing of the rusty side sucker that appeared on our 1987 button.

EVIDENCE FOR A GENETICALLY UNIQUE WALLEYE POPULATION IN THE UPPER TOMBIGBEE RIVER SYSTEM OF NORTHEASTERN MISSISSIPPI

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Abstract – Electrophoretic evaluation of walleye from several areas of the upper Tombigbee River system in northeastern Mississippi revealed no heterozygosity at any of the presumptive loci examined (skeletal muscle malate dehydrogenase and myogen, liver isocitrate dehydrogenase, and serum albumin), in contrast to widespread genetic heterogeneity observed in all other studies involving the species. This unique genetic character may be typical of walleye throughout the Gulf Coast drainages of Mississippi and Alabama. The genetic integrity of walleye in the Tombigbee River system is threatened by invasion of Mississippi River strain walleye through the Tennessee-Tombigbee Waterway. Genetic traits of Tennessee River walleye should be confirmed, and the invasion of these fish into the Tombigbee River system should be monitored. A captive breeding/transplantation program may be the only feasible method of preserving the genetically unique walleye of the upper Tombigbee River system.

INTRODUCTION

Walleye *Stizostedion vitreum vitreum* is one of the most important sportfish species in the United States and Canada. Because of their importance, they have been widely cultured and stocked both within and outside their native range (Hackney and Holbrook 1978; Laarman 1978). The natural range of the species extends from northwestern Canada to the southeastern United States (Radforth 1944; Barila 1980). Walleye have been reported from the Tombigbee River system in Mississippi and Alabama, in the Alabama River system of Alabama and Georgia (Brown 1962; Schultz 1971; Mettee et al. 1987; Boschung 1989), and the Coosa River system in northwestern Georgia (Spencer 1986; Beisser 1987; 1989). However, Colby et al. (1979) and Barila (1980) have indicated that populations of walleye in Atlantic drainage areas of the southeastern United States are probably introduced. Conversely, the former fish may be part of a distinct Gulf Coast strain of walleye postulated to exist from the extreme western portion of the Florida panhandle to the Pearl River, Mississippi (Hackney and Holbrook 1978). This strain may be different from the Mississippi River strain to the north in that it does not establish in reservoirs, populations do not reach high abundance even in preferred habitat, and individuals do not reach large sizes (Brown 1962; Hackney and Holbrook 1978). Wingo (1982) demonstrated some genetic differences between walleye of the Upper Tombigbee River system and fish from Iowa, New York, and Pennsylvania. If a unique Gulf Coast strain of walleye indeed exists, the creation of the Tennessee-Tombigbee Waterway (TTW) linking the Tennessee River with the Tombigbee River may allow passage of Mississippi River strain walleye into areas previously occupied exclusively by the Gulf Coast strain. The objective of the present study was to clarify the genetic traits of walleye from the Upper Tombigbee River system in Mississippi, in order to define baseline criteria for future evaluations of the genetic integrity of walleye in this area.

METHODS

All site numbers for collections are as described by Boschung (1989). Walleye (n=27) were collected from the Luxapallila River, Lowndes County, during the spring spawning season of 1985. All fish in this sample were collected within 5 km of the confluence with the Tombigbee River (near sites 157, 158, and 161), and are thought to represent Tombigbee River fish on a spawning run up the tributary stream (C.A. Schultz, Mississippi Department of Wildlife Conservation; personal communication). Additional samples were collected from the same area in spring 1988 (one fish) and spring 1989 (one fish); Yellow Creek, a Luxapallila River tributary (near site 167; one fish, spring 1985); the Buttahatchie River at Caledonia, Monroe County (near site 235; one fish, February 1989), and Sipsey Creek, a Buttahatchie River tributary (near site 242; two fish, April 1989). All fish were collected with gill nets or hoop nets, immediately frozen, and shipped to the Wildlife Genetics Laboratory at Texas A&M University for electrophoretic analyses. Liver and white muscle tissue samples were excised from each fish, and stored at –90 C pending electrophoretic analysis.

Subsamples of white skeletal muscle were thawed and homogenized in 0.5-1.0 mL grinding buffer (.01M Tris-0.001M EDTA, pH 6.8), and centrifuged (800 x gravity) at room temperature for 5 minutes. Liver samples were thawed, but not ground or centrifuged. Electrophoretic analyses were limited to protein systems demonstrated to be polymorphic in previous studies of the species (Uthe and Ryder 1970; Clayton et al. 1974; Terre 1985). Muscle and liver supernatants were subjected to starch gel electrophoresis (Selander et al. 1971), using N-(3-aminopropyl) morpholine-citrate buffer pH 6.1 (Clayton and Tretiak 1972). Malate dehydrogenase (MDH, ISN[1] 1.1.1.37) and isocitrate dehydrogenase (IDH, ISN[1] 1.1.1.42) were stained with specific enzyme stains from Harris and Hopkinson (1976). Vertical-slab polyacrylamide-gel electrophoresis (Hoefer Scientific Instruments 1980), with gel formulations from Davis (1964), was utilized to visualize muscle myogen (MYO) proteins (Uthe and Ryder 1970) and a general serum albumin (ALB) (Terre 1985). Muscle supernatant was mixed with an equal volume of layering solution (60% sucrose in distilled water), applied to a 12% acrylamide gel in 10-µl aliquots, and subjected to electrophoresis for 3,000 volt-

[1] International standard number (IUBNC 1984).

hours at 40 mA per gel. General proteins were stained with a 0.04%/5% Coomassie Brilliant Blue Green/perchloric acid solution, and destained with a 15%/10% ethanol/acetic acid solution.

RESULTS AND DISCUSSION

The walleye examined in this study were unique in that no heterozygosity was observed at any of the presumptive loci examined. This genetic fixation is in contrast to a significant amount of variability that has been observed at these loci in most other genetic studies of walleye (Table 1). While some of the variability currently evident in most walleye populations is probably a result of the widespread stocking of the species, considerable variability has been reported in populations across Canada (Uthe and Ryder 1970; Clayton et al. 1974) where stocking has probably impacted natural genetic structure less than populations in the United States. Murphy and Lee (1986) found that walleye from four to six sites in Minnesota were homozygous for the MYO-A^1 allele, but heterozygosity was observed in the same fish for the other three loci. No other cases of genetic fixation in walleye have been reported in the literature.

Genetic characteristics of walleye examined in this study are quite distinct from walleye in the Cumberland River segment of Dale Hollow Reservoir, Tennessee (Dryden et al. 1988), which presently show relatively high frequencies of genes that do not occur in the Tombigbee populations (Table 1). No specific information exists on the genetic characteristics of Tennessee River walleye, but they most likely bear some resemblance to walleye from the Cumberland River area since these rivers are adjacent Ohio River tributaries. A long history of stocking walleyes from northern populations into the reservoirs of the central Appalachian states would make it impossible to determine the genetic makeup of native Tennessee River walleye (Dryden et al. 1988). Assuming a genetic similarity between Tennessee River walleye and Cumberland River walleye, and assuming that the genetic fixation observed in this limited study is representative of all walleye in the Tombigbee River system, it should be possible to genetically trace any future invasion of the Tombigbee drainage by Tennessee River walleye through the TTW. Genetic characteristics of Tennessee River walleye should be verified as soon as possible to facilitate these comparisons.

The uniquely uniform genetic makeup of walleye examined in the present study seemingly invalidates the assumption that walleye were transplanted into the upper Tombigbee River system. Transplantation during modern times from any other area of North America likely would have introduced fish with much more genetic diversity than that observed in the present study. My results imply that walleye in the Tombigbee River drainage indeed represent a unique population of the species that has been isolated from other populations for a considerable period of time. The depauperate genetic nature of walleye observed in the present study may be the result of a genetic bottleneck, possibly linked to a limited stream capture event at some point in the past. This unique genetic character may be typical of walleye throughout the Gulf Coast drainages of Mississippi, Alabama, and Georgia; and it may be linked to the unique thermal tolerance traits reported for walleye from this area (Colby et al. 1979). More research is needed to verify the genetic characteristics of walleye throughout the suspected range of the Gulf Coast strain. The unique population described in this study, and other such populations that may be identified, may represent the last walleye populations in the United States that have not been impacted by the cross-stocking that has been so common in the management of this species. As such, they should be afforded protection from introgression with other strains to the maximum extent possible. Walleye populations in the upper Tombigbee River system should be monitored regularly to detect any invasion of walleye from the Mississippi River watershed through the TTW. If Tennessee River fish do indeed invade the Tombigbee River, a captive breeding/transplantation program may be the only feasible method of preserving the genetically unique walleye of the upper Tombigbee River system.

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Table 1. Gene frequencies for four presumptive loci for Mississippi walleye investigated in the present study, and frequencies reported for the same loci for walleye from other areas of North America.

Locus	Allele	MS[1]	TN[2]	TX[3]	VA[4]	PA[4]	KS[4]	NE[4]	MN[5]	Canada
MDH-B	1	0.00	0.01	0.00	<0.01	0.00	0.07	0.04	<0.05	0.00-0.62[6]
	2	0.00	0.86	0.43	0.55	0.80	0.84	0.54	0.31-0.69	0.07-0.70
	3	1.00	0.13	0.57	0.45	0.20	0.09	0.42	0.31-0.69	0.17-0.65
IDH-A	1	0.00	0.42	0.62	–	–	–	–	0.37-0.58	–
	2	1.00	0.58	0.38	–	–	–	–	0.42-0.63	–
MYO-A	1	1.00	0.52	0.91	0.53	0.65	0.88	0.85	0.83-1.00	0.38-0.84[7]
	2	0.00	0.48	0.09	0.47	0.35	0.12	0.15	0.00-0.17	0.06-0.62
ALB-A	1	1.00	0.09	0.82	–	–	–	–	0.10-0.92	–
	2	0.00	0.91	0.18	–	–	–	–	0.08-0.90	–

References: [1]Present study; [2]Dryden et al. 1988; [3]Terre 1985; [4]Murphy 1981; [5]Murphy and Lee 1986 (range reported for 6 lakes and rivers); [6]Clayton et al. 1974 (range reported for 19 lakes and rivers); [7]Uthe and Ryder 1970 (range reported for 5 lakes).