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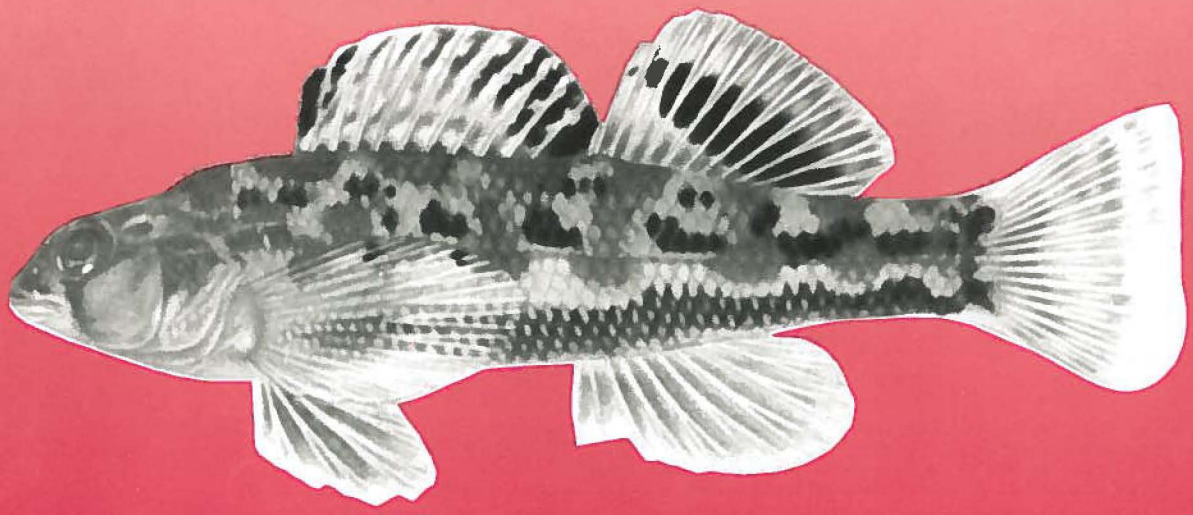

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TUSCALOOSA, ALABAMA

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Effects of Impoundments on Freshwater Mussels (Mollusca: Bivalvia: Unionidae) in the Main Channel of the Black Warrior and Tombigbee Rivers in Western Alabama

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ABSTRACT: Williams, J. D., S. L. H. Fuller, and R. Grace. Effects of impoundments on freshwater mussels (Mollusca: Bivalvia: Unionidae) in the main channel of the Black Warrior and Tombigbee rivers in western Alabama. Bulletin Alabama Museum of Natural History, Number 13:1–10, 3 tables, 1 figure. Freshwater mussels were sampled at six stations in the unimpounded upper Tombigbee River and at 14 stations in impounded segments of the Black Warrior and Tombigbee rivers. Specimens were collected by hand in shallow areas and by SCUBA diving in deep water. The mussel fauna of the unimpounded segment of the Tombigbee was 30 species compared with 19 species in the impounded segments of the Black Warrior and Tombigbee. Twenty-nine species of mussels were collected at a single station in the unimpounded Tombigbee River. The five most common species collected in the unimpounded segment of the Tombigbee were *Fusconaia ebena*, *Quadrula asperata*, *Ellipsaria lineolata*, *Obliquaria reflexa*, and *Pleurobema marshalli*. The most productive stations in the impounded segments of the Black Warrior and Tombigbee yielded 13 and 8 species, respectively. *Medionidus macglameriae*, known only from the type specimens collected from the Tombigbee River at Epes, Alabama, was not collected during this study. The Asian clam, *Corbicula fluminea*, was present in small numbers at 12 of the 20 stations in the study area. This exotic competitor for space and energy entered the Mobile River basin at least a quarter-century ago, but no damage to native mussels was detected in the study area. All of the 1930s' mussel species remained in the unimpounded Tombigbee in the 1970s'. Habitat destruction associated with impoundments has severely depleted mussels of the main channels of the Tombigbee and Black Warrior rivers. Based on published records and museum collections, 54 mussel species are known from these two rivers, 50 in the upper Tombigbee, 48 in the Black Warrior and 44 shared by both. Eleven (20.4%) of the mussel species in these two rivers are currently listed or are under review for listing as endangered by the U. S. Fish and Wildlife Service.

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Introduction

The first collections of freshwater mussels from the Black Warrior and Tombigbee rivers, like other rivers of the Mobile River basin, were taken during the early 1800s and reported by naturalists Timothy A. Conrad and Issac Lea. Lewis (1876), who compiled the first list of freshwater and land shells of Alabama, reported 24 species of unionid mollusks from the Black Warrior River system. Hinkley (1904) reported collecting 29 species from the Black Warrior River and the Mulberry River, a headwater tributary of the Black Warrior. Forty-one species of mussels were reported from the Tombigbee River system in Alabama and Mississippi by Hinkley (1906). Van der Schalie (1939a) reported 50 species (approximately 40 of these currently are recognized as valid) in four collections from the Tombigbee River in the vicinity of Epes, Alabama, and Columbus, Mississippi. Additional distribution records of unionids from the Tombigbee and Black Warrior rivers were reported by van der Schalie (1981a, 1981b). Williams (1982) and Hartfield and Jones (1989a, 1989b, 1990) reported on the status of endangered mussels in the Tombigbee River in Alabama and Mississippi. Other reports on mussels from these rivers have been limited to a few species included in taxonomic revisions and unpublished faunal studies.

Beginning in the early 1900s, a series of low navigation locks and dams was constructed along the Black Warrior and Tombigbee rivers. These low structures were replaced by larger dams to produce hydropower and increase the navigation channel depth to nine feet from the vicinity of Birmingham, Alabama, on the Black Warrior River downstream to Mobile, Alabama. These impoundments have drastically altered the main channels of the rivers and the lower portions of their tributaries. Both river systems have also been subjected to the widespread problem of siltation from agricultural and mining activities (sand and gravel in Costal Plain areas and coal in the upper Warrior basin). Pollution from industries along these rivers has caused localized problems. However, impoundments are the most important factor in restructuring the riverine ecosystem of the Mobile basin.

The purpose of this report is to examine the effects of impoundments on the species composition of the mussel fauna of an unimpounded segment of the Tombigbee River with the faunas of sections of the impounded segments of the Black Warrior and Tombigbee rivers. The mussels reported from the unimpounded segment of the Tombigbee River (stations T1–T6 of those described below) also represent base line data for the area that was impounded in 1976 as part of the Tennessee Tombigbee Waterway. We also provide a comprehensive list (Table 1) of mussels known to occur in the upper Tombigbee and Black Warrior rivers based on published reports and museum collections.

Study Area

The Black Warrior and Tombigbee rivers, draining portions of western Alabama and eastern Mississippi, are the westernmost rivers in the Mobile basin. The headwater tributaries of the Black Warrior River basin downstream to Tuscaloosa, Alabama, are developed on Paleozoic formations of the Cumberland Plateau. Streams draining this area are characterized by moderate to steep gradient and by rocky shoals and riffles. The Fall Line (inland boundary between the Coastal Plain and other physiographic provinces) extends across the Warrior watershed from the northwest to the southeast in Tuscaloosa County. About seventy five percent of the basin is above the Fall Line; twenty five percent, below.

The Black Warrior River downstream from Tuscaloosa, Alabama (the reaches below the Fall Line), and the Tombigbee River are developed on Cretaceous formations of the upper Coastal Plain. This terrain is characterized by low, gently rolling hills where elevations range from 150 to 300 feet above sea level. Rivers draining the upper Coastal Plain are typified by a low gradient (approximately one foot per mile) with sand, gravel, and mud substrates. The study area is shown in Figure 1 and is totally within the upper Coastal Plain physiographic province.

In the study area there are two locks and dams on the Black Warrior River, Warrior Lock and Dam and William Bacon Oliver Lock and Dam, and two on the Tombigbee River, Demopolis Lock and Dam and Gainesville Lock and Dam. The Demopolis Lock and Dam on the Tombigbee River also impounds the lowermost portion of the Black Warrior River. A tabulation of pertinent data about each navigation lock and dam is provided in Table 2.

The Warrior Lock and Dam site is an atypical navigation structure in having the dam on the river channel and the lock located apart in an excavated canal. The bendway below the dam is almost undisturbed in comparison to the area downstream from the lock canal and the area upstream from the dam. However, a major adverse impact in this bendway is the regulated (irregular) discharge from the dam.

Precipitation in the study area is rather evenly distributed throughout the year, with slightly higher accumulation in the winter and spring. The average precipitation is 52 inches annually. Temperatures for the area are moderate: the average daytime high in the summer is about 30°C; the average nighttime low, 20°C. Severe winter weather is rare, and temperatures below freezing usually persist less than 48 hours. The winter high-low range of temperatures is 5°C–15°C, and collective frost-free periods range from 200 to 250 days per year (Hays, 1973).

Table 1. List of unionid mollusks known to have occured in the upper Tombigbee and Black Warrior rivers. An "X" in the habitat column indicates the presence of a record of that species in that size stream. Species are arranged alphabetically.

SCIENTIFIC NAME	UPPER TOMBIGBEE	BLACK WARRIOR		HABITAT			
		Below Fall Line	Above Fall Line	Large River	Small River	Large Creek	Small Creek
Amblema plicata perplicata (Conrad, 1841)	X	X	X	X	X	X	
Anodonta grandis Say, 1829	X			X	X		
Anodonta imbecillis Say, 1829	X	X	X	X	X	X	
Anodonta suborbiculata Say, 1831	X			X			
Anodontoides radiatus (Conrad, 1834)	X	X	X			X	X
Arcidens confragosus (Say, 1829)	X	X		X			
Ellipsaria lineolata (Rafinesque, 1820)	X	X	X	X	X	X	
Elliptio arca (Conrad, 1834)	X	X	X	X	X		
Elliptio arctata (Conrad, 1834)	X	X	X	X	X	X	X
Elliptio crassidens (Lamarck, 1819)	X	X	X	X	X	X	
Epioblasma metastriata (Conrad, 1840)			X	X	X	X	
Epioblasma penita (Conrad, 1834)	X	X		X	X		
Fusconaia cerina (Conrad, 1838)	X	X	X	X	X	X	
Fusconaia ebena (I. Lea, 1831)	X	X	X	X	X		
Lampsilis altilis (Conrad, 1834)	X	X	X		X	X	X
Lampsilis ornata (Conrad, 1835)	X	X	X	X	X	X	
Lampsilis perovalis (Conrad, 1834)	X		X	X	X	X	
Lampsilis straminea claibornensis (I. Lea, 1838)	X	X	X	X	X	X	X
Lampsilis teres (Rafinesque, 1820)	X	X	X	X	X	X	
Lasmigona complanata alabamensis Clarke, 1985	X	X	X	X	X	X	
Leptodea fragilis (Rafinesque, 1820)	X	X	X	X	X	X	
Ligumia recta (Lamarck, 1819)	X	X	X	X	X		
Ligumia subrostrata (Say, 1831)	X					X	X
Medionidus acutissimus (I. Lea, 1831)	X	X	X	X	X	X	
Medionidus macglameriae van der Schalie, 1939	X			X			
Megalonaias nervosa (Rafinesque, 1820)	X	X	X	X	X	X	
Obliquaria reflexa Rafinesque, 1820	X	X	X	X	X		
Obovaria jacksoniana (Frierson, 1912)	X	X		X	X	X	
Obovaria unicolor (I. Lea, 1838)	X	X		X	X	X	
Plectomerus dombeyanus (Valenciennes, 1827)	X	X		X	X		
Pleurobema curtum (I. Lea, 1859)	X			X			
Pleurobema decisum (I. Lea, 1831)	X		X	X	X		
Pleurobema furvum (Conrad, 1834)			X	X	X		
Pleurobema marshalli Frierson, 1927	X			X			
Pleurobema perovatum (Conrad, 1834)	X	X	X	X	X	X	
Pleurobema rubellum (Conrad, 1834)			X	X	X		
Pleurobema taitianum (I. Lea, 1834)	X	X		X	X		
Potamilus inflatus (I. Lea, 1831)	X	X		X			
Potamilus purpuratus (Lamarck, 1819)	X	X	X	X	X	X	
Ptychobranchus greeni (Conrad, 1834)			X	X	X	X	
Quadrula apiculata (Say, 1829)	X	X	X	X	X	X	
Quadrula asperata (I. Lea, 1861)	X	X	X	X	X	X	
Quadrula metanevra (Rafinesque, 1820)	X	X		X	X		
Quadrula rumphiana (I. Lea, 1852)	X	X	X	X	X	X	
Quadrula stapes (I. Lea, 1831)	X	X		X			
Strophitus connasaugaensis (I. Lea, 1857)	X	X	X		X	X	X
Strophitus subvexus (Conrad, 1834)	X	X	X	X	X	X	X
Toxolasma parvus (Barnes, 1823)	X	X	X	X	X	X	X
Tritogonia verrucosa (Rafinesque, 1820)	X	X	X	X	X	X	X
Truncilla donaciformis (I. Lea, 1828)	X	X	X	X	X	X	
Uniomerus tetralasmus (Say, 1831)	X	X	X		X	X	X
Villosa lienosa (Conrad, 1834)	X	X	X		X	X	X
Villosa nebulosa (Conrad, 1834)	X	X	X	X	X	X	X
Villosa vibex (Conrad, 1834)	X	X	X	X	X	X	X

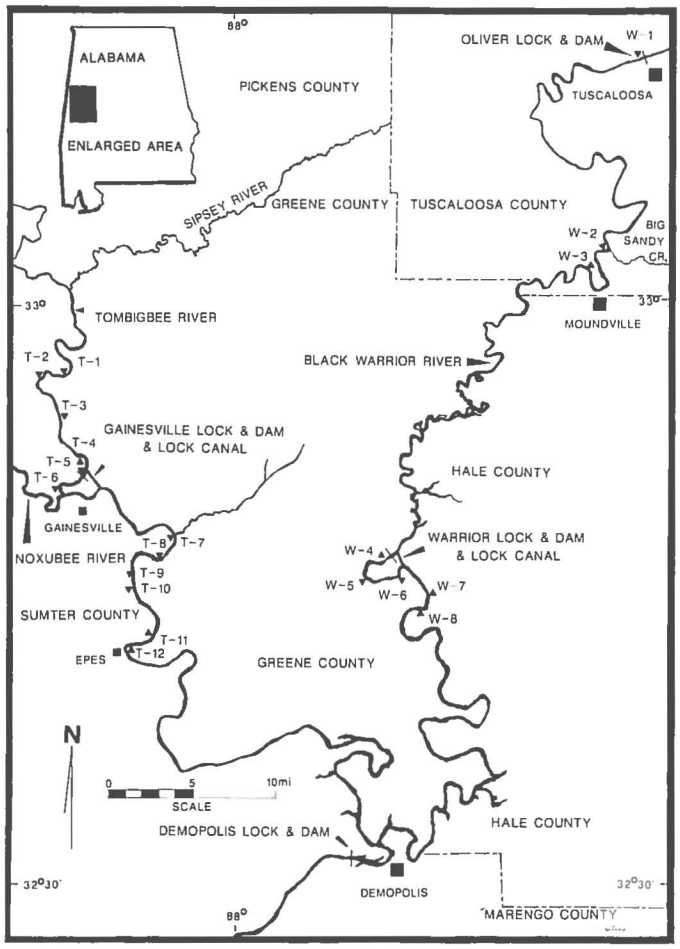

Figure 1. Sample sites on the Black Warrior and Tombigbee Rivers in western Alabama. Stations T1–T6 on the Tombigbee River were sampled prior to construction of the Gainesville Lock and Dam. The remaining stations on the Tombigbee River (T7–T12) and Black Warrior River (W1–W8) were sampled in impounded areas.

Methods

Two methods of collecting mussels were employed during the field sampling phase of this study. Hand collecting was used in the shallow areas (up to 3 feet of depth) throughout the study area. Most specimens collected using this method were taken along the banks and from islands and sand and gravel bars associated with shoal areas. In the unimpounded segment of the Tombigbee River large middens created by riverine mammals, usually in shoal areas, were sampled extensively. The second collecting method, SCUBA diving, was used in deeper, impounded segments of the study area. Preimpoundment topographic maps were used to locate impounded shoal areas that had potential as productive sites. Most specimens collected were freshly empty (hinge intact), but live individuals of some species were found. Field sampling occurred during the years 1972–1975.

For each collection we made notes describing the physical characters of the site, e.g., depth, substrate, and current. The location and a brief description of each station is presented in Appendix I. After collection the specimens were cleaned, identified, and shipped to the Museum of Zoology at The Ohio State University. There the collections received final cleaning, and each specimen was cataloged and deposited in the permanent museum collection. Badly eroded or broken specimens were recorded on the field data sheets and subsequently discarded.

Table 2. Date of completion, height and reservoir area of the four major impoundments located in the study area.

LOCK AND DAM	YEAR COMPLETED	HEIGHT OF DAM (FT)	ACRES OF RESERVOIR
Demopolis	1954	58	10,000
Warrior	1957	71	7,800
Wm. B. Oliver	1939	49	**
Gainesville	1976	71	6,400

(United States Army Corps of Engineers, 1979)
** reservoir primarily within original river banks

Twelve localities in the upper Tombigbee River (Tombigbee above its confluence with the Black Warrior River) and eight localities in the Black Warrior were sampled (Fig. 1). In the Tombigbee River six stations (T1–T6) were located in the main channel of the river in unimpounded waters between Gainesville and 0.2 mi upstream from Warsaw, Alabama. Six stations (T7–T12) were in the impounded river channel between Epes and Gainesville. In the Black Warrior River, one station (W1) was just below Oliver Dam; two stations (W2–W3), in the impounded river channel behind Warrior Dam; three (W4–W6), in the river bendway below Warrior Dam; and two (W7–W8), in the impounded river channel below Warrior Lock cutoff. The locality, date, and description of each collecting station are presented in Appendix I.

The list of mussels occurring in the Tombigbee and Black Warrior rivers was compiled from published records and museum collections in the Academy of Natural Sciences of Philadelphia, the Florida Museum of Natural History, and the National Museum of Natural History. In many cases it was not possible to determine the identity of some species reported in the pre-1900 literature; this was especially true in situations where there was a list of species without illustrations or descriptions. We use the common and scientific names presented by Turgeon et al. (1988).

Unionid Fauna of the Upper Tombigbee and the Black Warrior Rivers

The diverse unionid fauna of this region was the subject of considerable interest during the 1800s and early 1900s, but has received very little attention in the past seventy years. In recent decades systematic revisions have produced numerous taxonomic changes among the mussels recognized as valid species. In the course of identifying

material collected during this study we compiled a list of unionids known to occur in the upper Tombigbee and the Black Warrior rivers that is based on our own collections, museum records, and published reports (Table 1). Relative stream size (large vs small and river vs creek) data, also, are given for all species known to occur in the upper Tombigbee and the Black Warrior rivers (Table 1); these data are far from complete, but do reflect the information available from collections of unionids throughout the Mobile basin.

Of the 54 unionid species known to occur in the upper Tombigbee or the Black Warrior rivers 44 are shared by both. There are 50 species that are known to have occurred in the upper Tombigbee and 48 in the Black Warrior. Ten of the 54 species are known to occur in only one of the two basins. Twenty-one of the 54 species are endemic to the Mobile Basin. Distribution patterns and habitat requirements in other Mobile basin drainages suggest that 3 of these 10 species (*Anodonta grandis*, *A. suborbiculata*, and *Ligumia subrostrata*) probably occurred below the Fall Line in the Black Warrior. Each of the remaining seven species that are found in only one of the two river systems is localized in its geographic distribution and/or has habitat requirements that preclude its occurrence outside the system where it is found.

Six species (*Epioblasma penita*, *Pleurobema curtum*, *P. marshalli*, *P. taitianum*, *Potamilus inflatus*, and *Quadrula stapes*) of unionids from the Tombigbee and Black Warrior basins are listed as endangered species (U. S. Fish and Wildlife Service, 1991). An additional 5 species (*E. metastriata*, *Lampsilis altilis*, *L. perovalis*, *Pleurobema decisum*, and *P. rubellum*) are under consideration for listing as endangered or threatened species pending completion of field surveys. One species, *Medionidus macglameriae*, is known only from two specimens (found at Epes, Alabama), on which van der Schalie (1939a) based the original description; this species is presumed extinct (Turgeon et al. 1988). The 11 species that are listed as endangered or are under review for conservation status represent 20.4% of the total unionid fauna of the upper Tombigbee and Black Warrior basin recognized here. Much, immediate attention will be required to protect and recover these freshwater mussels.

Results and Discussion

The study area (Fig. 1) was divided into three segments defined by flow conditions and locations: (1) the unimpounded Tombigbee River (stations T1–T6), (2) the impounded Tombigbee River (T7–T12), and (3) the impounded Black Warrior River (W1–W8). Most samples from the free-flowing (unimpounded) segment of the Tombigbee River (T1–T6) were taken from shallow gravel shoals and riffle areas with moderate to swift current. This type of habitat contrasts sharply with the deeper, reservoir habitat present in the impounded segments of the Tombigbee (T7–T12) and Black Warrior (W1–W8). A list of mussels collected at each station is presented in Table 3.

The unionid fauna at stations in the unimpounded segment of the upper Tombigbee ranged from a low of 14 species (at T2) to a high of 29 species (at T5). The five most common species collected in the unimpounded segment were *Ellipsaria lineolata*, *Fusconaia ebena*, *Obliquaria reflexa*, *Pleurobema marshalli*, and *Quadrula asperata*. Each of four species (*Elliptio arca*, *Strophitus subvexus*, *Truncilla donaciformis*, and *Villosa vibex*) was taken at only one station and was represented by one or two individuals. The total mussel fauna for all stations in the unimpounded segment was 30 species, of which twelve (*Ellipsaria lineolata*, *Elliptio arca*, *Epioblasma penita*, *Lampsilis ornata*, *P. decisum*, *P. marshalli*, *P. taitianum*, *Q. metanevra*, *Q. stapes*, *S. subvexus*, *T. donaciformis*, and *V. vibex*) were not collected in the impounded segments of the Tombigbee and Black Warrior rivers.

The six stations (T7–T12) in the impounded portion of the Tombigbee River yielded very few mussels. At three of the six stations (T7, T8, and T12) *Corbicula fluminea* was present, but no unionids were found. Two species of mussels were collected at stations T9 and T11; eight, at station T10. A total of 10 species of mussels was collected in the impounded portion of the Tombigbee River. All of these 10 species were present in the unimpounded segment of the Tombigbee. One species, *Amblema plicata*, present in the impounded upper Tombigbee, was not found in the impounded Black Warrior.

Eighteen species of mussels were collected from the impounded portion of the Black Warrior River. The mussel fauna ranged from one species (at stations W7 and W8) to a high of 13 species (W6). At two stations (W1 and W4) no mussels were found, but *Corbicula fluminea* was present. At station W6 the most abundant of the 13 species present was *Elliptio crassidens*, followed by *Fusconaia ebena*, *Megalonaias nervosa*, *Plectomerus dombeyanus*, and *Quadrula asperata*. The shells of the larger individuals from station W6 were very badly eroded. This may have been caused by increased movement of sediments associated with the periodic releases from upstream reservoirs.

Although there are no comprehensive preimpoundment mussel studies of the Black Warrior River within the study area, a few species not encountered in this study have been reported. Conrad (1835–1838) reported *Medionidus acutissimus* from the Black Warrior River at Erie, Greene County, Alabama. Archaeological exploration of Indian middens located on the Black Warrior River southwest of Tuscaloosa revealed the remains of 16 species of mussels (R. W. Hanley, personal communication). Six of these (*Tritogonia verrucosa*, *Quadrula stapes*, *Amblema plicata*, *Pleurobema taitianum*, *Pleurobema* sp., and *Lampsilis ornata*) were not found at any of the eight Black Warrior River stations that we examined. The age of the Indian middens was estimated to be 400 years.

A total of 19 species of mussels was found in the im-

Table 3. Species of unionids and *Corbicula fluminea* taken in the upper Tombigbee and Black Warrior rivers study area (Fig. 1) and species reported from the Tombigbee River at Epes, Alabama, by van der Schalie (1939a) based on preimpoundment collections made in 1933 and 1935. The specimens collected from impoundment station T-12 at Epes, Alabama, are from the same locality as the preimpoundment collection reported by van der Schalie (1939a). Tombigbee River station numbers are preceded by a "T" and those of the Black Warrior by a "W". An "X" indicates the presence of a species, but number of individuals was not reported.

	Preimpoundment						Impoundment						Preimpoundment van der Schalie	Impoundment						
	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9	T-10	T-11	T-12	(1939a)	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8
Amblema plicata perplicata	2	1		2	16	5				1			16								
Arcidens confragosus																1					
Ellipsaria lineolata	42	13	71	1	161	9							26								
Elliptio arca					2								19								
Elliptio arctata													4								
Elliptio crassidens	4	1	1	1	6	6							10						138		
Epioblasma penita	3	8	4	1	62	1							4								
Fusconaia cerina	3	2	9	14	3	1							93						5		
Fusconaia ebena	86	70	97	5	498	24				2			91			2		2	85		
Lampsilis ornata	7		1	6	28	4							25								
Lampsilis straminea claibornensis	3				8	4									1	4					
Lampsilis teres	5	1	1	1	13	5				1			52		2	3			2		
Leptodea fragilis	2		2	1	13	5				1	1		1			1					1
Ligumia recta					2	2							1						1		
Medionidus macglameriae													2								
Megalonaias nervosa	1			1	1	2							66		1				49		
Obliquaria reflexa	30	6	28	5	148	25			1		1		12			2		5	3		
Obovaria jacksoniana													X								
Obovaria unicolor	18	6	3	1	13	1							7					1			
Plectomerus dombeyanus	1		1		7	3				1			1					1	28		
Pleurobema decisum	1		1		1																
Pleurobema marshalli	14	24	21	1	102	7							2								
Pleurobema taitianum	13	7	49		30	3							4								
Potamilus inflatus													1						1	1	
Potamilus purpuratus	4		2	1	8	7				1			8			1		1			
Quadrula apiculata	4		1		6	14							18		1	3			4		
Quadrula asperata	86	74	72	5	261	21				1			89					15	25		
Quadrula metanevra	14	3	6	1	88								17								
Quadrula rumphiana						5							2						1		
Quadrula stapes	2	2	3		24																
Strophitus subvexus					1									2							
Tritogonia verrucosa	1				9	2							44								
Truncilla donaciformis					1								1								
Villosa lienosa	1				1	3			1				10			3					
Villosa vibex					1																
Corbicula fluminea (Müller, 1774)					3	2	X	X				X		X	4	2	X	2	9		
TOTAL NUMBER OF SPECIES	25	14	19	15	30	24	1	1	2	8	2	1	31	1	5	9	1	7	14	1	1

pounded portions of the Tombigbee and Black Warrior rivers. In the Tombigbee segment only 10 species were collected; 18, in the Black Warrior segment. The reduced number of species and individuals in the impounded segment of the Tombigbee appears to be habitat-related. Habitat in the Tombigbee segment was characterized by slow to non-existent current over a bottom of sand, mud, or bedrock (chalk and marl). In the Black Warrior segment there was a more diverse habitat with varying substrate and flow conditions. The Black Warrior station supporting the most diverse mussel fauna (13 species) was W6, located approximately four miles below Warrior Dam in the old river channel at Hall Shoals. Of the eight stations sampled in the impounded Black Warrior, W5 and W6 were the least altered. The presence of more diverse mussel populations below dams in comparison to impounded areas above dams was discussed by Fuller (1974).

Of the 19 species of mussels collected from the 14 stations in the impounded segments of the study area, 11 species (57.9%) occurred at only one or two stations. The most widespread species in the impounded segments was *Obliquaria reflexa*, present at five of the 14 stations. This species has been reported from streams and impounded waters, where it was associated with a variety of substrates (Buchanan, 1980; Hurd, 1974). The facultative nature of the parasitic stage of *O. reflexa* (Fuller, 1974) probably contributes to survival of the species' juveniles. Three species (*Fusconaia ebena*, *Leptodea fragilis*, and *Lampsilis teres*) were taken at four of the 14 impoundment stations, and four species (*Plectomerus dombeyanus*, *Quadrula apiculata*, *Q. asperata*, and *Potamilus purpuratus*) were taken at three impoundment stations.

Hartfield and Jones (1989b) found 25 species of unionids alive along 46 transects in the Gainesville bendway (just above and below station T6 of this study). Quantified as the number of juveniles, recruitment was very low and was observed in only nine of the 25 species reported. Two of these nine, *Ellipsaria lineolata* and *Lasmigona complanata*, were not found in the impoundment stations sampled in this study. The remaining seven species with recruitment were present in our impoundment samples, also.

The preimpoundment mussel fauna of the Tombigbee River at Epes, Sumter County, Alabama, and Columbus, Lowndes County, Mississippi, was reported by van der Schalie (1939a). The Epes material was collected from gravel bars and shoals in 1933 and 1935. From the Epes locality van der Schalie reported 34 species of mussels, of which 31 are presently recognized. The impoundment of this area by Demopolis Dam in the mid-1950s drastically altered the riverine habitat. The most obvious changes are the increased depth, decreased current, and loss of gravel substrate due to sedimentation. The Epes area was sampled (station T12) by diving during this study, but no mussels were found. Assuming that the 10 species of mussels present at other stations in the impounded segment of the Tombigbee are present in the Epes area, one still would find a loss of 67.7% of the preimpoundment fauna.

We sampled a preimpoundment midden of undetermined age located on the west bank of the impounded upper Tombigbee River approximately 1.5 miles above the interstate route 59 bridge (station T10). Badly eroded remains of seven species (*Quadrula asperata*, *Q. stapes*, *Fusconaia cerina*, *F. ebena*, *Pleurobema* sp., *P. decisum*, and *P. taitianum*) were collected. Three of the seven species (*Q. asperata*, *F. cerina*, and *F. ebena*) were present in the dive sample at this locality. The shells in the midden were embedded in the bank a few feet above and below normal pool level. The four species taken only from the midden are omitted from Table 3 because they appear to be part of the preimpoundment mussel fauna.

The mussel fauna reported from Epes by van der Schalie (1939a) and that of the unimpounded segment of the Tombigbee River (stations T1–T6) are very similar. Of the 30 species present in the Tombigbee (T1–T6) only three (*Pleurobema decisum*, *Villosa vibex*, and *Lampsilis straminea claibornensis*) were not reported from Epes by van der Schalie (1939a). These three species, which are more abundant in small rivers, were present in limited numbers at stations T1–T6. Of the 31 species reported from Epes by van der Schalie (1939a) four species (*Elliptio arctata*, *Obovaria jacksoniana*, *Potamilus inflatus*, and *Medionidus macglameriae*) were not encountered in the unimpounded Tombigbee segment during this study. We have taken two of these, *E. arctata* and *O. jacksoniana*, at several localities upstream of the study area and one, *Potamilus inflatus*, has been collected in the Gainesville bendway in recent years (Hartfield and Jones, 1989b). The remaining species, *M. macglameriae*, has not been collected from the Tombigbee River system since 1935 and is considered to be extinct (Turgeon et al., 1988). In a monograph on the genus *Medionidus* Johnson (1977) recognized *M. macglameriae* as a valid taxon and commented on its relationship to other species in the genus, but offered no new data beyond those presented in the original description by van der Schalie (1939a).

The absence of *Potamilus inflatus* in most Tombigbee River mussel collections during the past twenty years is somewhat surprising. It was collected from the Tombigbee River in Alabama and Mississippi on several occasions during the late 1800s and early 1900s. The increased silt loads (van der Schalie, 1939a) resulting from poor agricultural practices may have brought about the reduced abundance of this species in the upper Tombigbee River. Our collection of *P. inflatus* from two stations (W6 and W7) in the Black Warrior River suggests that it is tolerant of some impoundment conditions. We note that one of these two stations (W6) was located just below Warrior Dam and usually had some current. This station was one of the least altered of the eight areas sampled in the Black Warrior.

Recent collections of *P. inflatus* from the Tombigbee in the upper portion of the Demopolis Pool and the Gainesville bendway (Hartfield and Jones, 1989b) appear to be from an area similar to the stations where we encountered the species in the Black Warrior.

The impact of reservoirs and impoundments on mussel populations is known to be generally detrimental. Ortmann (1909) pointed out the adverse effects of pollution and dams on the freshwater fauna, particularly mollusks and crustaceans, in western Pennsylvania. The adverse impacts of Tennessee Valley Authority (TVA) impoundments on the mussels in the Muscle (Mussel) Shoals area of the Tennessee River in northern Alabama are perhaps the best-documented case. Ortmann (1924) was the first to express concern about the reduction of the Muscle Shoals mussel fauna, the most diverse (approximately 70 species in 31 genera) in North America. Subsequent studies of this fauna (van der Schalie, 1939b; Stansbery, 1964; Isom, 1969) have shown a drastic reduction (approximately 50 percent) in the number of species present. This reduction is attributed almost entirely to the habitat alterations associated with impoundment. Fuller (1974) reviewed the impacts of dams on bivalve mollusks. A broader assessment of the impacts of dams and impoundments on the aquatic environment is discussed in Baxter (1977) and Baxter and Glaude (1980).

In reviewing the adverse effects of impoundments (dams) on mussels, Fuller (1974) singled out the disruption of the reproductive process as the most significant impact. The habitat alterations associated with impoundments bring about profound changes in the fish fauna and thus displace or eliminate glochidial (larval) hosts. If the host fish is present and glochidial infections are successful, the water quality and substrate conditions in impoundments may not be suitable for juvenile mussels. Scruggs (1960) found that silt deposits on the bottoms of Wheeler and Chickamauga impoundments were detrimental to young, as well as adult mussels. Ellis (1936) reported adult mussel mortality of approximately 90% for several species when one-fourth of an inch to one inch of silt covered the substrate in laboratory experiments. Scruggs (1960) found that the most productive substrates for mussels in Wheeler Reservoir were a mixture of rubble, gravel, and sand. Substrate conditions at the most productive impoundment station (W6 with 14 species) were rocky with patches of sand and gravel. The substrates at impoundment stations that were least productive consisted of clean, tightly packed sand or mixtures of sand and mud.

The Asian clam, *Corbicula fluminea*, was present throughout the study area, but was not abundant at any of the stations sampled. The exact date when this exotic species was introduced into the Mobile basin is not known, but appears to have been during the late 1950s. Hubricht (1963) reported it as abundant in the Mobile River in the spring of 1962 and (Hubricht, 1966) reported finding adults abundant below Demopolis Dam, Sumter County, Alabama, in the fall of 1965. The low densities of the Asian clam encountered during this survey suggest that it was not adversely impacting the mussel fauna in the impounded or unimpounded river segments within the study area.

Appendix I: Collecting Stations.

Brief descriptions of the collecting stations and sampling methods used are presented. River miles given in the station descriptions are taken from the U.S. Army Corps of Engineers River Navigation Charts. Initials of individuals participating in collection of specimens are given for each station: Herbert Boschung (HB), Glenn Clemmer (GC), Robert Esher (RE), Patricia Grace (PG), Randall Grace (RG), John Hall (JH), Philip Mundy (PM), Vicki Pearson (VP), David Stansbery (DS), Royal Suttkus (RS), James Williams (JW). Current or flow conditions for the Black Warrior stations were not described because of their variability depending on release from upstream reservoirs. Species of mussels taken at each station are presented in Table 3. Stations T1–T6 were not impounded when sampled. Stations T7–T12 and W1–W8 were impounded.

Tombigbee River System

T-1. Tombigbee River about 0.2 mi above (upstream) Warsaw, about 7.8 mi NNW of Gainesville, Sumter County (T23N; R2W; Sec.33–34), Alabama. 8 June 1972 and 21 August 1974. Collected by HB, RG, PM, and JW. Specimens were collected by hand in the shallows (to a depth of 3 ft.) of a large island. The substrate was predominately gravel mixed with some sand. The current was moderate to swift. Aquatic vegetation (*Justicia* sp.) was present along the channel on the east side of the island.

T-2. Tombigbee River about 0.2 mi below (downstream) Warsaw, about 7.6 mi NNW of Gainesville, Sumter County (T23N; R2W; Sec.33), Alabama. 8 June 1972. Collected by HB, PM, and JW. Specimens were collected by hand from a midden along the east bank. A gravel shoal along the west bank created a swift current across the entire river channel.

T-3. Tombigbee River approximately 5 mi NNW of Gainesville, Sumter County (T22N; R2W; Sec.15), Alabama. 8 June 1972 and 21 August 1974. Collected by HB, GC, RG, PM, and JW. The sample was taken by hand from middens along the east and west banks. The current was moderate. The substrate consisted of mixtures of sandy clay and gravel.

T-4. Tombigbee River approximately 3 mi N of Gainesville, Sumter County (T22N; R2W; Sec.26), Alabama. 26 October 1973. Collected by GC, RE, RS, and JW. Specimens were collected by hand in the shallows around a low island (1 to 2 ft. above the water). The substrate was gravel with some sand and mud. The current was moderate.

T-5. Tombigbee River approximately 2 mi N of Gainesville, Sumter County (T22N; R2W; Sec.25), Alabama. 24 June 1972, 14 September 1973, 26 October 1973, and 21 August 1974. Collected by GC, RG, JH, VP, DS, and JW. Specimens were collected by hand from shallows around an island and from middens along the east bank. The island and channels along the island were predominately gravel with some sand. The banks were a mixture of sand and clay. Current around the island was moderate to swift.

T-6. Tombigbee River approximately 0.2 mi above mouth of Noxubee River NW of Gainesville, Sumter County (T21N; R2W; Sec.3), Alabama. 24 June 1972 and 26 October 1973. Collected by GC, RE, VP, DS, RS, and JW. The samples were taken by hand from the gravel bar and shallow areas along the east bank. The west bank is a steep chalk bluff. Substrate was primarily gravel with some sand and clay at each end of the bar. The current was moderate to swift. This is the first shoal area above the backwaters of Demopolis Reservoir.

T-7. Tombigbee River at the mouth of Brush Creek, approximately 3.3 mi NW of Boligee, Greene County (T21N; R1W; Sec.14), Alabama. 26 July 1975. Collected by PG, RG, and JW. The shallows at the mouth of the creek were sampled by hand. The substrate was mud and mud mixed with sand. The current in and around the mouth of the creek was slow.

T-8. Tombigbee River at mouth of unnamed tributary on the east bank 3 mi WNW of Boligee, Greene County (T21N; R1W; Sec.26), Alabama. 26 July 1975. Collected by PG, RG, and JW. The sample was taken from shallows around the mouth of the creek and sand banks on the west side of the river. There was very little current. Bottom material was a mixture of sand and mud.

T-9. Tombigbee River about 2 mi above I-59 bridge crossing approximately 5 mi NNE of Epes, Sumter County (T21N; R1W; Sec.32), Alabama. 26 July 1975. Collected by PG, RG, and JW. The sample was collected by hand from shallows along the west bank. The substrate was predominately mud with the exception of one gravel area where a small intermittent stream entered the reservoir. Current in the area was slow.

T-10. Tombigbee River approximately 1.5 mi above I-59 bridge, about 4.5 mi NNE of Epes, Sumter County (T21N; R1W; Sec.32), Alabama. 26 July 1975. Collected by PG, RG, and JW. This area was sampled for 45 minutes by diving in the channel (10 to 15 ft. deep) and by hand for 30 min in the shallows along the east bank. Current in the channel was slow. An old preimpoundment midden on the west bank, was also sampled. The substrate in the channel was firm sand with small patches of gravel. Substrate along the east bank was mud mixed with sand.

T-11. Tombigbee River approximately 0.5 mi below the public access boat ramp at Miller, Greene County (T20N; R1W; Sec.16), Alabama. 26 July 1975. Collected by RG. The sample was taken by diving for 45 minutes in the channel where depths ranged from 18 to 20 ft. The bottom was rocky (eroded chalk) towards the east bank and clean coarse sand along the west bank. The current was slow.

T-12. Tombigbee River just above railroad bridge at Epes, Sumter County (T20N; R1W; Sec.20), Alabama. 26 July 1975. Collected by RG. The area was sampled by diving for 30 minutes in water approximately 18 ft. deep with little or no current. The bottom was primarily sand with a mixture of mud and sand in some areas.

Black Warrior River System

W-1. Warrior River below Oliver Lock and Dam at Tuscaloosa (River Mile 338.2) Tuscaloosa County (T21S; R5E; Sec.21), Alabama. 3 August 1975. Collected by JW. The sample was taken by hand in shallows (depth to 2 ft.) on the west bank. The substrate consisted of sand mixed with some gravel and clay. The shallow area is below a rock outcrop and is accessible only during periods of low discharge from upstream reservoirs.

W-2. Warrior River opposite the mouth of Big Sandy Creek (River Mile 307), Tuscaloosa County (T24N; R4E; Sec.24), Alabama. 2 August 1975. Collected by PG, RG, and JW. The shallow along the sand bar on the west banks were sampled by hand. The bottom was a mixture of sand and loose gravel. A dive sample was attempted, but discontinued after 30 minutes because the water was too swift.

W-3. Warrior River at Mud Bar (River Mile 302.3) about 1.5 mi N of Moundville, Tuscaloosa County (T24N; R4E; Sec.26), Alabama. 2 August 1975. Collected by PG, RG, and JW. The sample was taken in shallows along Mud Bar on the west bank. The substrate was a mixture of sand and gravel.

W-4. Warrior River just below Warrior Dam about 4 miles SSE of Eutaw, Greene–Hale County line (T21N; R2E; Sec.24), Alabama. 30 July 1975. Collected by PG, RG, and JW. Shallow areas on the east and west banks were sampled by hand. The substrate on the east bank was clay with some sand and gravel. The west bank was predominately sand and gravel.

W-5. Warrior River, about 3 mi below Warrior Dam, about 5 air miles SSE of Eutaw, Greene–Hale County line (T21N; R2E; Sec.27), Alabama. 29 July 1975. Collected by RG. The sample was taken by diving for 1 hour near midstream at a depth of approximately 15–18 ft. Substrate in the sample area was sand and gravel with small patches of gravel mixed with sand.

W-6. Warrior River, at Hall Shoals, about 0.2 mi above junction of Warrior Lock Channel, Greene–Hale County line (T21N; R2E; Sec.25), Alabama. 28 July 1975 and 30 July 1975. Collected by RG. The samples were taken by diving for approximately 1 hour each day in midstream at depths of 15 to 20 ft. The substrate was rocky (large pieces of chalk) with patches of sand and sand mixed with gravel.

W-7. Warrior River at River Mile 259.5, about 6.5 air miles SE of Eutaw, Greene–Hale County line (T21N; R3E;

Sec.31), Alabama. 29 July 1975. Collected by RG. The sample was collected by diving for about 30 minutes from near the east bank to midstream. The bottom was tightly packed sand (4–6 in. deep) gravel. Water depths ranged from 15 to 18 ft. in the sample area.

W-8. Warrior River at River Mile 257 about 8.3 air miles SSE of Eutaw, Greene–Hale County line (T20N; R3E; Sec.6), Alabama. 29 July 1975. Collected by RG. The sample was taken by diving for approximately 30 minutes in 15 to 18 ft. of water along the east side of the channel. The substrate was tightly packed sand (about 6 in. deep) over gravel. There were some stumps that protruded through the sand.

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Etheostoma chermocki, a New Species of Darter (Teleostei: Percidae) from the Black Warrior River Drainage of Alabama

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ABSTRACT: Boschung, Herbert T., Richard L. Mayden, and Joseph R. Tomelleri. 1992. *Etheostoma chermocki*, a new species of darter (Teleostei: Percidae) from the Black Warrior River Drainage of Alabama. Bulletin Alabama Museum of Natural History, Number 13:11–20, 3 tables, 3 figures. A new species of snubnose darter, *Etheostoma chermocki*, is described. The new species, vermilion darter, is endemic to a relatively small portion of Turkey Creek, a tributary to Locust Fork of the Black Warrior River drainage in Alabama. *Etheostoma chermocki* differs from other snubnose darters on the basis of fin and body color patterns in males and females. The species is compared with populations of the undescribed Warrior river snubnose darters for coloration, meristic variables, and head and body measurements. Both sexes differ from Warrior river darters in coloration; only males can be separated completely on the basis of body shape. *Etheostoma chermocki* varies in color with the seasons, the males being most colorful in early March and the females in late July. *Etheostoma chermocki* is morphologically most similar to species of the *E. duryi* group of snubnose darters. With its limited range and deteriorating habitat, the species requires immediate conservation measures.

Introduction

The subgenus *Ulocentra* sensu Bouchard (1977) and Bailey and Etnier (1988), or *Nanostoma* sensu Page (1981), commonly known as snubnose darters, contains 12 and 14 described species, respectively. Page (1981) includes *Etheostoma zonale* (recognized by Etnier and Starnes (1986) as two species, *E. zonale* and *E. lynceum*), as a "snubnose darter," thereby relegating *Ulocentra* to the synonymy of *Nanostoma*. Based on morphological and allozyme character variation, Robert M. Wood (pers. comm.) concluded that the snubnose species belong in the subgenus *Etheostoma*. Subgeneric placement of these fishes remains controversial and it is not for us to argue the cases here. The *E. zonale* complex is widely distributed throughout much of the Mississippi Basin (Tsai and Raney, 1974); however, most other snubnose darters, described and undescribed, are limited to southerly drainages of the

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Ohio Basin and Mobile Basin, except for an undescribed species in Coastal Plain drainages of Alabama and the Florida panhandle. Many snubnose darters have limited geographical distribution and are more often endemic to a single drainage or system (e.g., *E. etnieri, E. coosae, E. barrenense, E. rafinesquei, E. baileyi,* and *E. tallapoosae*).

Several new species of snubnose darters have been described in the past decade (Page and Burr, 1982; Bailey and Etnier, 1988; Etnier and Bailey, 1989; Suttkus and Etnier, 1991), and several more, some of which have been known for decades, await formal taxonomic description. Recently, another undescribed snubnose darter has captured our attention. The species, described herein, is endemic to Turkey Creek, Jefferson County, Alabama. Turkey Creek is a tributary of Locust Fork of the Black Warrior River drainage in the Mobile Basin. The new species, the vermilion darter, has a limited geographic distribution and is replaced in nearby streams throughout the Black Warrior drainage by more common undescribed snubnose darters that we call collectively "Warrior snubnose darters."

Methods

Counts and measurements were made following most recent descriptions of snubnose darters (Bailey and Etnier, 1988; Etnier and Bailey, 1989; and Suttkus and Etnier, 1991).

The new species is compared morphometrically and meristically with four other populations of Warrior River drainage snubnose darters: (1) Gurley Creek, tributary to Locust Fork, (2) Mill and Murphy creek, tributaries to Mulberry Fork, (3) Sipsey Fork proper and a tributary, Borden Creek, and (4) Fivemile Creek, tributary to Valley Creek. Observations of breeding and non-breeding coloration of males and females were taken from live specimens, color transparencies, and color prints. Color comparisons of the vermilion darter were made with the geographically proximate Gurley Creek population within the Locust Fork.

Statistical analysis of meristic and morphometric variables included bivariate and multivariate methods. Student's T test was employed for determining significant differences in sexual dimorphism within samples of the vermilion darter and other Warrior snubnose darter populations. Multivariate comparison of the five populations involved principal component analyses. Meristic and morphometric variables were evaluated separately. For meristic characters a standard PCA was used on a correlation matrix. Sheared PCA on a covariance matrix was used for $\log_{10}$ transformed morphometric variables (Mayden, 1988).

Institutional symbolic codes follow Leviton and Gibbs (1988). The following abbreviations are used: SL (standard length), HL (head length), BD (body depth), SNL (snout length), SDL (spinous dorsal length), LDS (longest dorsal spine), SDL (soft dorsal length), LDL (longest dorsal ray), CPL (caudal peduncle length), CPD (caudal peduncle depth), AFL (anal fin length), ASL (first anal spine length), LAR (longest anal ray), CFL (caudal fin length), PCFL (pectoral fin length), PVFL (pelvic fin length), and TPW (transpelvic width).

All specimens of the new species that were available to us for study are designated types.

Etheostoma chermocki, new species
Vermilion Darter
Figure 1A and B.

Etheostoma (*Ulocentra*) sp.—Caldwell, 1965 and Barclay and Howell, 1973 (in part; not distinguished from other Warrior snubnose darters).

Etheostoma sp. B.—Mettee et al., 1989 (in part; not distinguished from other Warrior snubnose darters).

Etheostoma species/"Black Warrior Snubnose Darter".—Kuehne and Barbour, 1983 (species account referred in part to *E. chermocki*; photograph (plate 12, page 98) labeled "Black Warrior snubnose darter" is *E. chermocki*).

Etheostoma (Ulocentra) sp. ("Black Warrior snubnose darter").—Gilbert and Walsh, 1991 (account for deposition of photographic materials from Kuehne and Barbour, 1983).

HOLOTYPE.—UAIC 10288.02, adult male, 52.5 mm standard length. Collected in Turkey Creek, tributary to Locust Fork of the Black Warrior River drainage in Jefferson County, Alabama, T 15 S, R 1 W, Sec. 29, NW 1/4 of SW 1/4., on Tapawingo Drive, about one mile north of Pinson and east off Hwy 75. Elevation 600 feet. Collected 9 March 1992 by B. R. Kuhajda, J. R. Tomelleri, R. L. Mayden, and H. T. Boschung.

ALLOTYPE.—UAIC 10288.03, 43.5 mm standard length, collected with the holotype.

PARATOPOTYPES.—UAIC 10288.04 (2 males, 4 females), collected with the holotype. UAIC 10441.01 (3 males, 2 females, one each of which were cleared and stained), 2 April 1992, R. L. Mayden and H. T. Boschung.

PARATYPES.—TURKEY CREEK AT HWY 79 BRIDGE (T15S, R1W, Sec 30, SW 1/4: CU 42112 (4 males, 6 females), 22 April 1962, Leslie W. Knapp and Robert V. Miller; UAIC 1400.04 (7 males, 3 females), 2 August 1964, R. Dale Caldwell and W. Mike Howell; UF 44006 (2 males, 6 females), 10 April 1972, Robert A. Kuehne; UAIC 10444.01 (1 female), 31 July 1992. TAPAWINGO SPRING AND SPRING RUN, TRIBUTARY TO TURKEY CREEK (near type locality): UAIC 1402.02 (3 males, 3 females), 2 August 1964, R. Dale Caldwell and W. Mike Howell; UAIC 3245.02 (1 female), 24 October 1966, W. Mike Howell. TRIBUTARY TO TURKEY CREEK BETWEEN HWYS 75 AND 79, T15S, R1W, Sec.30, SW 1/4: UAIC 1905.09 (1 male), 1

April 1966, James D. Williams and W. Mike Howell. TURKEY CREEK AT DUG HOLLOW ROAD, T15S, R1W, Sec.29, SE 1/4.: UAIC 10442.01 (1 male, 2 females), 31 July 1992. TURKEY CREEK UPSTREAM FROM GOODWIN ROAD, T15S, R1W, Sec. 33, NW 1/4: UAIC 10443.01 (1 male), 31 July 1992. DRY CREEK, TRIBUTARY TO TURKEY CREEK, T15S, R1W, Sec. 20, SE 1/4: UAIC 10445.01 (4 males, 3 females), 31 July 1992; SIUC 20116 (1 male, 1 female); UMMZ 220470 (1 male, 1 female); USNM 319766 (1 male, 1 female); UT 91.4159 (1 male, 1 female). TURKEY CREEK AT THE "NARROWS," T15S, R2W, Sec. 25, NE 1/4, off old Crosston-Pinson Road: UAIC 10446.01 (3 males, 12 females), 31 July 1992. All 31 July 1992 collections were made by B. R. Kuhajda, C. G. Haynes, P. E. Boschung, Jr., R. L. Mayden, and H. T. Boschung.

The entire range of *E. chermocki* is located on a single 7.5 minute series topographic map, the Pinson Quadrangle.

DIAGNOSIS.—*Etheostoma chermocki* is a member of the subgenus *Ulocentra/Nanostoma* as diagnosed by Bailey and Etnier (1988), and Page (1981) and Page and Burr (1991), respectively. It is distinguished from other members of the subgenus by coloration of the spinous and soft dorsal fins, caudal, anal, and pectoral fins, and lateral aspects of body. The spinous dorsal fin of breeding male *E. chermocki* has a cherry-red ocellus in first membrane and broad brick-red subdistal band in the remaining membranes. The soft dorsal fin has a dusky basal band, a broad brick-red medial band, and a dusky distal band. The caudal fin has two red-orange basicaudal spots separated by a clear membrane. The anal and pelvic fins are turquoise and black; pectoral fins are lemon yellow. The vermilion-colored venter extends dorsally and is adjacent to lateral band; lateral band composed of an olive-colored lateral stripe and blotches and a broad, wavy brick-red band. Lateral blotches and brick-red coloration are separated from the ventral vermilion coloration by straw-colored halos. Scales of the venter in males have narrow line of melanophores along distal edge, producing a single crescent on each scale.

DESCRIPTION.—*E. chermocki*, a relatively large snubnose darter, reaches 60.2 mm SL (UF 44006; Kuehne and Barbour, 1983). Sexual dichromatism conspicuous (Fig. 1A and B). Meristically no significant differences in sexes; however, morphometrically sexes differ significantly ($p = <0.5$) in 12 of 16 traits (Table 1). Males with longer head, greater body depth, greater snout length, longer spinous dorsal fin base, longer dorsal fin spines and soft dorsal fin rays, greater caudal peduncle depth, longer anal fin base, longer anal spine, longer anal fin rays, longer caudal fin length, and wider trans-pelvic base. Colors of both sexes differ markedly from spring to summer.

Frequency distributions of fin-ray and scale counts are provided in Tables 2 and 3, respectively. Lateral line complete and virtually straight from upper margin of gill opening to base of caudal fin. Lateral scale rows 44 to 52, usually 46 to 48. Transverse scale rows 11 to 14, usually 13. Caudal peduncle scale 16 to 19, usually 17. Scales absent from breast and nape but present on cheeks and opercle.

Frenum hidden in a shallow premaxillary groove; premaxillae slightly protractile. Gill membranes broadly joined; branchiostegal rays 5. Gill rakers 5 to 7 on both limbs (including rudiments), knobby, longest hardly more than twice its greatest diameter. Teeth of upper jaw conical, closely set, recurved, in four indistinct rows anteriorly, becoming two rows posteriorly. Lower jaw teeth similar, in three rows anteriorly and becoming a single row posteriorly. Vomer bone supports 2 or 3 small canine-like teeth. Infraorbital canal pores 5 (2 specimens), 6 (3), 7 (4), and 8 (6); preoperculomandibular pores 8 (4), 9 (11); lateral canal pores 5 (15); supratemporal canal complete (13) or interrupted (2), pores 0 (1), 1 (2), 3 (10), or 4 (2); supraorbital canal pores 3 (2) or 4 (13); and coronal pore single (15).

Coloration. Males and females are sexually dichromatic; males are more brightly colored than females throughout year, especially during spring. Coloration of breeding male and non-breeding female is illustrated in Figure 1A and B. The following color descriptions of males and females are based upon early March specimens.

Males. Dorsum of head and body of breeding males light olive to straw colored. Post-, sub-, and preorbital stripes dark olive. Upper margin of opercle dark olive. Ventral portion of opercles, subopercles, preopercles, cheeks, branchiostegals, and gular region with cream base color and/or with light lemon-green tint; breast, gular region, snout, and lips with light turquoise tint. Prepectoral region light orange and lemon green.

Dorsum of body crossed by eight dark olive saddles, beginning at nuchal region where darkest and separated from cranium by narrow cream-colored bar, to first procurrent ray of caudal fin. Dorsal saddles separated from one another by straw background coloration; saddles extend ventrolaterally three or four scale rows and interdigitate with dorsal extensions of wavy brick-red coloration along flank. Coloration along flanks complex; composed of large brick-red spots and dark olive-green blotches above and below lateral line. Above lateral line, lateral band consists of cream-colored line tracing lateral line and brick-red spots in wavy and regular pattern. Red coloration beginning at postemporal region and ending at base of caudal rays in basicaudal spot. Anterior to soft dorsal fin red blotches may be bisected by narrow, cream-colored line tracing lateral-line scale row, providing general appearance of two separate lateral bands; posterior to soft dorsal fin origin cream-colored line absent. Flank, belly, and ventro-lateral caudal peduncle scales below lateral band dark vermilion; coloration may extend dorsal to and connect with dark olive lateral stripe and/or brick-red blotches from dorsal portion of band; vermilion coloration separated from olive blotches by narrow halo of straw

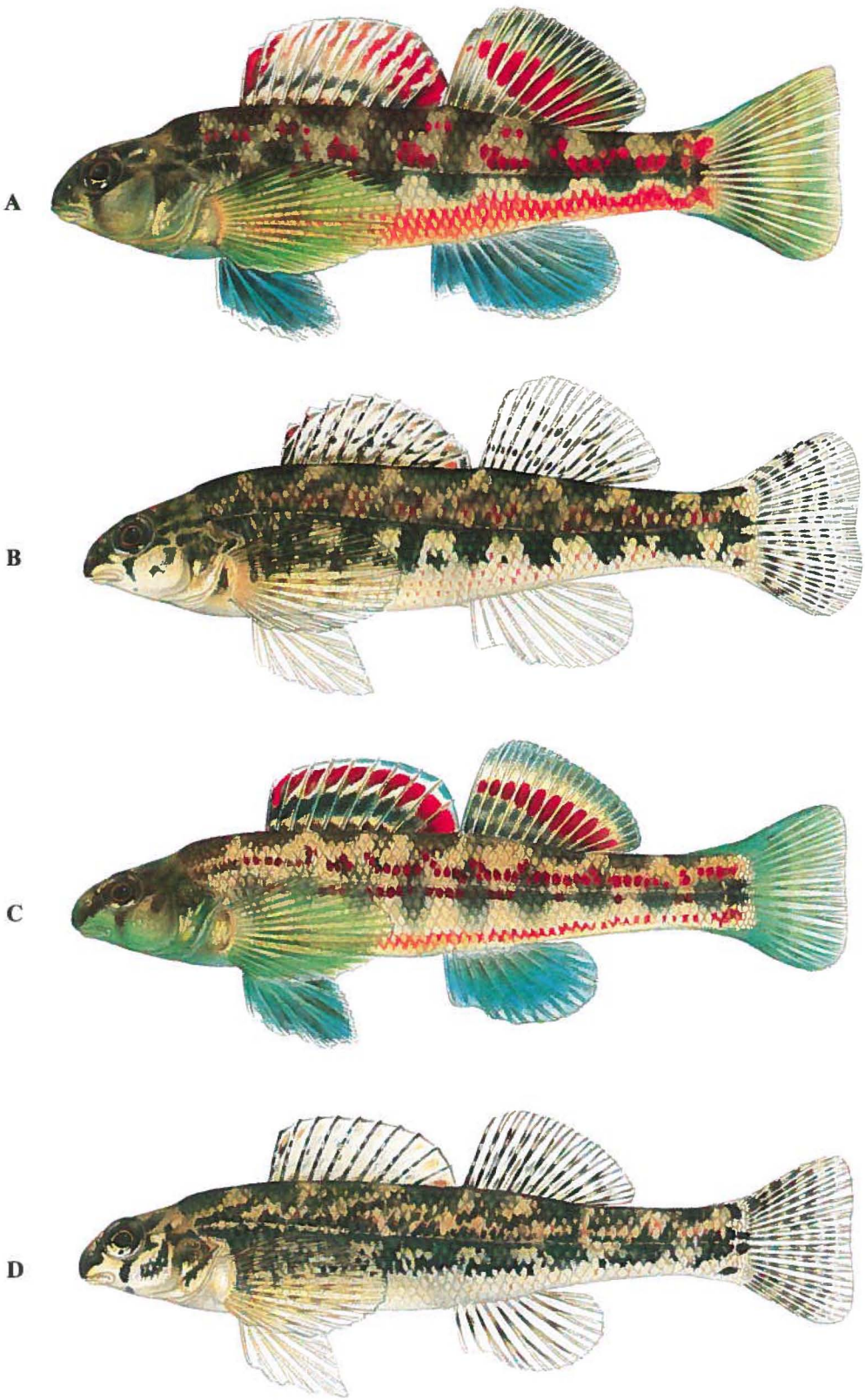

Figure 1. A. *Etheostoma chermocki*, holotype, male, 52.5 mm SL, UAIC 10288.02, Turkey Creek, 9 March 1992. B. *Etheostoma chermocki*, paratype, female, 45 mm SL, UAIC 10445.01, Dry Creek, tributary to Turkey Creek, 31 July 1992. C. *Etheostoma* sp., male, 42 mm SL, UAIC 10455.01, Gurley Creek, 2 April 1992. D. *Etheostoma* sp., female, 45 mm SL, UAIC 10447.01, Gurley Creek, 31 July 1992.

Table 1. Morphometric data of male and female *Etheostoma chermocki* and four populations of Warrior snubnose darters. Measurements are expressed in thousands of the standard length. * Indicates significant differences between the sexes at p = < 0.05 level.

E. chermocki

	Males (N=19)			Females (N=19)		
	Range	x̄	SD	Range	x̄	SD
SL	36–55	48		40–51	45	
HL *	233–251	240	4.9	221–251	236	7.6
BD *	200–244	223	11.4	195–236	206	9.3
SNL *	53–70	61	4.6	53–64	59	3.5
SDL *	261–312	294	12.5	236–306	273	16.9
LDS *	132–166	145	10.0	105–138	116	7.6
SDL	161–197	183	9.1	163–191	178	7.4
LDL *	154–183	168	8.8	137–172	149	8.8
CPL	265–302	280	9.3	263–304	282	10.6
CPD *	106–124	112	4.6	99–122	105	6.1
AFL *	120–154	138	9.6	112–146	123	9.0
ASL *	64–107	92	10.6	64–92	78	6.3
LAR *	138–167	154	7.3	111–162	135	15.5
CFL *	183–229	208	12.4	174–218	196	13.1
PCFL	243–291	264	13.9	238–288	258	13.4
PVFL	192–233	214	11.6	195–242	210	11.9
TPW *	74–91	82	5.1	69–86	75	4.0

Gurley Creek, Locust Fork population

	Males (N=10)			Females (N=10)		
	Range	x̄	SD	Range	x̄	SD
SL	41–51	44		36–41	38	
HL	217–228	223	4.2	219–232	224	4.2
BD	188–211	202	7.5	189–213	199	8.0
SNL	55–67	62	3.0	60–68	63	2.6
SDL *	268–301	285	8.6	252–291	274	10.8
LDS *	120–134	127	4.4	110–122	116	3.8
SDL	180–202	188	7.9	171–203	184	11.9
LDL *	140–160	151	6.4	136–149	142	4.8
CPL *	271–313	298	13.1	269–338	300	17.6
CPD	97–108	103	3.5	93–112	98	5.6
AFL	114–136	125	7.6	103–131	120	9.5
ASL	71–92	84	7.6	65–88	80	6.8
LAR	124–153	136	9.0	118–146	130	9.6
CFL	172–207	192	11.3	182–205	194	7.8
PCFL	239–265	247	7.5	223–251	240	7.5
PVFL	191–217	203	8.6	189–216	205	9.0
TPW *	73–81	77	2.7	67–76	72	3.4

Mulberry Fork population

	Males (N=10)			Females (N=10)		
	Range	x̄	SD	Range	x̄	SD
SL	37–47	42		36–46	39	
HL	230–245	239	4.9	222–244	236	6.9
BD	190–214	203	8.0	179–226	206	15.0
SNL	56–70	64	3.9	59–67	62	2.5
SDL *	277–305	295	8.0	279–299	287	5.6
LDS *	118–145	132	8.4	97–148	116	13.8
SDL	173–194	182	7.3	178–195	185	5.7
LDL *	150–171	160	6.0	145–165	154	6.0
CPL	294–320	307	9.1	276–323	300	13.2
CPD	104–112	108	2.3	103–110	106	2.9
AFL	121–140	129	6.0	120–133	127	4.9
ASL *	81–103	91	7.2	78–96	85	5.6
LAR *	129–156	146	8.9	117–156	137	10.2
CFL	190–224	207	8.8	192–219	207	8.8
PCFL	245–274	262	8.1	247–279	260	10.0
PVFL	195–220	211	8.6	200–227	215	8.2
TPW	71–81	75	3.0	73–80	76	2.2

Sipsey Fork population

	Males (N=10)			Females (N=10)		
	Range	x̄	SD	Range	x̄	SD
SL	36–44	37		36–42	38	
HL	223–239	232	4.9	228–243	236	5.2
BD	166–205	181	10.6	169–189	179	6.8
SNL	55–67	60	3.4	54–65	60	3.3
SDL	250–300	279	13.3	270–294	279	6.6
LDS *	120–138	130	6.4	107–119	116	3.2
SDL	164–189	178	8.0	168–195	178	7.8
LDL	133–152	141	6.8	135–158	144	6.2
CPL	289–307	299	6.5	281–308	295	8.9
CPD	97–107	103	3.9	97–105	101	2.9
AFL *	122–140	131	7.6	113–135	123	7.9
ASL	83–95	90	4.1	78–95	87	5.8
LAR	125–153	139	8.7	122–149	132	9.2
CFL	182–217	202	11.0	189–220	207	8.9
PCFL	242–272	255	10.4	243–276	257	10.4
PVFL	202–223	214	6.8	205–230	216	7.8
TPW	69–78	73	3.6	71–79	75	2.5

Valley Creek population

	Males (N=10)			Females (N=10)		
	Range	x̄	SD	Range	x̄	SD
SL	30–49	43		38–46	42	
HL	213–246	230	9.5	203–237	227	10.7
BD	173–200	188	8.7	153–190	178	12.4
SNL	52–64	59	4.2	47–62	57	4.2
SDL	261–297	278	10.9	231–283	265	16.8
LDS *	114–137	124	7.1	90–118	110	8.6
SDL *	167–221	190	15.6	153–180	172	9.8
LDL *	126–152	142	8.8	114–138	131	7.9
CPL	276–319	302	11.1	271–302	293	10.8
CPD *	91–106	100	4.4	82–97	93	4.7
AFL *	118–144	133	7.2	103–123	116	6.8
ASL	76–98	89	6.7	70–92	80	7.4
LAR	117–149	131	10.8	99–132	124	10.3
CFL *	185–222	199	9.7	180–205	189	7.8
PCFL	213–263	242	13.7	204–254	235	15.9
PVFL	198–212	205	4.4	168–208	195	13.6
TPW	64–76	70	3.9	61–74	69	4.0

Table 2. Frequency distribution of rays and spines in fins of *E. chermocki* and four populations of warrior darters.

	Dorsal spines					
	9	10	11	12	$\bar{x}$	SD
E. chermocki (N=74)		22	49	3	10.7	0.52
Warrior darters						
Locust Fork (N=77)	1	51	22	3	10.4	0.58
Mulberry Fork (N=80)	6	58	16		10.1	0.51
Sipsey Fork (N=63)	4	48	11		10.1	0.48
Valley Creek (N=78)		40	38		10.5	0.50

	Dorsal rays					
	10	11	12	13	$\bar{x}$	SD
E. chermocki (N=74)	8	58	8		11.0	0.47
Warrior darters						
Locust Fork (N=77)	4	62	10	1	11.1	0.48
Mulberry Fork (N=80)	4	53	23		11.2	0.53
Sipsey Fork (N=63)		50	13		11.2	0.41
Valley Creek (N=78)	1	62	15		11.2	0.42

	Anal rays					
	6	7	8	9	$\bar{x}$	SD
E. chermocki (N=74)		53	21		7.3	0.45
Warrior darters						
Locust Fork (N=77)	19	56	2		6.8	0.48
Mulberry Fork (N=80)	6	67	7		7.0	0.40
Sipsey Fork (N=63)	5	47	11		7.1	0.50
Valley Creek (N=78)	6	57	14	1	7.1	0.54

	Left pectoral rays					
	12	13	14	15	$\bar{x}$	SD
E. chermocki (N=74)		29	43	2	13.6	0.54
Warrior darters						
Locust Fork (N=77)		28	49		13.6	0.48
Mulberry Fork (N=80)		8	68	4	14.0	0.38
Sipsey Fork (N=63)	1	46	16		13.2	0.46
Valley Creek (N=78)	2	36	40		13.5	0.55

	Principal caudal rays						
	14	15	16	17	18	$\bar{x}$	SD
E. chermocki (N=74)	1	6	33	34		16.4	0.69
Warrior darters							
Locust Fork (N=77)		4	31	42		16.5	0.60
Mulberry Fork (N=80)		1	17	61	1	16.8	0.48
Sipsey Fork (N=63)		3	18	42		16.6	0.58
Valley Creek (N=78)	1	3	22	52	16.6	0.63	

background coloration, especially posterior to soft dorsal fin origin. Vermilion coloration extending posteriorly to hypural plate and base of ventral caudal rays, terminating in a basicaudal spot. Ventro-lateral and belly scales distinctly outlined along distal edges with narrow line of melanophores, creating a crescent pattern on each scale.

Spinous dorsal fin with four separate bands of coloration plus narrow clear distal and narrow black basal bands. First membrane of spinous dorsal fin with large, cherry-red ocellus subdistally, bordered ventrally by broad black band and dorsally by clear membrane; base of membrane with cream-orange band. Broad brick-red band below distal clear band of spinous dorsal fin extends from second membrane to end of fin; band expands from covering one half of the second membrane to all of membranes posterior to ninth spine. Anteriorly, red band may appear as broken and mixed with small slivers of clear membrane; posteriorly, red band is solid and darkest. Between second and ninth spines, broad brick-red band bordered ventrally by narrow cream band, narrow black band, and broad subbasal cream-orange band, respectively. Soft dorsal fin of breeding males with narrow black basal band, broad brick-red medial band, broad and dusky subdistal band, and narrow clear distal band. Black basal band deepest anteriorly and like broad subdistal black band, formed from dense concentrations of melanophores on membranes. Caudal fin membranes cream yellow centrally; dorsal- and ventral-most rays and procurrent rays turquoise. Proximal half of caudal rays dusky; distally rays with alternating subtle light and dark bands. Base of caudal fin with two distinct basicaudal spots formed as extensions of lateral bands; spots separated by clear membranes; dorsal spot brick red, ventral spot vermilion. Anal and pelvic fins turquoise with all interradial membranes dark dusky; some males with red in last two interradial membranes of anal fin. Interradial membranes of pelvic fins of some males entirely dark dusky; spines, rays, and distal edge of fin opaque. Pectoral fins lemon yellow to lime green. Spines and rays of all fins lightly pigmented with melanophores.

Females. Without bright coloration. Dorsum of body and head dark olive and cream colored, as in males. Lateral band less distinctly colored; brick red coloration above lateral line distributed as in males, but restricted to only a few red pigmented scales. Lateral band below lateral line similar to males except that blotches are more intense and contrast strongly with cream background coloration. A few small, dark olive clusters of melanophores may interdigitate between blotches. Anal, pelvic, and pectoral fins immaculate; no melanophores on rays or membranes. Dorsal fins with 2 or 3 dusky bands formed from melanophores along rays and membranes. Anal and pelvic fins, flanks below lateral blotches, and venter, from gular area to caudal fin, immaculate.

Table 3. Frequency distribution of scales counts in *E. chermocki* and four populations of warrior darters.

	Lateral line scale rows															
	42	43	44	45	46	47	48	49	50	51	52	53	54	55	$\bar{x}$	SD
E. chermocki (N=74)			8	5	12	16	12	8	8	2	3				47.4	2.08
Warrior darters																
Locust Fork (N=77)				8	7	10	17	15	9	6		4		1	48.4	2.15
Mulberry Fork (N=80)	1	1	1	7	7	18	10	7	16	8	1	1	2		48.2	2.36
Sipsey Fork (N=63)				3	8	13	12	10	6	7	2	2			48.4	1.98
Valley Creek (N=78)				2	7	8	11	19	16	10	4		1		49.0	1.82

	Transverse scale rows						Caudal peduncle scale rows					
	11	12	13	14	$\bar{x}$	SD	16	17	18	19	$\bar{x}$	SD
E. chermocki (N=74)		11	49	14	13.0	0.58	10	40	17	7	17.3	0.82
Warrior darters												
Locust Fork (N=77)		5	63	9	13.0	0.43	3	41	22	11	17.5	0.79
Mulberry Fork (N=80)	1	9	57	13	13.0	0.57		12	40	28	18.2	0.68
Sipsey Fork (N=63)	1	6	42	14	13.1	0.62	2	36	16	9	17.5	0.78
Valley Creek (N=78)		6	61	11	13.1	0.46		19	27	32	18.2	0.80

Seasonal color changes. Both males and females of *E. chermocki* vary in color with the seasons. While July females have attained brighter colors, males have become less colorful. The completely chromatic venter of spring males is reduced to a ventro-lateral vermilion band, one on each side but not converging at the mid-ventral line. The melanophores that formed crescents on the ventro-lateral and belly scales disappear. The red band of the spinous dorsal has weakened, but leaving the intense cherry-red ocellus in the first interradial membrane. Interradial membranes 3 through 6 are essentially without red pigment, but the last four membranes keep much of their red color. The color of the soft dorsal is virtually unchanged. The pelvic and anal fins are immaculate; the pectorals are very pale peach color with some melanophores on the upper rays. Melanophores on the caudal fin form four vertical bars.

Females, which are rather drab in early spring when the males are at the height of their coloration, become more colorful by late summer. Bright red-orange ocelli are in the first and last three spinous dorsal membranes, the latter more orange. The proximal third of the pectoral fin is peach color and the remainder of the fin is lemon yellow. Scattered brick-red colored spots form an indistinct narrow band above the pale lateral line. The spaces between the lateral blotches are pale lemon color; the lower flanks are streaked with pale orange chromatophores; and the belly is white. The pelvic and caudal rays are light lemon yellow. Melanophores on the caudal fin form 5 vertical stripes.

COMPARISONS.—*Etheostoma chermocki* is easily distinguished from the geographically proximate Warrior snubnose darters by fin and body coloration (Fig. 1C and D), as well as by male morphometrics (Fig. 2). In the Warrior snubnose darters the olive-colored median lateral band is narrow and separate from both the narrow brick-red band dorsally and the ventrolateral orange coloration. The median olive-colored lateral band terminates posterior to the hypural plate in a rectangular basicaudal spot more or less continuous with the posterior-most lateral blotch. The 7 or 8 olive-colored lateral blotches are larger, rectangular in shape, and extend 2 or 3 scale rows above and below the narrow lateral band. The red band above the lateral line is generally straight, not arched around lateral blotches as in *E. chermocki* and is rarely connected to dorsal saddles. It is generally formed by a single row of red-colored scales and is always separate from the narrow lateral band for most of its length by cream background coloration. Together, the dorsally located red band and the medially located olive band present a double lined pattern along the flanks. Below the lateral band the orange coloration is confined to 1 or 2 scale rows ventrolaterally and is separated from the olive lateral band above. The belly and ventral caudal peduncle are cream colored, not orange.

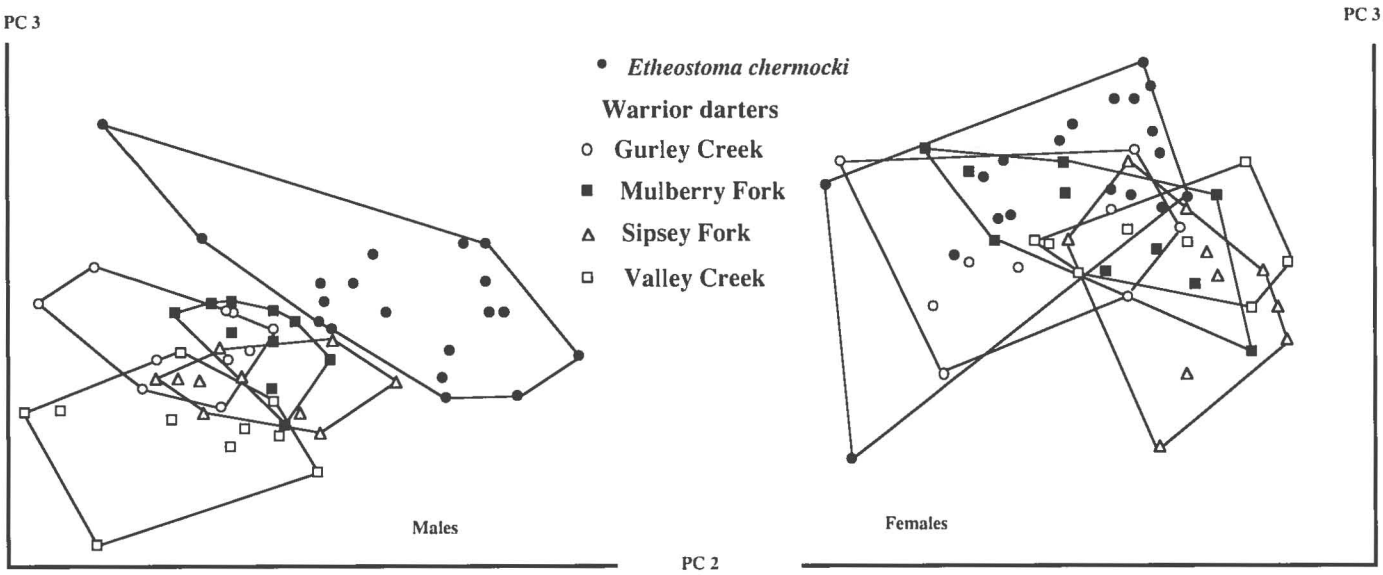

Figure 2. Principal component analysis of body measurements for males and females of *Etheostoma chermocki* and four populations of undescribed Warrior snubnose darters.

The spinous dorsal fin of *E. chermocki* is similar to that of the Warrior snubnose darters in having a cream-orange band above a black basal band. However, the red band of the latter is narrower, the red ocellus in the first membrane is smaller, and the narrow distal band is turquoise. The soft dorsal fin differs from that of *E. chermocki* in having a narrower medial brick-red band bordered dorsally by a narrow yellow band and a turquoise distal band. The caudal fin is turquoise with two cream-colored ocelli basally, separated by a median, rectangular olive blotch as an extension of the lateral stripe.

Females of *E. chermocki* differ from female Warrior snubnose darters in lateral coloration and pigmentation of fins. The latter possess melanophores in the anal fin and have dense concentrations of melanophores below the lateral band and between the lateral blotches, presenting a solid or nearly solid band below the medial lateral band.

Male and female *E. chermocki* are compared morphometrically with four different populations of Warrior snubnose darter (Table 1; Fig. 2). The sheared principal component analysis reveals considerable overlap in all populations of female Warrior snubnose darters and female *E. chermocki*; however, morphometrically male *E. chermocki* are completely separable from males of four populations of Warrior snubnose darters. Head, body, and anal fin measurements contribute significantly to the separation of *E. chermocki* from Warrior snubnose darters in PC analysis. *Etheostoma chermocki* males consistently possess a shorter snout, deeper body, taller spinous dorsal fin, shorter soft dorsal fin base, shorter caudal peduncle, and shorter anal spines and rays. *Etheostoma chermocki* was not found to differ significantly from any populations of Warrior snubnose darters for meristic characters (Tables 2 and 3).

Etheostoma chermocki is distinguished from some members of the subgenus *Ulocentra/Nanostoma* (*E. barrenense, E. duryi, E. etnieri, E. rafinesquei,* and *E. simoterum*) with its possession of the cream-colored stripe tracing the lateral line anteriorly, making it appear distinct from the red or orange lateral stripe anteriorly. *Etheostoma chermocki* is distinguished from *E. tallapoosae, E.* sp. (Coastal Plain darter), and *E.* sp. (Yazoo Darter) in its possession of the red ocellus in the first membrane on the spinous dorsal fin. *Etheostoma chermocki* differs from *E. brevirostrum, E. coosae, E. tallapoosae, E. zonistium,* and Warrior snubnose darters in lacking a turquoise-blue distal band on the spinous dorsal fin. Finally, *E. chermocki* differs from *E. pyrrhogaster* and *E. zonistium* in lacking a broad red basal band on the anal fin.

Bailey and Etnier (1988) recognize two species groups of snubnose darters based on the presence or absence of a premaxillary frenum and vomerine teeth: the *E. duryi* group (*brevirostrum, duryi, coosae, etnieri, flavum, pyrrhogaster, tallapoosae, zonistium,* and other unnamed species) lack a distinct premaxillary frenum (i.e., the premaxilla is free from the snout and a needle can be passed under the free flap of snout tissue) and in having vomerine teeth; whereas, the *E. simoterum* species group (*s. simoterum, s. atripinne, baileyi, barrenense,* and *rafinesque*) has a narrow frenum that allows only minimal protraction of the premaxillae and lacks vomerine teeth. *Etheostoma brevirostrum* often has vomerine teeth and either lacks a frenum or has a poorly developed one, therefore it is assigned to the *duryi* group. *Etheostoma chermocki* is most similar to the *E. duryi* group of snubnose darters.

ETYMOLOGY.—The species epithet *chermocki* is a patronym honoring Ralph L. Chermock (1918–1977) who founded the University of Alabama Ichthyological Collection. The

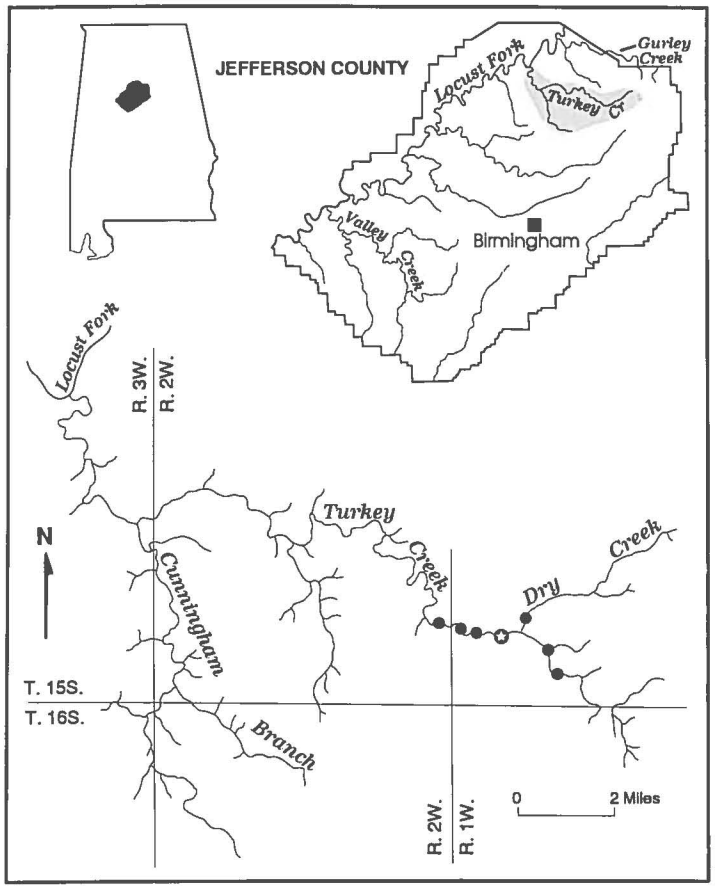

Figure 3. Distribution of *Etheostoma chermocki* within Locust Fork of Black Warrior River of the Mobile Basin. ✪ Type locality; ● Collection sites.

common name, vermilion darter, calls attention to the vermilion-colored ventro-lateral flanks and belly of breeding males. The color vermilion can refer to a broad spectrum of reds or red-oranges. Our use of vermilion refers to a red-orange coloration.

DISTRIBUTION AND HABITAT.—*Etheostoma chermocki* is known only from the headwaters of Turkey Creek, a tributary to Locust Fork, Black Warrior River in Jefferson County, Alabama, at the sites cited above (Fig. 3). The habitat of *E. chermocki* is small to medium-sized (3–20 meters wide), gravel-bottom streams with pools of moderate current alternating with riffles of moderately swift current. The riffles are of coarse gravel and cobble, and small rubble, whereas the bottoms of the pools are rock (sometimes bedrock), sand and silt. The most favorable habitat seems to be the swifter chutes where some vegetation abounds, such as watercress (*Nasturtium officinale*) or pondweed (*Potomogeton foliosus*).

Species collected with *E. chermocki* throughout its range are: *Campostoma anomalum, Cyprinella callistia, Luxilus chrysocephalus, Notropis stilbius, Semotilus atromaculatus, Hypentelium etowanum, Moxostoma duquesnei, Gambusia affinis, Cottus carolinae, Lepomis cyanellus, Lepomis macrochirus, Micropterus coosae, Micropterus salmoides, Etheostoma whipplei,* and *Percina nigrofasciata.*

CONSERVATION STATUS.—Inasmuch as this darter has a very limited range (Fig. 3), consisting of no more than about three miles of stream, which is in urban and suburban areas, its conservation status should be considered ENDANGERED. Undoubtedly the darter was formerly more widespread; however, parts of Turkey Creek are so degraded by domestic pollution, especially from silt issuing from construction projects, that the vermilion darter only occurs sporadically. Specimens were collected in good numbers in the 1960s and 70s at the Hwy 79 bridge site. At the same site, on 31 July 1992, 10 man-hours of collecting yielded one specimen. It is indeed unfortunate that we did not realize the uniqueness of the Turkey Creek darter 20 or 30 years ago. Measures could have been taken to name and describe this rare species and therefore afford it the protection of an endangered species. We think that the population is sufficiently small that immediate attention should be given to its protection.

Acknowledgement

The collections acquired by many students and colleagues over the past 30 years made this study possible. We are pleased to list their names in the section on type materials and in the following section on comparative materials. Carter Gilbert (Florida State Museum) and Julian Humphries (Cornell University) loaned specimens of the new species, and Lawrence M. Page (Illinois Natural History Survey) loaned specimens from Mulberry Fork. Joseph R. Tomelleri prepared the color figures (Fig. 1). Bernard R. Kuhajda ran the principal components analysis and gave freely of his time in collecting fresh specimens. Robert Wood ran the bivariate analysis. Andrew Simons prepared cleared and stained specimens. W. Mike Howell read the original manuscript and shared his knowledge and insights regarding the distribution and systematics of Mobile Basin snubnose darters. We thank two peer reviewer's for helpful suggestions that improved the paper. This research was supported by NSF (BSR9007513) and the Tanglewood Fund.

Comparative Materials

Locust Fork. GURLEY CREEK AT HWY 79, Jefferson County, T14S, R1W, Sec.30, NW 1/4, about 0.2 mi from Jefferson-Blount county line: UAIC 1879 (1 female), 8 February 1966, J. D. Williams and J. G. Armstrong; UAIC 1906.14 (2 males, 2 females), 1 April 1966, R. D. Caldwell, W. M. Howell, and J. D. Williams; UAIC 3305.17 (1 female), 17 March 1969, L. A. Barclay and W. M. Howell; UAIC 10447.01 (2 males, 2 females), 31 July 1992, B. R. Kuhajda, C. G. Haynes, P. E. Boschung, Jr., R. L. Mayden, and H. T. Boschung. GURLEY CREEK AT HWY 75, 0.4 mi north Jefferson-

Blount county line in Blount County, T14S, R1W, Sec. 34, SW 1/4: UAIC 6258.07 (4 females), 22 September 1980, D. L. Nieland, H. T. Boschung, R. A. Kasprzak, and K. Newkirk; UAIC 6364.06 (12 males, 15 females), 6 March 1981, D. L. Nieland; UAIC 6425.01 (9 males, 36 females), 13 April 1981, D. L. Nieland; UAIC 6428.01 (2 males, 4 females), 19 April 1981, D. L. Nieland; UAIC 7164.01 (2 males, 2 females), 10 March 1984, D. L. Nieland, R. E. Smith, Jr., and D. R. Woods; UAIC 9843.01 (1 male), 9 February 1990, R. L. Mayden, B. R. Kuhajda, S. R. Layman, A. M. Simons, and R. M. Wood.

Mulberry Fork. MILL CREEK, Blount County, T13S, R2W, Sec. 4, SW 1/4, SW 1/4: UAIC 3804.07 (9 males, 8 females), 13 February 1970, C. R. Duckett, W. M. Howell, and L. A. Barclay. MILL CREEK, Blount County, T13S, R3W, Sec. 12, SE 1/4, NW 1/4: UAIC 3806.06 (2 males, 8 females), 20 February 1970, C. R. Duckett and L. A. Barclay; UAIC 5347.05 (1 male, 6 females), 27 May 1977, D. A. Black. MILL CREEK, Blount County, T13S, R3W, Sec. 2, SE 1/4: UAIC 5346.04 (1 male, 2 females), 27 May 1977, D. A. Black. MURPHY CREEK, Blount County, T13S, R3W, SEC. 12, SW 1/4: INHS 76157 (7 males, 13 females), 19 April 1977, L. M. Page, M. C. Retzer, R. L. Mayden, D. L. Swofford; INHS 87637 (9 males, 11 females), 6 April 1982, B. M. Burr and L. M. Page; UAIC 10267.01, 2 April 1992, R. L. Mayden and H. T. Boschung.

Sipsey Fork. BORDEN CREEK, TRIBUTARY TO SIPSEY FORK, Lawrence County on Bunyard Road, T8S, R8W, Sec. 32, NE 1/4, (Bee Branch Quad.): UAIC 1696.14 (1 male, 4 females), 12 July 1978, B. R. Wall, P. E. O'Neil, and W. B. Brown; UAIC 3868.08 (4 males, 6 females), 22 August 1970, W. M. Howell, Mike Hopiak, and Jim Manasco; UAIC 3886.06 (1 male, 3 females), 31 August 1970, W. M. Howell, Mike Hopiak, and Don Dycus; UAIC 6264.09 (2 males, 17 females), 11 October 1980, D. L. Nieland; UAIC 6427.02 (2 males, 3 females), 19 April 1981, D. L. Nieland. BORDEN CREEK, Lawrence County, T8S, R8W, Sec. 28, NE 1/4: UAIC 4963.12 (2 males, 2 females), 19 August 1974, Monte Seehorn, H. T. Boschung, and T. S. Jandebeur. SIPSEY FORK PROPER, Winston County, T9S, R8W, Sec. 22, NW 1/4: UAIC 3852.12 (3 males, 4 females), 3 November 1971, Don Dycus and David Johnson; UAIC 3855.10 (4 males), 8 November 1971, Don Dycus, W. M. Howell, and Mike Hopiak. CANEY CREEK, Winston County, T9S, R8W, Sec. 20, NW 1/4: UAIC 3859.08 (1 male, 5 females), 17 November 1971, Don Dycus and Mike Hopiak.

Valley Creek. FIVEMILE CREEK NEAR BESSEMER, Jefferson County, T19S, R5W, Sec. 36, NW 1/4, NW 1/4: UAIC 1934.10 (6 males, 22 females), 11 April 1966, R. D. Caldwell and W. M. Howell; UAIC 2011.02 (1 female), 20 April 1966, R. D. Caldwell and W. M. Howell. UAIC 2504.08 (1 male, 3 females), 19 March 1966, J. D. Williams and J. G. Armstrong; UAIC 3041.15 (8 males, 3 females), 15 August I968, H. Harima and T. S. Jandebeur; UAIC 6481.01 (1 male, 1 female), 8 October, 1976, D. A. Black; UAIC 10448.01 (1 male, 1 female), 6 August 1992, W. M. Howell, B. R. Kuhajda, and H. T. Boschung. FIVEMILE CREEK, Jefferson County, T19S, R5W, Sec. 24, SW 1/4: UAIC 10449.01 (2 males, 5 females), 6 August 1992, W. M. Howell, B. R. Kuhajda, and H. T. Boschung. FIVEMILE CREEK, Jefferson County, T19S, R5W, Sec. 14, SE 1/4: UAIC 10450.01 (8 males, 15 females), 6 August 1992, B. R. Kuhajda, W. M. Howell, and H. T. Boschung.

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