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THE UNIVERSITY OF ALABAMA
TUSCALOOSA, ALABAMA

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Elassoma alabamae, a New Species of Pygmy Sunfish Endemic to the Tennessee River Drainage of Alabama (Teleostei: Elassomatidae)

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ABSTRACT: Richard L. Mayden. 1993. *Elassoma alabamae*, a New Species of Pygmy Sunfish Endemic to the Tennessee River Drainage of Alabama (Teleostei: Elassomatidae). Bulletin Alabama Museum of Natural History Number 16, 14 pages, 6 tables, 3 figures. The spring pygmy sunfish, *Elassoma alabamae*, is described and distinguished from other members of the genus, bringing the total number of described species in the family Elassomatidae to six. *Elassoma alabamae* is distinguished from congeners by meristic, mensural, and coloration characteristics. Most notable among these include the lack of humeral spots and dorsal head scales, the occurrence of three dorsal fin spines, clear or white windows in the dorsal and anal fins, usually 6 or 7 broad, dark bars, and usually 5 or 6 narrow, iridescent interbars along the flanks of both sexes. This species has been recorded from only three springs and associated habitats in the Tennessee River Drainage of north Alabama. Today a native population survives in only one spring complex; a planned repopulation of one other spring complex previously inhabited by the species represents a potential secondary stronghold for the species. Potential threats from cropdusting practices, vegetation control, the byproducts of livestock, and agricultural practices threaten this rare and geographically restricted pygmy sunfish.

Introduction

The endemic North American fish family Elassomatidae is presently known to include five described and two undescribed species. All of these species are diminutive in size and, with the exception of *Elassoma zonatum*, rarely exceed 30 millimeters in standard length. About one half of the members of this family have restricted geographic distributions, occupying only portions of one or two river systems to only one or two springs, while others such as *Elassoma zonatum* and *E. evergladei* are more widespread in distribution. The banded pygmy sunfish, *E. zonatum*, occurs throughout drainages of the Coastal Plain from eastern Texas to North Carolina and north on the Mississippi Embayment to southern Illinois. All *Elassoma* are generally associated with spring- and swamp-like habitats.

Over a half century ago, on 5 November 1937, Tennessee Valley Authority biologist L. F. Miller sampled Cave Spring, Lauderdale County, Alabama and captured, among other fishes, a new species of pygmy sunfish. The fishes collected by Miller were sent to the University of Michigan Museum of Zoology and some specimens were identified by Dr. Carl L. Hubbs and Mr. Milton B. Trautman as an undescribed species of *Elassoma*. Since that time this species has been known only by its informally adopted common name, the "spring pygmy sunfish." This species has been recorded historically from only three small, isolated spring locations in northern Alabama, all three of which occur above the Fall Line. Unfortunately, two of three populations have since been extirpated.

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This paper presents a taxonomic description of the spring pygmy sunfish. The new species is endemic to Alabama and is the most geographically restricted member of the family. Today, this rare species has its native distribution restricted to only one spring complex and associated habitats, and is in imminent danger of extinction.

Methods

Institutional symbolic codes used below follow Leviton and Gibbs (1988). Methods used for making body measurements and scale counts follow those outlined in Hubbs and Lagler (1974) and Rohde and Arndt (1987). Body measurements of *Elassoma alabamae* and *E. zonatum* were taken with electronic needle-point calipers using a dissection microscope; meristic data follow traditionally used variables for the family. Comparative meristic and morphometric data for *E. boehlkei* and *E. okatie* were derived from Rohde and Arndt (1987) and museum specimens; data for *E. evergladei*, *E. okefenokee*, and *E. zonatum* were derived from museum specimens.

Statistical analysis of mensural and meristic data for *E. alabamae* and *E. zonatum* included SAS univariate and multivariate analyses. Students' T test was used to test for sexual dimorphism and differences between *E. zonatum* and *E. alabamae*. Sheared principal components analysis (Rohlf and Bookstein, 1990) was used with head, body, and fin measurements to summarize mensural differences; standard principal component analysis was used to summarize meristic variation. A correlation matrix was used in the principal component analysis of meristic data; a covariance matrix was used in analysis of $\log_{10}$ transformed measurement data. Sexes were analyzed separately in the analysis of mensural data because of observed sexual dimorphism in some characters.

Details of body and fin coloration of *E. zonatum* and *E. alabamae* were taken from live specimens and color transparencies of live and freshly-preserved specimens; a detailed description of *E. zonatum* is presented in Walsh and Burr (1984). Comparative coloration data of other species were derived from personal observations of live specimens, color transparencies, and color descriptions provided in Rohde and Arndt (1987).

Elassoma alabamae, new species
Spring Pygmy Sunfish
Figure 1A and 1B

HOLOTYPE.—University of Alabama Ichthyological Collection, UAIC 10275.01, adult male, 17.4 mm SL, Tennessee River Drainage, Alabama, Limestone County, Moss Spring and effluent run into Beaverdam Creek, 1.4 mi N of Greenbriar (T4S, R3W, Sec. 16), 2 March 1992, R. L. Mayden, B. R. Kuhajda, H. T. Boschung, T. S. Jandebeur, and J. R. Tomelleri.

ALLOTYPE.—UAIC 10275.05, adult female, 17.4 mm SL, same locality and collection information as holotype.

PARATYPES.—UAIC 10275.06, 50 specimens (13.7–18.8 mm SL), same locality and collection data as holotype. UAIC 4129.04, 36 specimens (11-15), Alabama, Limestone County, Moss Spring, Beaverdam Creek, vicinity of Greenbriar (T4S, R3W, Sec. 16), 31 July 1973, J. C. Hall, M. F. Mettee, and E. C. Beckham. UAIC 4606.01, 5 specimens (17–23), Alabama, Limestone County, Pryor Spring, 9 mi S of Athens (T4S, R4W, Sec. 22), 25 April 1941, C. M. Tarzwell (formerly UMMZ 133263). UAIC 4923.11, 13 alcoholic and 3 cleared and stained specimens (11–15), same locality data as holotype, 5 August 1974, M. F. Mettee, R. D. Suttkus, and G. Clemmer. UAIC 10146.05, 4 specimens (21.4–24.5), same locality data as holotype, 25 April 1989, R. L. Mayden, H. T. Boschung, J. D. Williams, N. M. Burkhead, M. T. Ferguson. UAIC 10454.01, 8 specimens (18.8–19.7), Alabama, Limestone County, unnamed spring run, tributary to Beaverdam Creek (T4S, R3W, Sec. 15), 19 April 1983, M. F. Mettee. INHS 28324, 10 specimens (15–20), same collection and locality data as UAIC 10275.06. SIUC 20341, 10 specimens (17–20.5), same collection and locality data as UAIC 10275.06. TU 165003, 10 specimens (15–20), same collection and locality data as UAIC 10275.06. UF 93287, 10 specimens (15–20), same collection and locality data as UAIC 10275.06. UMMZ 132689, 1 specimen (22), Alabama, Lauderdale County, Cave Spring near Smithsonia (T3S, R13W, Sec. 15; TVA Map 35 SW, preimpoundment), 5 November 1937, L. F. Miller (original TVA number 37–638). UMMZ 132690, 5 specimens (20–23), same collection and locality data as UMMZ 132689. UMMZ 133263, 50 specimens (16.0–26.0), same collection and locality data as UAIC 4606.01, received from Tennessee Valley Authority. UMMZ 200793, 2 specimens (20–21.5), Alabama, Limestone County, Pryor Spring Branch, (T4S, R4W, Sec. 28; Wheeler Reservoir, TVA Map 68 NW, preimpoundment), 25 April 1941, C. M. Tarzwell. USNM 218407, 14 alcoholic and 3 cleared and stained specimens (17.6–19.3), Alabama, Limestone County, Moss Spring, swampy area above and below beaver dam on Beaverdam Creek (T4S, R3W, Sec. 15, SW 1/4), 23 February 1975, T. S. Jandebeur and J. D. Williams. USNM 243805, 20 specimens (16.1–20.3), Alabama, Limestone County, Beaverdam Creek and Moss Springs, 1.5 mi NE of Greenbriar, 7 March 1975, R. D. Suttkus, G. H. Clemmer, W. C. Starnes. UT 90.92, 5 specimens (19–21), Alabama, Limestone County, Moss Spring at extreme headwaters, ca. 5 mi W Madison (T4S, R3W, Sec. 10), 17 February 1973, D. A. Etnier, R. A. Stiles, R. L. Henson, F. V. Oakberg, G. R. Boronow, and J. Winfield.

NONTYPE MATERIALS.—AUM 23966, 13 specimens (19.1–23.0 mm SL), same locality data as holotype, M. F. Mettee, 19 April 1983. UAIC 8799.02, 1 alcoholic and 5 cleared

Figure 1. A. *Elassoma alabamae*, holotype, male, 17.4 mm SL, Moss Spring and effluent run into Beaverdam Creek, 1.4 mi N of Greenbriar (T4S, R3W, Sec. 15), Limestone County, Alabama, 2 March 1992 (UAIC 10275.01). B. *Elassoma alabamae*, allotype, female, 17.4 mm SL, (UAIC 10275.05) same locality and collection information as holotype. C. *Elassoma zonatum*, male, 29.2 mm SL, Five Runs Creek at Alabama Hwy 55, 5.5 mi S of Andalusia, Covington County, Alabama, 4 March 1992, (UAIC 10280.01). D. *Elassoma zonatum*, female, 28.8 mm **SL, same collection and locality data as male.**

and stained specimens (15–17), Moss Spring Run in Beaverdam Swamp, ca. 1.8 mi NNE of Greenbriar (T4S, R3W, Sec. 15), 17 September 1977, B. H. Bauer, J. E. Böhlke, E. B. Böhlke, D. A. Etnier, J. L. Harris, W. C. Starnes, and L. B. Starnes. UT 90.260, 5 specimens (15–17), same collection and locality data as UAIC 8799.02.

Diagnosis.—*Elassoma alabamae* is the smallest member of Elassomatidae, attaining an average adult body size of about 17.4 mm SL (N=122); maximum adult body size observed was a 25 mm SL female. This species is distinguished from all other Elassomatidae on the basis of meristic, mensural, and coloration characters. Dorsal spines II–IV, usually III; lateral scale rows 27–32, usually 28 or 29; transverse scale rows usually 11 or 12; caudal peduncle scale rows 15–20, usually 16–18; broad, black or dark olive bars along flanks 5–8, usually 6 or 7, separated by 4–8, usually 5 or 6 narrow iridescent blue-green or cream-colored interbars; broad, dark bars with discrete edges in males, edges less discrete in females; broad bars wider than those of other species of *Elassoma*; narrow interbars less numerous than in other *Elassoma*; dorsal fin of breeding males with basal dark band containing two large depigmented ocelli; dorsal and anal fins of males with clear to white narrow windows in posteriormost membranes, accentuated by adjacent darkly pigmented rays and membranes; females without windows in dorsal and anal fins; base of caudal fin with two indistinct, cream to white ocelli bordered anteriorly by dark brown to olive bar, not bounded posteriorly by bar; scales absent on the dorsum of head; dark scapular or shoulder blotches absent; gular region and lips pigmented.

Description.—Variation in head, body, and fin measurements for males and females are presented in Table 1. Variation in number of scale rows, fin rays and spines, lateral bars, and gill rakers are presented in Tables 2–4. General head and body physiognomy is shown in Figure 1A and B.

Body laterally compressed; body depth greatest at dorsal fin origin. Head laterally compressed and with rounded anterior profile. Dorsal and anal fins with spines and rays and with rounded distal profile. Caudal fin with rounded distal profile. Pelvic fin with spine and rays; median rays longest and presenting pointed fin margin.

Small species of *Elassoma*, mean adult body length 17.6 mm SL (N=44) in males and 18.8 mm SL (N=26) in females. Largest specimen 25 mm SL female.

Bars along flanks generally evenly spaced, numbering 5–8, usually 6 or 7 ($\bar{x}$=6.2, SD=0.66). Bars broad, in male average 1.7 mm in width (range 1.2–2.5, SD=0.38), averaging 13.1 times wider than iridescent interbar width (range 4.2–22.0, SD=5.35) (interbar width range 0.06–0.43, $\bar{x}$=0.16, SD=0.09). In females, average dark bar width 1.9 mm (range 1.0–2.8 , SD=0.54), averaging 9.5 times wider than lighter interbar width (range 4.7–16.0, SD=3.18) (interbar width range 0.10–0.48, $\bar{x}$=0.24, SD=0.10).

Lateral scales 27–32, usually 28 or 29, not pored. Transverse scale rows 10–13, usually 11 or 12. Scales around caudal peduncle 15–20, usually 16–18. Total vertebrae 28 (5 specimens) or 29 (3) ($\bar{x}$=28.4, SD=0.48). Scales cover trunk; top of head without scales. Nape, opercle, and breast with embedded scales. Cheek and preopercle without scales.

Dorsal fin spines II–IV, usually III; dorsal fin rays 8–13, usually 10 or 11. Anal fin spines I–III, usually III; anal fin rays 5–8, usually 6 or 7. Pectoral fin rays 14–19, usually 16 or 17. Pelvic fin long and pointed, generally extending beyond anal fin origin in males, but not females ($P<0.0001$); pelvic spines I; pelvic fin rays 5 (63 specimens) or 6 (7) ($\bar{x}$=5.1, SD=0.30). Branched caudal fin rays 10–13, usually 12.

Gill rakers on lower arch usually small, generally as long as wide. Rakers number 2–5, usually 3. Branchiostegal rays 4 (6 specimens), 5 (69), or 6 (3) ($\bar{x}$=5.0, SD=0.36). Sensory pores on head common and conspicuous. Supraorbital-postemporal canal usually uninterrupted, pores 7 (18); canal interrupted, pores 8 (2). Prenasal canal pores 2 (20). Preopercular canal uninterrupted, pores 3 (1) or 4 (19). Mandibular and suborbital canals absent. External neuromasts common on head; single row along each mandible (mandibular line, sensu Branson and Moore, 1962), on cheek below eye to and along prenasal canal (infraorbital line), between naris and orbit (nasal line), across preopercle (postmaxillary line), and on dorsum of head above eye, around snout (median supraorbital line), and around occiput.

Palatine and vomer without teeth. Premaxilla and mandible with elongate and villiform teeth; teeth in two or three rows anteromedially and one row laterally. Teeth slightly recurved near symphysis and generally erect laterally. Infrapharyngeals two and not fused, covered with elongate and erect teeth similar to larger teeth on jaws. Ceratobranchials 5 with enlarged surface covered with large, elongate, and erect teeth.

Coloration. Males and females are sexually dichromatic; males are generally more brightly colored than females, especially during spring months. Coloration of breeding male and female is illustrated in Figure 1A and B. The following color descriptions are based on live breeding males, live breeding females, live juveniles and non-breeding adults, and preserved specimens.

Males. Breeding males (Fig. 1A) brilliantly colored. Body of freshly captured male may be very dark to black except for narrow iridescent blue-green bars along flanks and iridescent mottling on cheeks, preopercles, central opercles, preopercles, and subopercles. Body coloration of these males becoming more subdued with handling. Dorsum olive green to light brown and, in some males, crossed by five to six narrow, dark saddles from flank coloration; first saddle forming near origin of dorsal fin and last saddle forming along caudal peduncle. Predorsal region may be mottled with patches of dark olive over light

Table 1. Proportional measurements of adult males and females of *Elassoma alabamae* and *Elassoma zonatum*. Proportions expressed as thousands of standard length except for the last three measurements which are proportions of head length. Significant differences between sexes are indicated by asterisks (P<0.05).

Elassoma alabamae	Males (N=21; includes holotype)				Females (N=20)		
	Holotype	Range	$\bar{x}$	SD	Range	$\bar{x}$	SD
Standard Length*	17.4	16.1–20.4	18.1	1.3	14.2–24.5	20.4	2.5
Head Length*	339	311–361	338	12.4	286–359	323	17.9
Head Depth*	167	115–192	175	15.9	142–190	162	11.7
Body Depth	305	271–356	301	19.5	276–353	302	20.2
Preanal Length*	552	528–574	552	15.4	528–630	583	25.4
Predorsal Length*	443	417–474	445	14.5	436–502	462	17.7
Prepelvic Length	362	347–405	374	16.2	339–393	367	15.0
Caudal Peduncle Length	276	254–328	287	20.1	248–307	280	15.4
Caudal Peduncle Depth*	138	106–147	129	10.6	99–141	114	9.7
Dorsal Fin Length*	397	364–448	405	23.9	332–393	357	17.4
Anal Fin Length*	253	225–320	280	25.2	189–275	227	18.6
Pectoral Fin Length*	144	106–148	133	12.0	74–122	105	11.9
Pelvic Fin Length*	241	181–260	223	21.1	145–197	169	15.3
Snout Length	75	54–90	73	9.3	62–84	73	5.6
Eye Diameter*	80	80–102	89	5.4	69–92	81	5.6
Upper Jaw Length*	75	67–91	78	6.3	63–79	71	5.2
Bar Width	75	71–132	95	17.6	68–123	96	18.4
Interbar Width	3	3–22	9	4.8	5–21	11	4.3
Snout Length	220	161–268	218	28.6	189–257	226	18.1
Eye Diameter*	237	233–296	264	16.4	227–281	251	12.8
Upper Jaw Length	220	196–273	231	21.6	176–257	220	20.1

Elassoma zonatum	Males (N=10)			Females (N=10)		
	Range	$\bar{x}$	SD	Range	$\bar{x}$	SD
Standard Length*	22.4–32.1	28.1	3.1	22.8–28.8	25.5	1.9
Head Length	327–366	352	13.5	329–349	342	5.9
Head Depth*	158–188	173	10.4	154–167	160	4.0
Body Depth	277–315	297	12.5	285–341	310	15.4
Preanal Length*	601–627	612	8.9	635–667	654	9.9
Predorsal Length	418–469	448	17.8	414–475	456	18.4
Prepelvic Length	346–392	374	15.6	339–408	383	20.7
Caudal Peduncle Length*	229–309	257	22.1	202–257	231	19.1
Caudal Peduncle Depth*	145–169	155	8.5	124–156	136	9.8
Dorsal Fin Length*	487–546	522	19.1	447–502	469	22.7
Anal Fin Length*	308–341	324	9.7	247–278	264	11.3
Pectoral Fin Length*	184–212	197	7.6	158–184	169	8.6
Pelvic Fin Length*	227–283	250	15.9	198–240	215	15.1
Snout Length	73–92	83	6.4	73–85	78	4.0
Eye Diameter	65–84	77	6.0	69–88	79	5.8
Upper Jaw Length	67–100	87	10.1	70–85	80	4.5
Bar Width*	31–51	40	7.1	35–77	56	12.9
Interbar Width	17–30	23	4.8	14–28	20	4.4
Snout Length	207–255	234	16.2	211–253	227	13.0
Eye Diameter	194–234	218	12.5	202–253	230	18.3
Upper Jaw Length	183–286	246	30.4	200–253	233	14.5

Table 2. Variation in lateral scale rows, transverse scale rows, and caudal peduncle scale rows in *Elassoma alabamae* (N=70) and select samples of *Elassoma zonatum* (N=76) from Alabama. Holotype is indicated with asterisk.

	Lateral Scale Rows														
	27	28	29	30	31	32	33	34	35	36	37	38	39	$\bar{x}$	SD
Elassoma alabamae	8	23	21*	10	7	1								28.9	1.20
Elassoma zonatum					2	7	11	15	17	14	6	3	1	34.6	1.73

	Transverse Scale Rows							
	10	11	12	13	14	15	$\bar{x}$	SD
Elassoma alabamae	5	29	31*	5			11.5	0.73
Elassoma zonatum			11	35	29	1	13.6	0.72

	Caudal Peduncle Scale Rows														
	15	16	17	18	19	20	21	22	23	24	25	26	27	$\bar{x}$	SD
Elassoma alabamae	4	10	29*	12	8	7								17.4	1.31
Elassoma zonatum						1	10	15	28	16	5		1	22.9	1.24

olive background. Lateral coloration above midline darker olive brown; edges of scales highlighted with melanophores. Dark shoulder blotches absent. Below midline flanks lighter olive to tan; some scales outlined with melanophores or iridescence along margins. Scales along flanks and above belly, posterior to pectoral fin insertion and anterior anal fin with peach to light orange iridescence. Flanks with five to seven broad, dark brown to olive bars separated by five to seven narrow iridescent blue-green interbars; iridescent interbars extending from just above midline to belly and lower caudal peduncle where expanded slightly; first bar just posterior to pectoral fin insertion, last bar anterior to hypural plate. Belly and ventral caudal peduncle light tan to cream with some some scales margined with iridescence.

Dorsum of head olive green to brown; mottled in some individuals. Postorbital and preorbital stripes well developed and continuous through eye; postorbital stripe extending along dorsal margin of opercle. Preorbital stripe extending anteriorly across both lips and continued inside mouth along mandibles. Lips dusky between preorbital bars; laterally, lips immaculate or lightly pigmented with melanophores. Snout between preorbital stripes brown to dark olive. Pupil black and surrounded by yellow ring; remainder of eye brown to tan. Cheek, preopercular region, ventral opercle, and subopercle brilliantly colored with iridescent blue, green, and yellow spots. Spots separated by three to four bars radiating from anteroventral and posteroventral margins of orbit; bars broken and composed of clusters of grouped melanophores. Subopercle, preopercle, and interopercle with large iridescent blue to green spots against dark olive to brown background coloration. Gular region and branchiostegals with scattered melanophores, most intense on adult males. Prepectoral region heavily pigmented with melanophores and with iridescent blue-green cast. Breast and interpelvic regions cream colored and heavily pigmented with melanophores.

Dorsal fin with distinctive banding pattern. Fin with broad dusky distal band, forming narrow margin in spinous membranes and broad margin in membranes of rays; band occupying up to one half of last membrane. Basal portions of interspinal membranes cream; basal portions of interradial membranes with broad dusky band. Basal band beginning at first ray and continuing to last ray. Band with two large basally clear to white ocelli contained within band. Central portions of spines, rays, and interspinal and interradial membranes cream to light yellow-orange. Posteriorly, dusky distal and basal bands separated by distinct clear to white narrow stripe creating distinctive "window." Spines and rays of dorsal fin lined with melanophores and darkest distally, except in clear spots of basal band and posterior window; first spine and distal tips of posterior spines black. Caudal fin with broad dusky distal band; band continuous along distal edges of all branches of caudal rays. Base of caudal fin with two poorly defined cream or white basicaudal ocelli, separated by posterior extension of lateral band; ocelli bounded anteriorly by dark bar extending onto procurrent rays but not bordered posteriorly by dark bar. Medially, caudal fin membranes and rays yellow to cream. All rays lined by melanophores. Anal fin with leading spine and membrane black; dark dusky band extending along distal edge of fin. Band narrow anteriorly,

expanded at first anal ray, and extending to posterior-most ray and membrane as broad dusky band. Base of fin from third spine to last ray darkly pigmented; band shallow anteriorly and broad posteriorly. Distal and basal bands separated posteriorly by narrow white to clear stripe, creating distinctive "window." Pelvic fins dusky with broad dark distal margin; dark pigment best developed at distal edges of central rays. Pectoral fin clear; rays lined with melanophores.

Females. Breeding females (Fig. 1B) generally drab in coloration; body not as brightly colored as males. Dorsum light brown. Nape may appear mottled with large, dark olive blotches over tan to light brown background coloration. Flanks with five to eight broad dark olive to dark brown bars; bars may extend dorsally and connect with blotches on nape or cross dorsum as narrow saddles; saddles forming from dorsal fin origin to procurrent rays of caudal fin, creating a regular saddled pattern. Margins of broad bars along flank generally irregularly formed; bars separated by four to eight narrow iridescent to tan interbars. Narrow interbars extending ventrally to belly and ventral caudal peduncle; interbars more iridescent anteriorly. Belly and lower flanks iridescent yellow-green to orange; belly cream to white. Lower caudal peduncle dark brown to olive brown.

Dorsum of head olive to light brown with some mottling posteriorly. Midline of snout olive to light brown. Postorbital and preorbital stripes dark olive brown and well developed; postorbital stripe extending posteriorly across dorsum of operculum and terminating at opercular margin. Preorbital stripe extending anteriorly across both lips and present inside mandible. Lips, between preorbital stripes, dusky; lateral to preorbital stripe, lips white or lightly pigmented with melanophores. Cheek region with three to four darkly colored bars radiating anteroventrally to posteroventrally from eye; bars formed from dusky concentrations of melanophores. Areas between bars with light cast of iridescent green yellow. Dorsal one half of opercle below postorbital stripe brightly iridescent yellow-green or green-orange. Center of operculum and subopercular bright iridescent yellow-green and orange. Branchiostegals, gular region, and breast cream colored to white and lightly pigmented with melanophores. Prepectoral region iridescent yellow-orange over background of cream to light tan.

Dorsal fin with broad basal dusky band; band with three large centrally and posteriorly located dark spots; spots occur in same locations as where basal band of males connects with dorsum of body. Medially, dorsal fin yellow to cream. Distally, dorsal fin clear to dusky. Dorsal fin spines and rays lined with melanophores, creating three to four dusky bands; distal dusky band formed from melanophores along rays and spines. First dorsal spine darkly pigmented. Posteriorly located depigmented or white window of males absent. Caudal fin as in males except that dusky distal band lighter and bar on caudal peduncle not as intense. Anal fin coloration similar to dorsal fin; base with two dark spots, one located centrally and one posteriorly. First anal spine black. Centrally, anal fin cream to yellow; membranes clear; rays outlined by melanophores, creating light dusky edge. Posteriorly located depigmented or white window of males absent. Pelvic and pectoral fins immaculate except for few melanophores along edges of rays.

Juveniles and non-breeding adults. Juveniles and non-breeding females as in live breeding females except that irides-

Table 3. Variation in dorsal fin spines and rays, anal fin spines and rays, pectoral rays, and caudal rays in *Elassoma alabamae* (N=70) and select samples of *Elassoma zonatum* (N=76) from Alabama. Holotype is indicated with asterisk.

	Dorsal Fin Spines						Dorsal Fin Rays							
	2	3	4	5	$\bar{x}$	SD	8	9	10	11	12	13	$\bar{x}$	SD
Elassoma alabamae	11	57*	2		2.9	0.41	1	4	27*	31	6	1	10.6	0.84
Elassoma zonatum		2	41	33	4.4	0.54	2	16	34	22	1	1	10.1	0.88

	Anal Fin Spines						Anal Fin Rays						
	1	2	3	4	$\bar{x}$	SD	4	5	6	7	8	$\bar{x}$	SD
Elassoma alabamae	1	7	62*		2.9	37		5	28*	36	1	6.5	0.65
Elassoma zonatum			74	2	3.0	0.16	2	43	26	5		5.4	0.66

	Pectoral Fin Rays								Caudal Fin Rays							
	14	15	16	17	18	19	$\bar{x}$	SD	10	11	12	13	14	$\bar{x}$	SD
Elassoma alabamae	2	11	21	25*	7	1	16.5	1.02	1	12	46*	11		12.0	0.62
Elassoma zonatum	7	22	36	10	1		15.7	0.87	1	13	29	30	3	12.3	0.84

Table 4. Variation in number of dark lateral bars, iridescent interbars, and gill rakers in *Elassoma alabamae* (N=70) and select samples of *Elassoma zonatum* (N=76) from Alabama. Holotype is indicated with asterisk.

	Number Dark Bars									
	5	6	7	8	9	10	11	12	$\bar{x}$	SD
Elassoma alabamae	6	42*	20	2					6.2	0.66
Elassoma zonatum				14	27	21	13	1	9.5	1.03

	Number Light Interbars									
	4	5	6	7	8	9	10	11	$\bar{x}$	SD
Elassoma alabamae	1	24	35*	8	2				5.8	0.77
Elassoma zonatum				12	23	20	16	5	8.7	1.16

	Number Gill Rakers								
	2	3	4	5	6	7	8	$\bar{x}$	SD
Elassoma alabamae	8	41*	14	7				3.3	0.80
Elassoma zonatum		5	10	28	18	11	4	5.4	1.24

cence subdued or lacking from face, opercle, and narrow bars. Body coloration of juveniles generally with greater contrast between cream background coloration and darker bars or mottling along flanks and dorsum. Some juveniles or non-breeding females may have some iridescence on operculum and along narrow bars.

Coloration of non-breeding males as in breeding males except coloration more subdued. Broad bars with distinct edges and separated by narrow interbars. Depigmented areas at base of dorsal fin; posterior clear to white window present. Mottling on face with reduced iridescence. Pelvic fins as in breeding males except that distal band not as intense. Caudal fin as in breeding males except that yellow central coloration and distal dark margin not as intense.

Alcohol preserved males. Iridescent coloration of males lost soon after fixation. Flanks and dorsum of body straw colored with narrow dark brown saddles crossing dorsum posterior to nape. Nape occasionally mottled tan and dark brown. Broad bars along flank dark brown; narrow interbars cream. Margins of bars with discrete edges. Venter cream colored with some melanophores along scale margins of lower caudal peduncle. Breast, gular region, and branchiostegals cream colored with some melanophores; melanophores more heavily concentrated anteriorly along branchiostegal rays, gular region, and tip of snout.

Dorsum of head brown to tan. Preorbital and postorbital stripes black to dark brown. Cheek region, preopercle, subopercle, and opercle with cream colored background with mottling of black to dark brown; cream colored background coloration formerly iridescent in breeding males. Postorbital stripe creates dark brown dorsal margin on operculum.

Dorsal fin medially and distally dusky from dense concentration of melanophores. Base of fin darker, with dark dusky band and two depigmented spots. Posteriorly, narrow white to clear stripe or "window" extending perpendicular to rays and separating basal and distal dusky bands. Caudal fin dusky from melanophores along margins of rays and on membranes. Vertical basicaudal band and cream-colored basicaudal spots distinct. Anal fin with broad dusky basal band. Distally, anal fin dusky with heavy concentration of melanophores on rays and membranes. Distal and basal bands separated posteriorly by white to clear stripe or "window." Pelvic fins dusky, especially along broad distal margin. Pectoral fins clear, except for melanophores along membranes.

Alcohol preserved females. Iridescence of head and body lost immediately following fixation. Dorsum and flanks tan to cream colored; mottling of nape and dorsal saddles dark brown, if present. Broad bars brown and separated by narrow and light cream bars. Edges of bars irregular as in live females. Belly and lower flanks cream to tan.

Dorsum of head brown. Preorbital and postorbital stripes dark brown. Dorsum of opercle dark brown to black from postorbital stripe. Remainder of opercle, cheeks, interopercle, and subopercle mottled dark brown over cream background coloration; mottling formed from three to four poorly developed bars radiating anteroventrally to posteroventrally from eye. Cream background coloration of opercle, subopercle, and cheek formerly lightly iridescent. Gular region and branchiostegals cream colored with light speckling of melanophores.

Coloration of fins as in live females except that medial yellow coloration of dorsal, caudal, and anal fins lost. Melanophores along rays form basal dusky band and dark spots in dorsal and anal fins. Caudal rays distinctly outlined with melanophores.

Sexual Dimorphism.—The most conspicuous difference between males and females is coloration. The head, body, and dorsal and anal fins of males are more brilliantly colored than those of females throughout most of the year. The broad, dark bars along the flanks of males generally have well defined vertical edges; in females the edges of bars are more irregularly formed, often making it difficult to discern distinct bars.

Males and females differ significantly ($P<0.05$) in standard length; males are generally smaller than females (Table 1). The sexes also differ significantly in head, body, and fin proportions (Table 1). Males possess longer dorsal, anal, pectoral, and pelvic fins, longer and deeper heads, deeper caudal peduncles, larger eyes, and longer upper jaws, relative to standard length. Pelvic fins of most males extend posterior to origin of anal fin. Females have both the dorsal and anal fins placed more posterior on the

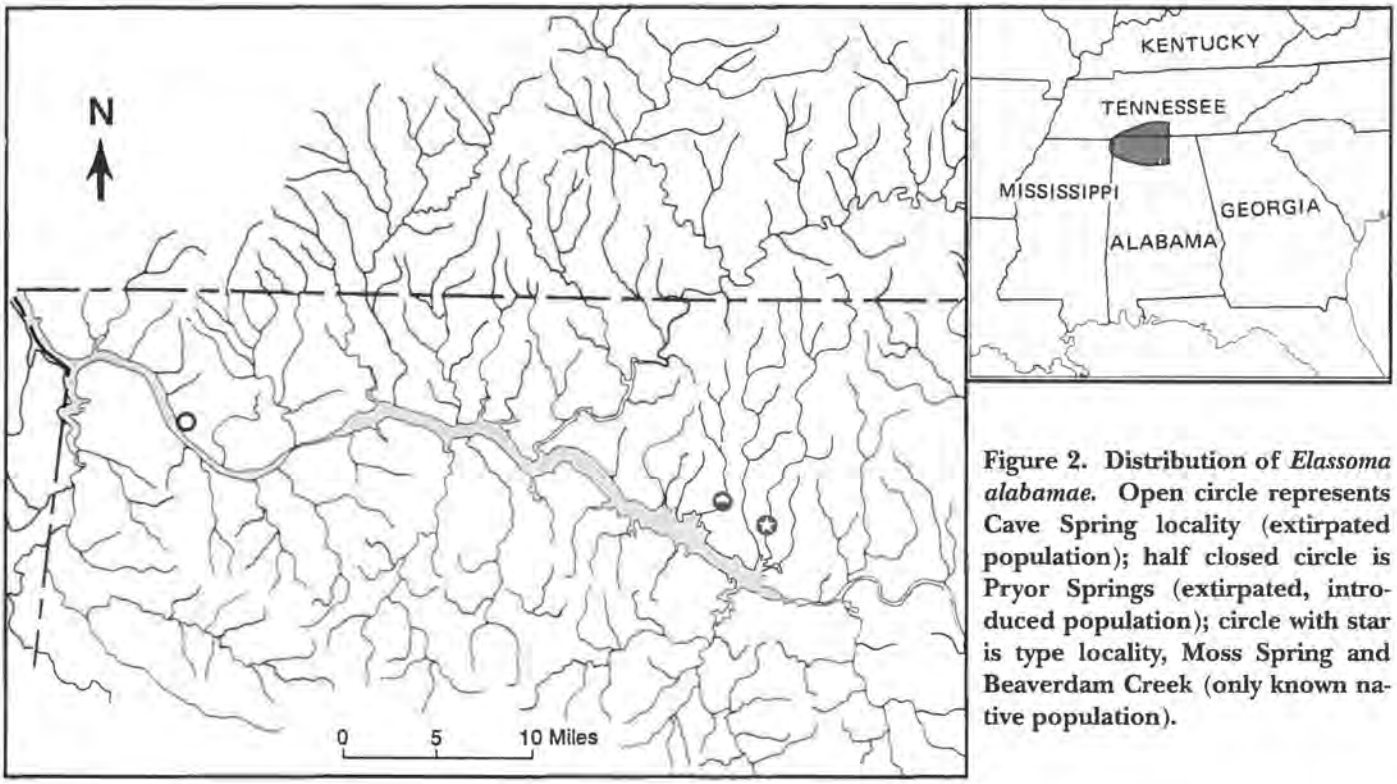

Figure 2. Distribution of *Elassoma alabamae*. Open circle represents Cave Spring locality (extirpated population); half closed circle is Pryor Springs (extirpated, introduced population); circle with star is type locality, Moss Spring and Beaverdam Creek (only known native population).

body, relative to standard length, than do males. When upper jaw length, snout length, and eye diameter were considered relative to head length only eye diameter differed significantly between the sexes; males possess larger eyes (Table 1). Bar width did not differ significantly for males and females; however, relative bar width did differ significantly. Broad, dark bars are wider relative to interbar space in males than in females ($P<0.01$). No significant differences between sexes were noted for meristic variables or number of bars or interbars along flanks.

ETYMOLOGY.—The species epithet *alabamae* refers to this rare species being endemic to the State of Alabama. The common name, spring pygmy sunfish, refers to the macrohabitat typically occupied by this species.

DISTRIBUTION.—The spring pygmy sunfish is known only from the Tennessee River Drainage in northern Alabama, and is the only known species in the genus *Elassoma* to have its entire geographic distribution above the Fall Line (Fig. 2). *Elassoma alabamae* was first collected by Tennessee Valley Authority biologist L. F. Miller on 5 November 1937 from Cave Spring near Smithsonia (T3S, R13W, Sec. 14), Lauderdale County, Alabama (Fig. 2; open circle), prior to impoundment of the adjacent Tennessee River. About four years later, on 25 April 1941, a collection by C. M. Tarzwell (TVA) from Pryor Springs System provided an additional record of the species (Fig. 2; half open circle). Both of these collections were forwarded to and identified as a distinct species by the late Dr. Carl L. Hubbs, then at the University of Michigan Museum of Zoology, and Mr. Milton B. Trautman, Ohio State University.

Natural populations of *Elassoma alabamae* from the Cave Spring and Pryor Springs areas have been extirpated. The Cave Spring locality, and habitat for the spring pygmy sunfish, was inundated by the formation of Pickwick Lake three months after the new pygmy sunfishes were found (dam closure on 8 February 1938; reservoir filled to elevation of 124.4 meters by 18 February 1938). Subsequent collection efforts and general surveys of this and surrounding areas for potential habitat have resulted in no additional specimens nor any potential habitat (Jandebeur, 1979, 1982). Native pygmy sunfishes were likely extirpated from the Pryor Springs system in the 1940's when (1) the indigenous vegetation in the springs was replaced by the parrots feather (*Myriophyllum brasiliense*) and (2) the waters were treated on 28 May 1945 with the herbicide 2, 4, D to control existing vegetation (Jandebeur, 1979). Subsequent to these disturbances the Pryor Springs system has also been channelized and subjected to agricultural pollutants.

Between 1941 and 1973 the spring pygmy sunfish was thought to be extinct. However, in January 1973 Dr. David A. Etnier (University of Tennessee, Knoxville) and students discovered *E. alabamae* along the margins of a spring-fed lake formed below Beaverdam Spring (T4S, R3W, Sec. 10) in Limestone County, Alabama (Fig. 2; circled star). Subsequent to this discovery, *E. alabamae* was also found in

Table 5. Morphological characters useful in distinguishing species of *Elassoma*. For each characteristic the state shown represents the common condition for the species.

Characteristic	*E. alabamae*	*E. zonatum*	*E. evergladei*	*E. okefenokee*	*E. boehlkei*	*E. okatie*
Lateral Scale Rows	28-30	33–36	23–32	31–34	26–28	25–29
Caudal Peduncle Scale Rows	16–18	21–24	20–24	19–20	19–20	18–20
Transverse Scale Rows	11–12	13–14	11–13	11–12	11–12	10–12
Dorsal Spines	3	4–5	4	4	4	4–5
Dorsal Rays	10–11	9–11	8–10	10–13	9–11	9–11
Anal Rays	6–7	5–6	4–6	6–8	5–7	5–7
Pectoral Rays	16–17	15–16	13–15	14–17	14–15	14–16
Windows on Dorsal and Anal Fins	present	absent	absent	absent	absent	absent
Shoulder Spots[1]	none	1–3	none	none	none	non
Vertical Bars[2]	broad; 6–7	narrow; 8–11	indistinct[3]	indistinct[3]	narrow; 12–14	narrow; 9–12
Head scales	no	no	yes	no	no	no
Pigmentation on Center of Lips	dusky	dusky	dusky	light	dusky	dusky
Postocular Stripe	present	present	absent	absent	absent	absent
Subocular Bar	poorly developed	well developed	absent	absent	well developed	well developed
Basicaudal Ocelli	not clearly bordered posteriorly	bordered posteriorly	bordered posteriorly	bordered posteriorly	bordered posteriorly	bordered posteriorly

1. May not be obvious in live specimens; more obvious in preserved specimens and generally formed as dorsal portion of dark bars.
2. In breeding males dark bars may be obliterated by very dark overall breeding coloration or bars may be separated by only narrow iridescent interbars; dark bars more obvious in preserved specimens.
3. Bars indistinct anteriorly on adults; body coloration appears mottled, dark, or dusky, depending upon breeding condition and sex. Bars best developed posteriorly on caudal peduncle, especially on males; number of bars may vary from 1–5, generally less than 3. Flanks of juveniles distinctly mottled anteriorly and barred posteriorly. Dark bars on *E. evergladei* wider than interbar spaces; width of bars on *E. okefenokee* about equal to width of interbar space.

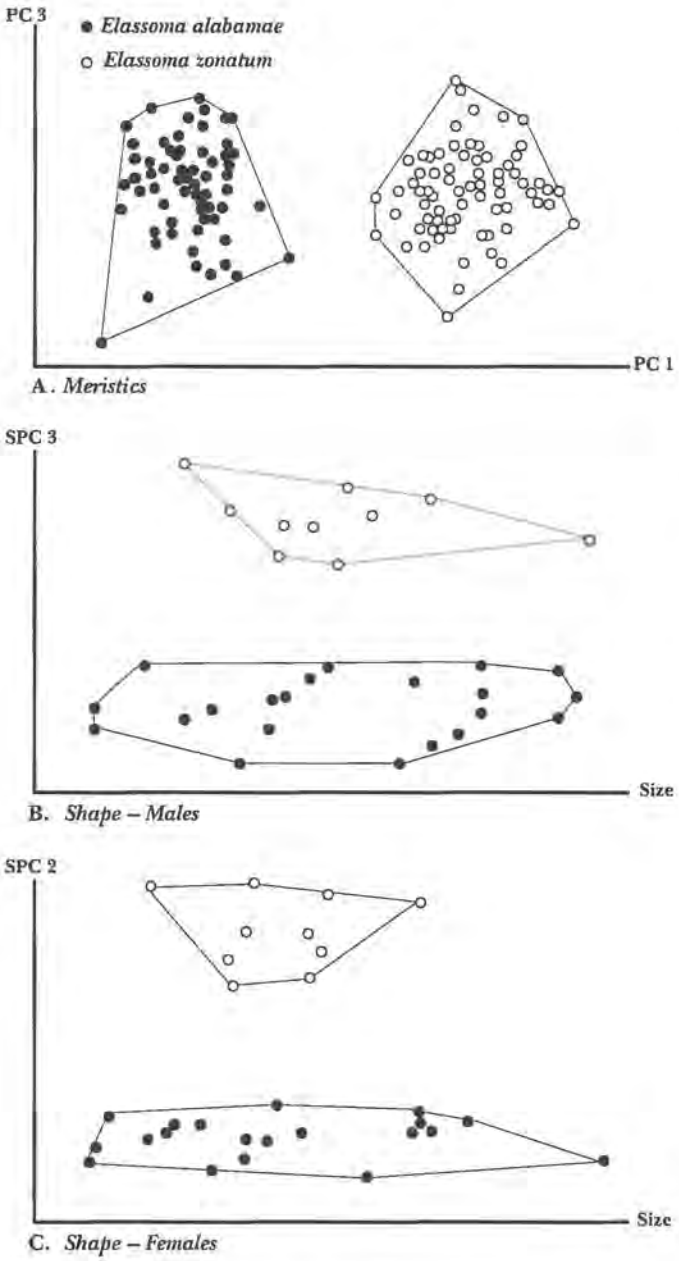

Figure 3. Principal component (PC) analysis of variation in fourteen meristic and eighteen mensural variables for *Elassoma alabamae* and *Elassoma zonatum*. Variable loadings are presented in Table 6. SPC = Sheared principal component.

Moss Spring (T4S, R3W, Sec. 16) and Lowe's Ditch and run, both draining into the lake within Beaverdam swamp (T. S. Jandebeur, pers. comm., 8 December 1992). Significant collecting efforts in other potential spring and swamp locations in north Alabama have failed to reveal any additional populations of this species outside of Beaverdam Spring and swamp complex (inclusive of Moss Spring and Lowe's Ditch) (Jandebeur, 1979, 1982). Within the Beaverdam Spring and swamp system *E. alabamae* has been collected from a number of locations, appears to be seasonal in its habitat selection, and is generally common within Moss Spring (Jandebeur, 1979; Darr and Hooper, 1991; pers. obs.). No specimens of *E. alabamae* have been found in Beaverdam Spring proper or in the Beaverdam Creek and swamp below the confluence with Moore Branch (T. S. Jandebeur, pers. comm., 8 December 1992).

As a conservation measure, on 17 February 1984, 36 adult specimens (11 males, 25 gravid females) of *E. alabamae* from Moss Spring (T4S, R3W, Sec. 16) were successfully introduced into its former range. These specimens were placed in "an unnamed spring tributary (T4S, R4W, S21) to Pryor Branch, which is located approximately 300 yards west of U. S. hwy 31" . . . "also called Lower Pryor Spring" (Mettee and Pulliam, 1986:14) or spring number 2 of the Pryor Springs system (Mettee et al., 1986). In the following year, 120 additional specimens (37 males and 83 females) were transferred to Pryor Spring #2 upon determination of successful stocking effort in this spring in the previous year. In January 1987, 58 males and 59 females were moved from Moss Spring to the original Pryor Spring where the species had been extirpated. The status of this latter introduction was reported as unknown by Pierson (1990), but was considered successful by T. S. Jandebeur (pers. comm., 8 December 1992). Jandebeur (pers. comm.) surveyed the Pryor Spring System as recent as 19 and 28 September 1992. On both occassions *E. alabamae* was determined to be common and occupying, in addition to the springs, flooded and impounded (beaver dam on Pryor Branch) regions west of Hwy 31S, between Pryor Spring and Pryor Spring #2, in areas formerly not inhabitated by this species. Today, extant populations of *E. alabamae* are restricted to the Beaverdam Creek watershed and Pryor Spring system where they live in close association with nearby wetlands and swamps.

HABITAT.—In 1937 L. F. Miller described Cave Spring as having clear water and abundant and thickly matted vegetation along the shoreline. The substrate was a fine sand and mud. The shoreline was lined with blue-grasses and weeds and was marshy in some areas. Depth of capture was from 15 cm to 1 m, in waters that were up to 1.4 m deep. This characterization of the Cave Spring ecosystem accurately describes the Moss Spring area where *E. alabamae* is commonly found today.

In the Moss Spring and Beaverdam Creek/Swamp area *Elassoma alabamae* is most commonly found above the substrate in association with rooted, submergent vegetation (generally *Ceratophyllum, Myriophyllum, Utricularia,* and *Elodea*). The water is clear and the substrate consists largely of fine sand, clay, mud, and/or limestone. The shoreline is generally lined with sparse to abundant hardwood trees, some shrubs, and grasses (sometimes as a marsh-like wetland). Apparently, the species is very mobile and uses the different spring and swamp macrohabitats at different times of the year (Jandebeur, 1979; Darr and Hooper, 1991).

Table 6. Principal component (PC) loadings for fourteen meristic variables (Fig. 3A) and eighteen mensural variables (Fig. 3B and C) in *Elassoma alabamae* and *Elassoma zonatum*. SPC=Sheared principal component.

Meristics		Measurements				
			Males		Females	
Variable	PC1	Variable	Size	SPC3	Size	SPC2
Dorsal fin spines	0.8604	Standard length	-0.1316	0.0692	-0.1706	0.0411
Dorsal fin rays	-0.2506	Preanal length	-0.1286	0.1284	-0.2167	0.0777
Anal fin spines	0.3163	Predorsal length	-0.1150	0.1084	-0.1561	0.0463
Anal fin rays	-0.6560	Prepelvic length	-0.1439	0.0439	-0.1745	0.0676
Pectoral fin rays	-0.3333	Body depth	-0.1667	0.0400	-0.2034	0.0324
Pelvic fin rays	-0.5057	Caudal peduncle length	-0.1709	-0.0058	-0.1744	-0.0880
Caudal fin rays	0.2233	Caudal peduncle depth	-0.2184	0.1013	-0.1310	0.1982
Lateral scales	0.8897	Head length	-0.1095	0.1242	-0.1208	0.1136
Transverse scales	0.8101	Head depth	-0.1257	0.0705	-0.1052	0.0862
Caudal peduncle scales	0.9170	Eye diameter	-0.1352	-0.0275	-0.1240	0.0451
Broad vertical bars	0.9353	Snout length	-0.2705	-0.0678	-0.1736	0.0917
Interbars	0.9030	Upper jaw length	-0.2412	-0.0238	-0.1920	0.1080
Branchiostegals	-0.0613	Dorsal fin length	-0.1878	0.1361	-0.1545	0.2290
Gill rakers	0.7276	Anal fin length	-0.2290	0.0725	-0.1123	0.1891
		Pectoral fin length	-0.1280	0.3261	-0.1245	0.3956
		Pelvic fin length	-0.2014	0.0392	-0.1119	0.2502
		Dark bar width	-0.2107	-0.8125	-0.4310	-0.5964
		Interbar width	-0.6791	0.0169	-0.6496	-0.0034

Other fish species found in association with the spring pygmy sunfish in Cave, Pryor, and Moss springs include *Amia calva, Clinostomus funduloides, Cyprinella whipplei, Hemitremia flammea, Luxilus chrysocephalus, Notemigonus crysoleucas, Pimephales vigilax, Semotilus atromaculatus, Erimyzon sucetta, Minytrema melanops, Ameiurus natalis, Esox americanus, Esox niger, Gambusia affinis, Chaenobryttus gulosus, Lepomis cyanellus, L. macrochirus, L. microlophus, L miniatus, Micropterus dolomieu, Etheostoma duryi, E. nigripinne,* and *E. tuscumbia.*

Life History.—No one study has focused on all aspects of the life history of *Elassoma alabamae.* General habitat has been described Ramsey et al. (1972), Mettee (1974), Ramsey (1976), Jandebeur (1979, 1982), Mettee and Ramsey (1986), and Darr and Hooper (1991). Jandebeur (1979, 1982) reported that critical habitat for the species existed in heavily vegetated areas within Moss Spring and its discharge into Beaverdam Creek, Lowe's Ditch, and the Beaverdam Creek and swamp system. Reproductive biology and development was studied by Mettee (1974). Most spawning occurs in March and April (Darr and Hooper, 1991; pers. obs.). Females can produce up to 65 eggs per spawning (Mettee and Ramsey, 1986). Based on results from Mettee (1974), Mettee and Ramsey (1986)and Darr and Hooper (1991), the spring pygmy sunfish is thought to be an annual species; adults spawn at one year of age and die within a few days to months after spawning. Population demography data presented by Darr and Hooper (1991) support this hypothesis; however, population estimates were not provided in this study. These authors recorded number and size of specimens captured, condition of the specimens, sex, maturity, and parasites. Following spring spawning activities adults die in late spring and early summer. By September, the population consists only of offspring from the spring spawning of the same year. Spawning behavior of *E. alabamae* and other *Elassoma* species was described by Mettee (1974). Species of *Elassoma* apparently do not construct nests on the substrate like members of the family Centrarchidae and possess more complex and elaborate courtship and spawning behaviors (Walsh and Burr, 1984). The eggs of pygmy sunfishes are generally attached to aquatic vegetation (usually *Ceratophyllum*) above the substrate. Walsh and Burr (1984) provide a detailed review of the biology of *Elassoma.*

Conservation status.—The extremely small geographic distribution and short life span of *E. alabamae* affords this species a largely precarious future. *Elassoma alabamae* is known to be sensitive to habitat alterations and an unsuccessful spawning season could easily result in its extinction. Two populations have already been lost through impoundment and poor land-use practices. Today, the stronghold for the species is surrounded by pasture lands, secondary growth, and agriculture. Many acres of farm and pasture lands, some of which are dusted aerially with pesticides and herbicides, surround the spring and serve as a significant portion of its watershed. Unless safe land-use practices are monitored and enforced in the Pryor Springs Complex and the Moss Spring and Beaverdam Creek watershed, one careless mistake might result in the loss of the only known native population of this species.

In the Pryor Springs Complex, where *E. alabamae* has been introduced from Moss Spring, the species appears to be reproducing with some success and has even spread its range to occupy new flooded and impounded areas formed by beaver dams on Pryor Springs Branch (T. S. Jandebeur, pers. comm., 8 December 1992). In the Moss Spring system *E. alabamae* is common. Darr and Hooper (1991) monitored this population to determine mortality and recruitment estimates. Their monitoring study indicated that *E. alabamae* was the most common fish species in the spring complex, the preferred habitat of the species included margins of the spring in submerged and surface vegetation, and that most reproduction occurred in March.

Given the restricted distribution of *E. alabamae* and its generally fragile life history, this species has been considered endangered by Ramsey et al. (1972), Ramsey and Mettee (1986), and Pierson (1990). An informal and renewable agreement has existed between landowners at Moss Spring and Beaverdam Swamp, U. S. Fish and Wildlife Service, and Alabama Department of Conservation and Natural Resources to continue to preserve the habitat quality for the spring pygmy sunfish. However, given the close proximity of both extant populations to local highways, livestock, and active agricultural practices, and their potential exposure to harmful levels of pesticides and herbicides, it would be advisable that this extremely rare species receive State and Federal protection as an endangered species and have populations monitored regularly. Furthermore, a more complete study of the biology and phylogenetic relationships of this species may provide a better understanding of the factors limiting the geographic range of this species. Likewise, a more thorough understanding of the genetic variation in *E. alabamae* is warranted before any additional transfers to new locations is conducted.

COMPARISONS.—Diagnosable characters for species of *Elassoma* are presented in Table 5. *Elassoma alabamae* differs from all other species of *Elassoma* in having only three dorsal fin spines, six or seven broad and dark bars along flanks separated by narrow and lightly colored interbars, 16–18 caudal peduncle scale rows, a single narrow, white to clear window in the dorsal and anal fins of males, and cream to white basicaudal ocelli bounded anteriorly, but not posteriorly, by a dark bar. Other species of *Elassoma* generally possess 4–5 dorsal fin spines, greater than 7 dark bars along flanks, narrower dark bars along flanks, more narrow and lightly colored interbars, 18–24 caudal peduncle scale rows, no white windows in dorsal and anal fins, and basicaudal ocelli bounded anteriorly and posteriorly by dark bars. *Elassoma alabamae* may be further separated from *E. zonatum*, geographically the closest congeneric, on the basis of coloration (Fig. 1, Table 5), meristic features (Fig. 3A, Tables 2–6), and body shape (Fig. 3B and C, Tables 1 and 6).

Elassoma alabamae differs significantly from *E. zonatum* with respect to all meristic variables ($P<0.0001$) (Tables 2–4), except for number of branchiostegal rays. Variation in all meristic variables for both species and both sexes is summarized in the principal component analysis of these variables (Fig. 3A, Table 6). The first principal component provides the best separation of *E. alabamae* and *E. zonatum*; variables loading heavily on this axis include number of bars and interbars along flanks, dorsal fin spines, anal fin rays, caudal peduncle scale rows, transverse scale rows, lateral scale rows, and gill rakers (Fig. 3A, Table 6). The second and third principal components provided no separation using meristic variables. Variability of mensural features for males and females of both species is summarized in sheared principal component analysis of these characters (Fig. 3B and C, Table 6). Males differ primarily in width of dark bars, head length, preanal and predorsal lengths, caudal peduncle depth, and length of the dorsal and pectoral fins; *Elassoma alabamae* possesses wider bars, a shorter head and preanal and predorsal length, a narrower caudal peduncle, and shorter dorsal and pectoral fins relative to *E. zonatum* (Fig. 3B, Tables 1 and 6). Females differ primarily in width of dark bars, head length, caudal peduncle depth, and length of fins; *E. alabamae* possesses wider bars, a shorter head, a narrower caudal peduncle, and shorter fins relative to *E. zonatum* (Fig. 3C, Tables 1 and 6).

Comparative Materials

The following specimens were employed in various aspects of comparisons with *Elassoma alabamae*. *Elassoma boehlkei*: ANSP 158482 (25 specimens), NCSM 12832 (61), NCSM 12833 (61). *Elassoma okatie*: ANSP 150053 (67), 158484 (71), NCSM 12834 (6), NCSM 12835 (3). *Elassoma okefenokee*: UAIC 8777.04 (28), UAIC 8833.03 (40), UAIC 8932.05 (15). *Elassoma evergladei*: UAIC 1226.08 (5), UAIC 1556.05 (28), UAIC 1559.08 (13), UAIC 4690.05 (3), UAIC 5277.04 (2). *Elassoma zonatum*: UAIC 44.03 (1), UAIC 1834.02 (42), UAIC 2027.01 (6), UAIC 2806.24 (11), UAIC 2854.01 (2), UAIC 3601.10 (1), UAIC 4210.05 (1), UAIC 4211.07 (2), UAIC 4212.13 (2), UAIC 4676.06 (2), UAIC 8334.09 (5), UAIC 8335.03 (3), UAIC 8403.02 (4), UAIC 9597.04 (3), UAIC 9640.08 (1), UAIC 10280.01 (28).

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A New Species of *Percina* (*Odontopholis*) from Kentucky and Tennessee with Comparisons to *Percina cymatotaenia* (Teleostei: Percidae)

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ABSTRACT: Burr, Brooks M. and Lawrence M. Page. 1993. A new species of *Percina* (*Odontopholis*) from Kentucky and Tennessee with comparisons to *Percina cymatotaenia* (Teleostei:Percidae). Bulletin Alabama Museum of Natural History, Number 16:15–28, 6 tables, 5 figures. A new species of *Percina* (*Odontopholis*) is described and compared with the bluestripe darter, *Percina* (*O.*) *cymatotaenia*, the only closely related and morphologically similar species. The new species differs from *P. cymatotaenia* by having usually 58–69 lateral-line scales (vs. 66–74 in *P. cymatotaenia*) and, on large males, two wide black bands in the first dorsal fin, a black bar on the throat, and a black suborbital bar (teardrop). *Odontopholis* is a particularly interesting taxon in that it appears to constitute the basal group within *Percina* and consists of two species with small, widely separated relictual ranges.

Introduction

The bluestripe darter, *Percina cymatotaenia*, until now the only described member of the subgenus *Odontopholis*, is endemic to the Osage and Gasconade rivers of southcentral Missouri. It has been described in detail and shown in color at least five times (Kuehne and Barbour, 1983; Page, 1983; Boschung et al., 1983; Pflieger, 1984; Johnson, 1987) and has been studied ecologically by Pflieger (1971, 1975, 1984) who provided detailed accounts of the species' distribution, life history, and conservation status.

The new species of *Odontopholis* described here, referred to in recent literature as the blackfin darter, *Percina* (*Odontopholis*) species, has been recognized as an undescribed species for at least 30 years. While this species is known principally to ichthyologists, it has been referred to more than 25 times in the literature since the subgenus *Odontopholis* was described (Page, 1974). The species has had its range mapped accurately at least seven times (Kuehne and Barbour, 1983; Page, 1983; Boschung et al., 1983; Wiley and Mayden, 1985; Burr and Page, 1986; Burr and Warren, 1986; Page and Burr, 1991), has been described in considerable detail three times (Branson and Batch, 1974; Clay, 1975; Kuehne and Barbour, 1983), has been diagnosed once (Page and Burr, 1991), has been shown in color four times (Kuehne and Barbour, 1983; Page, 1983; Johnson, 1987; Warren and Burr, 1988), and has had its conservation status considered six times (Branson, 1977; Starnes and Etnier, 1980; Branson et al., 1981; Burr and Warren, 1986; Johnson, 1987; Etnier and Starnes, 1991).

Undescribed species cause considerable confusion to natural resource agency personnel attempting to list and protect rare species (e.g., Williams et al., 1989), and we urge competent ichthyologists to publish descriptions of

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known but taxonomically undescribed North American fishes and to stabilize common names so that confusion over names will not continue to impede review and protection of rare fishes. *Odontopholis* is a particularly interesting subgenus and deserves attention for a number of reasons, not the least of which is that it appears to us to constitute the basal group within *Percina* and consists of two species with small, widely separated relictual ranges. Unfortunately, *P. cymatotaenia* has experienced a dramatic reduction in its historical range and now inhabits only 384 km of six streams: Big Piney River, Gasconade River, Roubidoux Creek, Osage Fork, Whetstone Creek, and Niangua River (Pflieger, 1984). The new species is more common but also is suffering from man-induced modifications of its environment and has disappeared from parts of its historical range.

We describe below the frecklebelly darter, *Percina stictogaster*, and compare it with the bluestripe darter, *Percina cymatotaenia*, the only closely related and morphologically similar species. The common name blackfin darter, used in the past for the new species, recently was applied to *Etheostoma* (*Catonotus*) *nigripinne* by Braasch and Mayden (1985).

Methods

Counts and measurements (dial calipers, nearest 0.1 mm) follow Hubbs and Lagler (1974) except as follows. Transverse scale rows were counted from anal fin origin to first dorsal fin. Body depth was measured at origin of first dorsal fin. Interorbital width was least fleshy width. Number of lateral blotches was from opercle to caudal fin base. Cephalic lateralis pore counts follow Hubbs and Cannon (1935). Unless otherwise indicated, lengths are standard lengths (SL).

Color notes were taken from freshly captured specimens and from color transparencies of living or freshly preserved specimens. Sex was determined by color pattern, presence of a caudal keel, or by examination of gonads. Means of morphometric variables were tested for sexual dimorphism within three populations (Gasconade River, Kentucky River, Green River) using a Student's T-test. Variable means and modes were examined for geographic variation. When significant variation was absent, samples were successively amalgamated into major drainages.

Truss-geometric protocol (Strauss and Bookstein, 1982; Bookstein et al., 1985) was used in part to archive body form and included 27 measurements distributed among three sagittal truss cells with appended posterior and anterior triangles. One additional measurement (body depth) was included in the morphometric analysis. Principal components were factored from the covariance matrix of log-transformed morphometric characters following recommendations of Bookstein et al. (1985). Multivariate analysis of the morphometric data was accomplished using sheared principal components analysis (PCA) (Humphries et al., 1981; Bookstein et al., 1985) to eliminate overall size effects. Because of observed sexual dimorphism, males and females were subjected separately to sheared PCA. Multivariate analyses were conducted on the SIUC mainframe computer using programs available in the Statistical Analysis System (SAS Institute Inc., 1982) and as modified by David L. Swofford.

The synonymy for the frecklebelly darter includes all references known to us; that for *P. cymatotaenia* is skeletal including those references that contain substantial biological or systematic information. Most references to the frecklebelly darter mention *P. cymatotaenia*. Symbolic codes for fish collections follow those recommended by Leviton et al. (1985) and Leviton and Gibbs (1988), except that WLP and KDFWR refer to collections of William L. Pflieger of the Missouri Department of Conservation and the Kentucky Department of Fish and Wildlife Resources, respectively.

Percina cymatotaenia (Gilbert and Meek)
Bluestripe Darter
Figure 1

Etheostoma (*Hadropterus*) *cymatotaenia* Gilbert and Meek in Gilbert, 1887:51–52 (original description; types from Niangua River, Osage Fork of Gasconade River near Marshfield, and Sac River near Greenfield). Meek, 1891:123–125 (Osage Fork, Little Piney Creek, Maries River).

Hypohomus cymatotaenia: Jordan and Evermann, 1896b: 1041–1042 (description; range; synonymy).

Percina (*Hypohomus*) *cymatotaenia*: Bailey and Gosline, 1955:12, 35 (vertebral counts 43–45). Collette, 1965:575–576 (male with well-developed caudal keel, 26 August). Collette and Knapp, 1966:26 (lectotype selection; counts; location of types; figure).

Percina cymatotaenia: Pflieger, 1971:233, 237, 422–423, 541 (history; reference to types; synonymy; distribution; habitat; zoogeography). Miller, 1972:245, 248 (threatened in Missouri). Pflieger, 1975:282, 298–299 (in key; characters; distribution; habitat; life history; close relative in uplands of Kentucky). Deacon et al., 1979:40 (threatened in Missouri). Stauffer, 1980:723 (range; habitat; figure). Williams, 1981:334 (threatened in Missouri). Boschung et al., 1983:579, color plates 235–236 (description; habitat; range; figures). Ono et al., 1983:241 (threatened by habitat alteration in Missouri). Pflieger, 1984:1–22 (distribution; conservation status; life history; color figures). Johnson, 1987:25, color plate 11.2 (special concern). Williams et al., 1989:12, 14 (status changed from threatened to special concern). Page and Burr, 1991:276–277, map 313 (diagnosis; range map; habitat; comparisons).

Etheostoma cymatotaenia: Collette and Bănărescu, 1977:1454 (type of subgenus *Odontopholis*).

Figure 1. Lateral views of *Percina cymatotaenia* and *P. stictogaster*. Above, *Percina cymatotaenia*, Big Piney River, Texas County, Missouri, March1982, length unknown (photo by William L. Pflieger). Middle, *Percina stictogaster*, Red Bird River, Clay County, Kentucky, 28 April 1985, length unknown (photo by William N. Roston). Below, holotype of *Percina stictogaster* (photo by B. M. Burr).

LECTOTYPE.—Collette and Knapp (1966:26) designated a lectotype: USNM 36215, an adult male 68 mm SL, Niangua R., [Missouri R. drainage], near Marshfield, Missouri, taken during summer 1884 by C. H. Gilbert and S. E. Meek. The lectotype is figured in Collette and Knapp (1966:26).

PARALECTOTYPES.—USNM 198090, adult male 63 mm SL, removed from USNM 36215; USNM 36260, two males, 63–68 mm SL, Osage Fork of Gasconade River [Missouri River drainage], near Marshfield, Missouri, summer 1884, C. H. Gilbert and S. E. Meek; USNM 36308, five specimens, 40–44 mm SL, Sac River [Missouri River drainage], near Greenfield, Missouri, summer 1884, C. H. Gilbert and S. E. Meek; SU 2603, four specimens, 39–54 mm SL, same data as USNM 36308 (Collette and Knapp, 1966).

According to Collette and Knapp (1966) "additional syntypes from SU 3949, with the same data as USNM 36215, became mixed with nontype specimens from Kentucky, collected by A. J. Woolman as a result of the 1906 earthquake."

DESCRIPTION.—Descriptions of *P. cymatotaenia* appear in Pflieger (1975, 1984), Boschung et al. (1983), Kuehne and Barbour (1983), Page (1983), and Page and Burr (1991). The only substantial information to be added to these descriptions is that large males from March collections (WLP 80-6, WLP 80-1) have white capped horny scales, which may function as breeding tubercles on their lower sides and thickened ridges on the anal fin rays. *Percina cymatotaenia* is contrasted with *P. stictogaster* below.

GEOGRAPHIC VARIATION.—*Percina cymatotaenia* shows little geographic variation; however, individuals from the Osage River system have modally fewer lateral-line scales (Table 1) than individuals from the Gasconade River.

DISTRIBUTION.—*Percina cymatotaenia* occupies the Gasconade and Osage River systems, both of which are tributaries of the Missouri River in southcentral Missouri (Fig. 2). A collection consisting of one very old (no specific date) specimen (MCZ 24639), labeled "Arkansas, Geo. Stolley" presumably is mislabeled. Many subsequent collections from Arkansas have failed to produce specimens of *P. cymatotaenia* (Robison and Buchanan, 1990).

MATERIALS EXAMINED.—Numbers in parentheses are numbers of specimens. **MISSOURI.** ***Gasconade River System:*** AUM 13226 (6), Big Piney River, 16 km NW Licking, Texas Co., 21 December 1971. INHS 27450 (2), Gasconade River, Hazelgreen, Laclede Co., 13 August 1979. INHS 27885 (1), Gasconade River, 0.8 km W Hazelgreen, Laclede Co., 11 October 1970. INHS 27886 (1), Gasconade Rover, 1.6 km W Hazelgreen, Pulaski Co., 11 October 1970. INHS 64991 (6 of 10), Gasconade River, 1.6 km SE Hazelgreen, Pulaski Co., 4 September 1971. INHS 75290 (10 of 20), Gasconade River, 2 km SE Hazelgreen, Pulaski Co., 18 July 1970. INHS 76694 (1), Gasconade River, 6.4 km SE Hazelgreen, Pulaski Co., 21 May 1977. INHS 79418 (2), Gasconade River, 1.6 km W Hazelgreen, Pulaski Co., 24 April 1978. INHS 81760 (3), Gasconade River, 0.8 km W Hazelgreen, Laclede Co., 10 September 1967. KU 7979 (1), Osage Fork Gasconade River, T31N, R17W, Sec. 2, Webster Co., 2 August1962. KU 9900 (1), Gasconade River, 8 km SW Crooker, Pulaski Co., 14 November 1964. KU 19126 (1), Roubidoux Creek, T33N, R12W, Sec. 15, Texas Co., 27 June 1979. KU 19127 (1), Roubidoux Creek, T33N, R12W, Sec. 15, Texas Co., 13 August 1980. KU 19131 (1), Roubidoux Creek, T33N, R12W, Sec. 15, Texas Co., 28 June 1979. KU 19132 (1), Roubidoux Creek, T33N, R12W, Sec. 10, Texas Co., 27 April 1981. KU 19162 (1), Roubidoux Creek, T33N, R12W, Sec. 15, Texas Co., 11 March 1979. KU 20837 (1), Roubidoux Creek, T33N, R12W, Sec. 10, Texas Co., 8 October 1983. USNM Creek (1), Osage Fork Gasconade River, Marshfield, 1889. SIUC 11858 (2), Gasconade River at Rt. E Crossing, Wright Co., 13 April 1985. USNM 42536 (1), Little Piney River, Newburg, 1889. USNM 42564 (1), Osage Fork Gasconade River, Marshfield, 1889. WLP 80-1 (7), Roubidoux Creek

Table 1. Frequency distributions of lateral-line scales in species of *Odontopholis*. Value for holotype is in boldface.

	Number of scales																													
Species and Drainage	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	N	$\bar{x}$	SD
Percina stictogaster																												
Kentucky R.	1	–	2	1	3	9	18	12	**18**	7	8	2	3	1	–	2										87	61.5	2.58
Green R.					2	1	3	2	6	8	7	7	9	11	6	4	1	1								68	64.9	2.90
Percina cymatotaenia																												
Gasconade R.												1	2	4	4	6	3	9	5	9	6	–	3	1	4	57	71.5	3.27
Osage R.												1	6	–	–	4	1	–	–	1						13	67.7	2.32

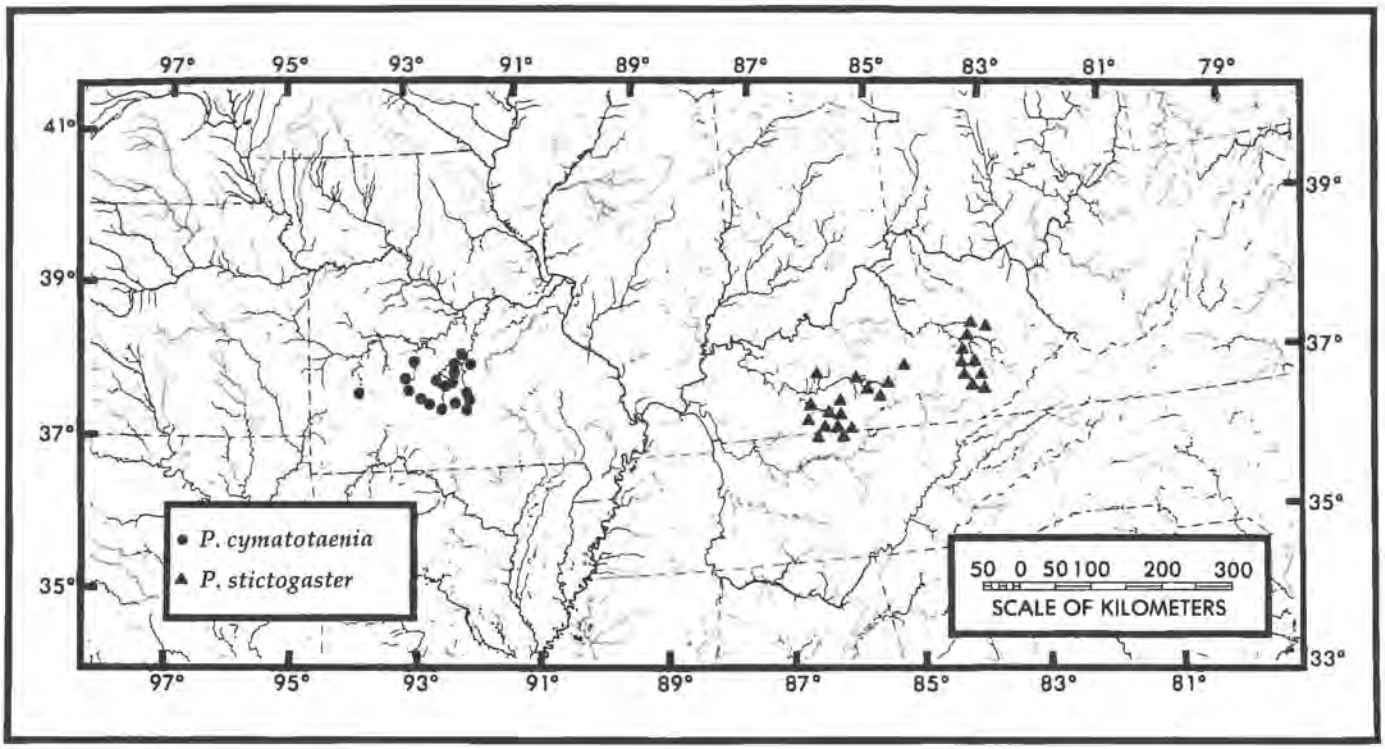

Figure 2. Geographic range of *Odontopholis* as represented by material examined and records from Pflieger (1971, 1975, 1984) and Burr and Warren (1986).

at Hwy. 17 just above Ft. Leonardwood, Texas Co., 24 March 1980. WLP 80-6 (7), Whetstone Creek, above Hwy. 38, 11.2 km NE Hartville, Wright Co., 25 March 1980. ***Osage River System:*** INHS 28528 (3), Niangua River, 0.4 km E Celt, Dallas Co., 4 October 1961. INHS 28529 (7), Niangua River, 3.2 km SW Windyville, Dallas Co., 24 February 1977. INHS 28530 (1), Niangua River, 6 km N Charity, Dallas Co., 24 March 1981. SU 2603 (4), Sac River, 1884. UF 43614 (1), Niangua River at Moon Valley Ford, Dallas Co., 15 May 1968.

Percina stictogaster, new species
Frecklebelly Darter
Figure 1

Etheostoma cymatotaenia: Woolman, 1892:260, 288 (localities in upper Green River, Kentucky; some counts and measurements). Garman, 1894:42 (Green River). Boulenger, 1895:67 (western Kentucky included in range).

Hypohomus cymatotaenia: Jordan and Evermann, 1896a:359 (western Kentucky included in range). Jordan and Evermann, 1896b:1042 (western Kentucky included in range). Evermann, 1918:355, 367 (Green River records of Woolman repeated).

Percina cymatotaenia: Eddy, 1957:203 (western Kentucky included in range). Murphy ,1964:72 (Green River, Kentucky). Zorach, 1968:481 (species associate of *Etheostoma bellum* in Goose Creek, Kentucky). Eddy, 1969:230 (western Kentucky included in range). Pflieger, 1971:423, 541 (western Kentucky included in range). Branson and Batch, 1974:32–34, 45, 60–62 (brief description; habitat, localities in Red River, Kentucky; comparison to Missouri material; erroneously recorded from Paducah, Kentucky). Clay, 1975:295, 299–301, 405 (figure; description; in key; range [including Missouri and Arkansas]; records for Kentucky and Tennessee). Branson, 1977:71 (Kentucky range; misidentified *Percina sciera* from Big Sandy and Licking rivers and Obion Creek as *Percina cymatotaenia*). Eddy and Underhill, 1978:172 (western Kentucky included in range). Dixon et al., 1983:115 (occupies stream orders 3–5 in upper Kentucky River). Kuehne and Barbour, 1983:11, 26, 45–46, color plate 4 (in key; description; range mapped; natural history; abundance).

Percina (*Hypohomus*) species: Collette, 1965:575, 576 (males apparently lack breeding tubercles; description of caudal keel scales of three males from Green River, Kentucky, 5 April). Kuehne and Small, 1971:26 (species associate of *Etheostoma barbouri* in Brush Creek, Kentucky).

Undescribed form related to *Percina cymatotaenia*: Jenkins et al., 1972:95 (Green River drainage and Red River system of Kentucky River drainage).

Percina (*Odontopholis*) species: Page, 1974:66–84 (unde-

scribed form; in phenograms; phenetically closest to *P. cymatotaenia*; original description of subgenus). Jenkins, 1976:644 (in list of undescribed freshwater fishes of the continental U.S. and Canada). Page, 1976:257, 259, 261 (undescribed species in Kentucky; lacks midbelly row of modified scales). Starnes and Etnier,1980:B113–B114 (description; range; ecology; management factors). Page, 1981:6, 7,1 2, 46, 51, 56, 61, 66 (in cladograms or phenograms as closest relative or most similar species to *P. cymatotaenia*). Branson et al., 1981:82 (special concern in Kentucky). Page and Burr, 1982:9 (occurrence in upper Kentucky and Green River drainages, Kentucky). Stauffer et al., 1982:46 (in list for Kentucky and Green rivers). Page, 1983:43, 185, color plate 5C, map 14 (figure; range map; zoogeography). Burr and Page, 1986:296, 298, 313 (range map; closest relative is *P. cymatotaenia*; zoogeography of *Odontopholis* clade). Hocutt et al., 1986:192 (paired with *P. cymatotaenia*; zoogeography). Etnier and Starnes, 1991:129 (in need of protected status in Tennessee).

Percina species Undescribed: Burr, 1980:80 (long known under the name *P. cymatotaenia* but is undescribed; Kentucky range). Burr and Warren, 1986:344, 357, 359, 379 (Kentucky distribution mapped; subgenus *Odontopholis*; habitat; conservation status; zoogeography; total range mapped).

Percina sp. (*melanoptera*): Bell and Hoyt, 1980:38 (nomen nudum; Middle Fork Drakes Creek, Kentucky).

Percina (*Odontopholis*) species n. sp. cf. *cymatotaenia*: Branson and Batch, 1983:14 (Kentucky River records; mature adults taken 14 March; habitat). Branson and Batch, 1984:9 (special concern; Sturgeon Creek, Kentucky).

Undescribed species in Kentucky: Pflieger, 1984:2 (only other member of subgenus *Odontopholis*). Mayden, 1985:203 (*P. cymatotaenia* is sister taxon).

Percina sp. cf. *cymatotaenia*: Wiley and Mayden, 1985:611, 622 (range map; *Odontopholis* is example of clade possibly conforming to Pleistocene origin hypothesis). Mayden, 1987:217 (occurs in Ohio River, Kentucky; *Odontopholis* clade has suffered from extinction).

Percina sp.: Cross et al., 1986:401 (sister species is *P. cymatotaenia*; range in Kentucky and Green rivers, Kentucky).

Percina (*Odontophiles*) sp.: Meade et al., 1986:124 (misspelling; Red River, Kentucky).

Blackfin darter, *Percina* sp.: Johnson, 1987:26, 30, color plate 11.6 (special concern in Kentucky and Tennessee).

Blackfin darter: Warren and Burr ,1988:14–16, color plate (Kentucky range map; closest relative is in Missouri).

Frecklebelly darter, *Percina* species: Page and Burr, 1991:277, map 313 (diagnosis; range map; habitat; comparisons).

Holotype.—Illinois Natural History Survey (INHS 28535), an adult male 61.1 mm SL collected in Red Bird River, tributary of South Fork Kentucky River, at mouth of Jack's Creek, along Hwy. 66, at Eriline (Lat: 37° 11' 28"; Long: 83° 35' 31"), Clay County, Kentucky, on 13 November 1992 by B. M. Burr and R. R. Cicerello.

Paratopotypes.—INHS 64304 (16; 33.6–57.3 mm SL), 23 August 1988. SIUC 652 (2; 41.6–45.1), 28 May 1981. SIUC 677 (1; 56.2), 28 October 1980. UAIC 6750.12 (2; 38.6–43.6), 13 March 1983. UAIC 10470.01 (3; 41.0–64.0), 25 September 1992. USNM 231070 (3; 37.3–43.3), 13 May 1969. KU 23130 (2; 51.8–54.7), ex. INHS 64304.

Nontype Materials Used for Counts and Measurements.—Numbers in parentheses are numbers of specimens. **KENTUCKY**. ***Kentucky River System***: ANSP 147538 (1), Red River at Hwy. 77 bridge, Powell/Menifee Co., 24 April 1981. INHS 78977 (1), Red River, 19.2 km N Pine Ridge, Wolfe Co., April 1967. INHS 79030 (10), Red Bird River, mouth Jack's Creek, Clay Co., 22 March 1978. INHS 79097 (3), South Fork Station Camp Creek, Hwy. 89 bridge, Jackson Co., 23 March 1978. INHS 79198 (10), Sexton Creek, 1.6 km E Sexton Creek, Clay Co., 22 March 1978. INHS 79886 (5), Station Camp Creek, 4.8 km SE Wagersville, Estill Co., 23 March 1978. INHS 87429 (1), Red River, 1.6 km NE Nada, Powell Co., 27 May 1981. KDFWR 1805 (2), Big Goose Creek, 0.8 km below Island Creek, Clay Co., 11 October 1972. KU 13188 (3), Red River, below Sky Bridge, Powell Co., 1 July 1967. SIUC 6731 (3), Goose Creek at Lipps, Clay Co., 17 October 1978. SIUC 6824 (3), Sturgeon Creek, at Ky. 587 bridge, Lee Co., 19 October 1978. SIUC 6962 (1), Buck Creek, 0.8 km E on Buck Creek Rd. from jct. with Ky. 847, Owsley Co., 3 July 1978. SIUC 11510 (4), Station Camp Creek, 3.2 km NW Ky. 1209 & Hwy. 58 jct., Jackson Co., 7 June 1982. SIUC 12031 (8), Station Camp Creek, 2 km N Alumbaugh, Estill Co., 17 June 1982. SIUC 12444 (2), Right Fork Chimney Top Creek, 100 m above confluence with Chimney Top Creek, Wolfe Co., 5 July 1985. SIUC 12453 (2), Indian Creek, 100 m above confluence with Leatherwood Creek, Menifee Co., 5 August 1985. SIUC 12456 (2), Leatherwood Fork of Indian Creek, below confluence with Smallwood Branch, Menifee Co., 31 July 1985. SIUC 12459 (2), Chimney Top Creek, ca. 100 m above Rough Trail 221, Wolfe Co., 5 July 1985. SIUC 12480 (2), Salt Fork, 100 m above confluence with Gladie Creek, Menifee Co., 3 July 1985. UAIC 6493.14 (10), Little Sexton Creek, 2 km E Sexton Creek, Clay Co., 9 March 1982. UAIC 6773.11 (4), Little Sexton Creek, 2 km E Sexton Creek, Clay Co., 13 March 1983. USNM 231069 (3), Red Bird River, at Hwy. 66, Leslie Co., 13 May 1969. USNM 231175 (10), Red River, at Ky. 715, Powell Co., 20 May 1970. ***Green River System***: AUM 11856 (1), Drakes Creek, 11.2 km SE Bowling Green, Warren Co., February 1968. INHS 74866 (1), Long Creek, 11.2 km S Scottsville, Allen Co., 29 January 1965. INHS 76642 (4), East Fork Barren River.

Table 2. Proportional measurements of species and drainage populations of *Odontopholis*, expressed in thousandths of SL. Ratios differing significantly (in all three populations) between the sexes at p = < 0.05 level are indicated as M for male and F for female. Note that there is no significant difference between the sexes in *P. cymatotaenia* for pectoral fin length (i.e., the value for the sexes combined is listed for "pectoral fin length, M").

	Percina stictogaster				*Percina cymatotaenia*	
	Kentucky River (N = 30; 16 M, 14 F)		Green River (N = 30; 15 M, 15 F)		Gasconade River (N = 24; 9 M, 15 F)	
Measurement	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
Standard length	51.7–67.5	57.5	50.2–73.1	61.5	55.5–69.0	61.5
Predorsal length	333–390	362	348–390	361	335–365	353
Head length	251–293	267	244–285	267	240–272	260
Head width	118–184	148	110–158	138	114–166	138
Interorbital width	41–69	49	35–55	47	42–60	50
Snout length	49–77	60	53–74	63	55–70	62
Eye length	54–73	63	51–69	59	50–62	55
Body depth	180–237	207	179–227	202	180–233	205
Body width	112–152	129	110–150	126	97–159	129
Caudal peduncle depth	90–136	96	75–123	94	71–113	84
Caudal fin length	138–181	159	127–178	152	133–154	143
Pelvic fin length	184–219	201	164–219	192	162–207	188
First dorsal fin base length	223–325	268	216–333	264	209–303	262
Second dorsal fin base length	145–205	169	119–276	171	139–177	158
Pectoral fin length, M	214–257	228	192–245	218	159–213	190
Pectoral fin length, F	196–227	214	169–224	198		
Anal fin length, M	219–280	234	179–252	223	230–285	258
Anal fin length, F	193–232	212	156–229	195	195–228	208
Second dorsal fin length, M	194–244	225	162–222	188	200–262	239
Second dorsal fin length, F	160–237	182	142–203	172	155–198	180
Anal fin base length, M	141–181	164	148–196	164	159–172	165
Anal fin base length, F	119–180	147	96–166	141	123–151	138

Monroe Co., 11 July 1961. INHS 76784 (10), Long Creek, 4.8 km downstream from Tennessee line, Allen Co., 12 July 1961. INHS 76997 (2), Salt Lick Creek, Monroe Co., 23 May 1961. KDFWR 1290 (2), Salt Lick Creek, 0.8 km above jct. with Long Hungry Creek, Monroe Co., 23 May 1961. KDFWR 1330 (6 of 16), Line Creek on Hwy. 37, Monroe Co., 24 May 1961. KDFWR 1419 (4), East Fork Barren River, Monroe Co., 11 July 1961. KDFWR 1603 (1), Peter Creek, 3.2 km W Peter Creek, Barren Co., 13 September 1961. KDFWR 1669 (2), Green River at old bridge on Ky. 55, Green Co., 17 October 1961. KDFWR 1779 (10 of 12), Difficult Creek, Allen Co., 21 August 1963. KDFWR 1852 (2 of 13), Green River at Ruperts Ford, 0.2 km below mouth of Allen Creek, Casey Co., 11 September 1962. SIUC 57 (1), Trammel Creek, 3.2 km SW Halfway, Allen Co., 25 May 1981. SIUC 10173 (4), Trammel Creek, 1.6 km NE Red Hill, Allen Co., 21 July 1984. SIUC 11070 (12), Trammel Creek, 2 km upstream from Drakes Creek confluence, Warren Co., 16 July 1982. SIUC 16306 (1), Russell Creek at White Oak Church crossing, Adair Co., 18 March 1988. SU 68335 (1), Green River, Greensburg, Green Co., no date. UAIC 6497.07 (1), Long Creek, 8.2 km SSE Scottsville, Allen Co., 11 March 1982. UAIC 7968.21 (3), Trammel Fork, 1.6 km NNE Red Hill, Allen Co., 4 October 1987. UAIC 8413.20 (1), same locality as UAIC 7968.21, 21 June 1988. UL 6380 (2), Green River, Casey Co., 19 October 1953. UL 12823 (1), West Fork Drakes Creek, Simpson Co., 8 November 1964. USNM 163063 (1), trib., Green River, 9.6 km NE Liberty, Casey Co., 25 April 1952. USNM 163064 (1), trib., Green River, 7.2 km SSW Liberty, Casey Co., 25 April 1952. USNM 208592 (2), Trammel Creek, 2.4 km above mouth, Warren Co., 21 August 1964. USNM 211275 (1), trib., Green River, 6 km NE Creston, Casey Co., 12 June 1965. USNM 211276 (1), trib., Green River, N Yosemite, Casey Co., 22 April 1957. USNM 211277 (1), Goose Creek, Dunnville, Casey Co., 26 April 1957. **TENNESSEE.** ***Green River System:*** KDFWR 1130 (2), Salt Lick Creek at Rose Bottom, Macon Co., 18 June 1959. KDFWR 1271 (3), White Oak Creek at bridge between White Oak and Galen, Macon Co., 23 May 1961.

Materials Examined But Not Used For Counts Or Measurements.—Complete collection locality data are available from the authors. **KENTUCKY.** ***Kentucky River System:*** INHS 28496 (5), 64334 (8), 79086 (5). KDFWR 1801 (7). SIUC 2094 (11), 7801 (2), 7817 (2), 8484 (3), 10095 (3),

15989 (4), 20362 (2), 20377 (1), 20393 (1), 20404 (4), 20426 (1), 20447 (5), 20457 (1), 20478 (1), 20492 (1). USNM 231065 (3). ***Green River System***: INHS 59096 (1). KDFWR 1250 (5), 1419 (4), 1669 (2), 1736 (5), 1847 (9), 1900 (6). SIUC 18204 (1), 18339 (9).

Diagnosis.—Member of subgenus *Odontopholis* as diagnosed by Page (1974). Distinguished from *P. cymatotaenia*, the only other member of the subgenus, by having two wide black bands (one distal, one medial) in first dorsal fin of large male (best developed in breeding male); black bar on throat of large male; black suborbital bar (teardrop), sometimes broken into 2–3 black specks; usually 58–69 lateral-line scales.

Description.—Body proportions are given in Table 2 and shown in Figure 1. A slender darter with slightly pointed snout and terminal mouth. Cheek fully scaled; some scales may be partly embedded; opercle, nape, and prepectoral area fully scaled. Breast scaled except along anterior margin, scales vary from small and embedded to relatively large and exposed; 1–3 (modally 2) modified (enlarged and strongly toothed) scales between pelvic fins. Belly usually fully scaled; scales may be missing just posterior to pelvic fins. Lack modified scales found on midline of belly of other *Percina* (Page, 1976), but large male may have a few enlarged scales immediately anterior to anus. The largest males examined from the Kentucky and Green River systems measured 70.6 mm and 73.1 mm, respectively; the largest females, 59.5 mm and 68.5 mm.

Lateral line complete, 54–71 (usually 58–69, Table 1) pored scales (rarely 1–2 scales unpored); 15–21 (usually 17–18, Table 3) transverse scale rows; 6 (11 specimens), 7 (104), 8 (40), $\bar{x}$ = 7.2, SD = .54, scale rows above lateral line; 8 (15), 9 (62), 10 (42), 11 (13), 12 (2), $\bar{x}$ = 9.5, SD = .87, scale rows below lateral line; 18–26 (usually 20–24, Table 3) caudal peduncle scales rows. Dorsal fin spines 11–15 (usually 13–14, Table 4); 11–14 (usually 12–3, Table 4) dorsal fin rays. Anal fin spines 2; 8–11 (usually 9–10, Table 5) anal fin rays; 11–13 (Table 5) pectoral fin rays. Branched caudal fin rays 12 (3), 13 (75), 14 (5), 15 (1), $\bar{x}$ = 13.1, SD = .38; 6–6 branchiostegal rays. Gill rakers on first arch 12 (1), 13 (21), 14 (24), 15 (23), 16 (3), 17 (3), $\bar{x}$ = 14.2, SD = 1.07. Cephalic lateralis system without interruptions; infraorbital canal pores 7 (4), 8 (78), 9 (17), $\bar{x}$ = 8.1, SD = .44; preoperculomandibular pores 9 (9), 10 (80), 11 (2), $\bar{x}$ = 9.9, SD = .34.

Pigmentation. In life (Fig. 1), a broad scallop-edged black stripe along midside followed by round to wedge-shaped, black basicaudal spot, latter flanked above and below by cream-colored areas. Lateral line runs through black stripe as thin cream-colored line. Above black stripe is broad brown stripe, subtended by thin cream-colored stripe. Black stripe along midside sometimes broken into series of large rectangular or round blotches numbering 8 (39), 9 (44), or 10 (19); brown stripe may be interrupted by thin black stripe extending from head to below second dorsal fin. Along middorsum a black stripe extends from head to second dorsal fin or beyond; expansions of stripe may form vague dorsal saddles. Additional interrupted, thin, cream-colored vermiculations may be found to either side of black middorsal stripe. Preorbital bars connect on tip of snout; a postorbital bar joins with midside stripe; subor-

Table 3. Frequency distributions of transverse scale rows and scale rows around caudal peduncle in species of *Odontopholis*. Values for holotype are in boldface.

	Number of Transverse Scale Rows									
Species and Drainage	15	16	17	18	19	20	21	N	$\bar{x}$	SD
Percina stictogaster										
Kentucky R.		5	**44**	29	6	1	2	87	17.5	0.93
Green R.	2	7	22	21	12	3		67	17.6	1.12
Percina cymatotaenia										
Gasconade R.		1	3	16	20	11	3	54	18.9	1.05
Osage R.			5	5	3		13	18.9	0.80	

	Number of Scale Rows Around Caudal Peduncle											
Species and Drainage	18	19	20	21	22	23	24	25	26	N	$\bar{x}$	SD
Percina stictogaster												
Kentucky R.	1	–	**15**	29	24	15	4			88	21.6	1.16
Green R.			1	11	9	23	17	6	1	68	22.9	1.29
Percina cymatotaenia												
Gasconade R.			1	1	10	16	17	8	4	57	23.5	1.28
Osage R.					2	4	5	1	1	13	23.6	1.12

Table 4. Frequency distributions of dorsal spines and rays in species of *Odontopholis*. Values for holotype are in boldface.

Species and Drainage	Number of Spines 11	12	13	14	15	N	$\bar{x}$	SD
Percina stictogaster								
Kentucky R.	3	11	47	**23**	4	88	13.2	0.83
Green R.		4	28	31	3	66	13.5	0.69
Percina cymatotaenia								
Gasconade R.	2	25	22	8		57	12.6	0.77
Osage R.		3	6	4		13	13.1	0.76

Species and Drainage	Number of Rays 11	12	13	14	N	$\bar{x}$	SD
Percina stictogaster							
Kentucky R.	13	**59**	16		88	12.0	0.58
Green R.	3	40	22	1	66	12.3	0.59
Percina cymatotaenia							
Gasconade R.	5	16	26	10	57	12.7	0.86
Osage R.		4	9		13	12.7	0.48

bital bar sometimes broken into black specks. Top of head mostly black or brown except for cream-colored spot on top of snout. Belly, breast, lower caudal peduncle, and underside of head white to cream-colored and heavily speckled with large black spots. First dorsal fin of male has black distal and medial bands, of female has rows of black spots. Other fins have concentric rows of small black spots.

The breeding male, though not as brightly colored as many species of darters, is striking, developing intense black bands in first dorsal fin, black bar on throat, black suborbital bar, and large keel at anterior lower margin of caudal fin. Black stripe on side separates into series of distinct round to rectangular blotches; many black spots on underside of body become obscured by thickened flesh. Iris of eye orange. Black stripe or blotches along flanks develop greenish sheen in life nearly identical to that shown for *P. cymatotaenia* (Fig. 1). Color of breeding female similar but lacks intense black bands in first dorsal fin (a gray subdistal band often is present) and black bar on throat.

SEXUAL DIMORPHISM.—Sexual dichromatism is discussed above. Males develop significantly longer pectoral, second dorsal, and anal fins than do females (Table 2), and the base length of the anal fin of males is longer than in females. The anal fin of the adult male is extremely long

Figure 3. Caudal keel of a sexually mature male *Percina stictogaster* (UAIC 6497.07).

and reaches to the caudal keel. The caudal keel, best developed during the breeding season, is located on the ventral side of the caudal peduncle and is an extension of the lower caudal peduncle and caudal fin (Fig. 3; see also Page, 1976; Pflieger, 1984). It is covered with large, strongly-toothed scales that presumably serve to provide tactile stimulation to females during spawning in much the same way as do tubercles in other fishes. Females do not develop a caudal keel. The male genital papilla is a short triangular flap, grooved at its tip; that of the female is short, somewhat round or square, flattened, grooved, and sometimes bilobed at its tip. Males from March collections (INHS 79198, 79030) have thickened scales on the venter from the posterior part of the breast to the caudal keel; these white-capped, horny scales may function as breeding tubercles. Starnes and Etnier (1980) report "tuberculate males" from April and May.

GEOGRAPHIC VARIATION.—The most substantial geographic variation in morphology is a difference in scale size between Green and Kentucky River populations. Individuals from Green River have smaller scales, which is most evident in counts of lateral-line scales (Table 1) and scale rows around the caudal peduncle (Table 3). Body measurements among females show considerable overlap between the two drainage populations when expressed as ratios (Table 2) and when in sheared principal component space (Fig. 4).

COMPARISONS.—*Percina cymatotaenia* has no wide black medial band and only a narrow distal band in the first dorsal fin, no black blotch or black bar on throat, no suborbital bar, and usually 66–74 lateral-line scales (Table 1). Other differences in meristic counts of the two species are shown in Tables 3, 4, and 5. In addition to the trenchant characters distinguishing the species of *Odontopholis* (see Diagnosis), some mensural features (Table 2) are useful in characterizing the two species. When compared to *Percina cymatotaenia*, *P. stictogaster* has a longer head, larger eye,

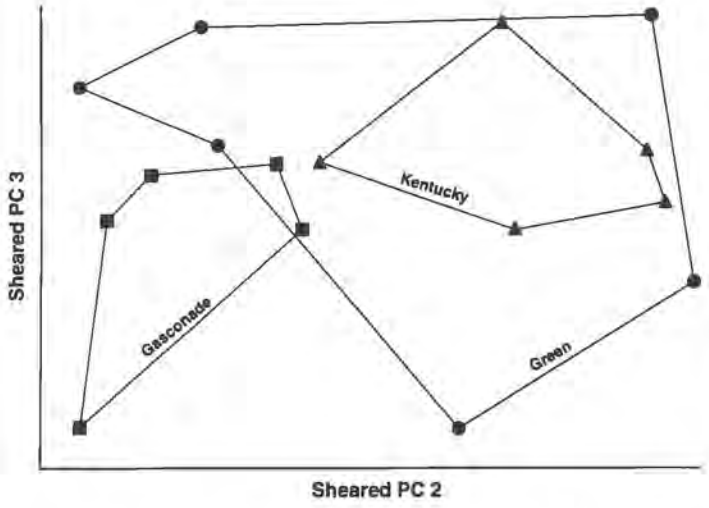

Figure 4. Morphometric scores on sheared PCA axes 2 and 3 for females of *Odontopholis* from three river systems, with polygons bounding river systems.

longer predorsal length, and a deeper caudal peduncle. Relative lengths of the fins vary considerably between males of the two species with *P. cymatotaenia* generally having longer anal and second dorsal fins, and *P. stictogaster* generally having longer pectoral, caudal, and second dorsal fin base lengths. Adults of *P. cymatotaenia* appear to be more slender than those of *P. stictogaster.*

A sheared principal component analysis of morphometric variables revealed that females of *P. stictogaster* are nearly separable from females of *P. cymatotaenia* (Fig. 4). When males only were compared and when males and females together were compared, significant overlap among populations was obtained. Variables loading most heavily on sheared PC-2 were head length, interorbital width, anal fin base length, and caudal peduncle width. On sheared PC-3 were distance from tip of snout to branchiostegal junction, caudal peduncle width, pectoral fin length, and head length (Table 6).

ETYMOLOGY.—The specific epithet, *stictogaster,* is in reference to the "punctured, dappled, [or] spotted" (Brown, 1956) belly. The common name, frecklebelly darter, is in reference to the numerous black specks and blotches on the belly of all individuals except breeding males.

DISTRIBUTION.—*Percina stictogaster* occupies the upper Green, upper Barren (a tributary of Green River), and upper Kentucky River systems of Kentucky and Tennessee (Fig. 2). It is found primarily in upland streams of the Cumberland Plateau and central portions of the Highland Rim. This is the only fish species known to be exclusively shared by the Kentucky and Green River systems. In the Kentucky River system, it is found only from Red River upstream and including the South Fork. No records are available from either the North or Middle forks of the Kentucky River system. In the Green River it occurs primarily upstream of the confluence of the Little Barren and Green rivers; in the Barren River it is most common upstream of the confluence of Drakes Creek and the Barren River. In Tennessee, it is restricted to large tributaries of the Barren River system in Clay, Macon, and Sumner counties (Starnes and Etnier, 1980). One early record (mid-1800s, probably 1870s; 1 specimen; MCZ 50781) is from Rock Creek (Nolin River drainage), Grayson Spring, Kentucky; the species no longer occurs in the Nolin River system. The report of this species (as *P. cymatotaenia*) from Obion Creek in western Kentucky (Smith and Sisk, 1969), creeks near Paducah, Kentucky (Branson and Batch, 1974), and the Big Sandy and Licking River drainages, Kentucky (Branson, 1977), are all based on misidentified specimens of *Percina sciera.*

HABITAT AND NATURAL HISTORY.—*Percina stictogaster* generally inhabits clear, rocky, flowing pools, backwater pools, or vegetated riffle margins of creeks and small rivers (usually stream orders 3–5). The species often is found near beds of water willow (*Justicia*), tree roots, woody debris, or undercut banks. Unlike most darters, *P. stictogaster* retains a fairly large swim bladder and spends more time swimming in midwater than darting about on the bottom in more characteristic darter fashion. According to Starnes and Etnier (1980), R. A. Stiles observed individuals swimming about in the water column, often resting on submerged mats of tree roots

Table 5. Frequency distributions of left pectoral rays and anal rays in species of *Odontopholis*. Values for holotype are in boldface.

Species and Drainage	Number of Left Pectoral Rays 11	12	13	N	$\bar{x}$	SD
Percina stictogaster						
Kentucky R.	3	**42**	43	88	12.5	0.57
Green R.	2	50	13	65	12.2	0.45
Percina cymatotaenia						
Gasconade R.	8	39	10	57	12.0	0.57
Osage R.	1	8	3	12	12.2	0.58

Species and Drainage	Number of Anal Rays 8	9	10	11	12	13	N	$\bar{x}$	SD
Percina stictogaster									
Kentucky R.	2	30	**52**	2			86	9.6	0.57
Green R.		11	49	5			65	9.9	0.49
Percina cymatotaenia									
Gasconade R.		3	21	16	6	1	47	10.6	0.88
Osage R.			6	7			13	10.5	0.52

Table 6. Sheared principal component loadings for 27 morphometric variables on 44 (14 from Kentucky River drainage, 15 from Green River drainage, 15 from Gasconade River drainage) female specimens of *Odontopholis*.

Measurement	Size	Sheared PC-2	Sheared PC-3
Standard length	0.150	-0.087	0.002
Body width	0.261	-0.138	-0.009
First dorsal fin length	0.176	0.017	-0.156
Predorsal length	0.157	-0.058	0.020
First dorsal origin to pelvic origin	0.180	-0.186	0.031
Caudal peduncle depth	0.178	0.181	-0.079
Caudal peduncle width	0.240	-0.308	0.462
Head length	0.087	-0.394	-0.246
Second dorsal origin to anal origin	0.209	-0.001	0.095
Head width	0.218	-0.213	0.051
Snout length	0.177	-0.104	-0.083
Eye length	0.166	0.215	0.128
Interorbital width	0.109	-0.339	-0.007
First dorsal fin base length	0.203	0.255	0.047
Second dorsal fin base length	0.220	0.270	0.037
Second dorsal fin length	0.224	0.034	0.052
Anal fin length	0.141	-0.102	-0.049
Dorsal origin to anal origin	0.169	-0.117	0.047
Pelvic origin to second dorsal origin	0.196	-0.124	0.109
Pectoral fin length	0.217	0.253	0.286
Pelvic fin length	0.193	0.044	0.038
Anal origin to dorsal caudal peduncle	0.139	-0.108	0.023
Anal fin base length	0.299	0.356	-0.104
Second dorsal origin to ventral caudal peduncle	0.144	-0.063	0.060
Caudal fin length	0.185	0.008	0.035
Snout tip to branchiostegal junction	0.228	-0.061	-0.705
Supraoccipital edge to branchiostegal junction	0.190	0.194	-0.203
Eigenvalue	0.049	0.008	0.005
Proportion	0.572	0.089	0.058
Cumulative	0.572	0.660	0.719

along the bank. In winter it may be found in accumulations of dead leaves (Branson and Batch, 1974).

The life history of *P. stictogaster* is undoubtedly very similar to that of *P. cymatotaenia*. Pflieger (1984) provided details of the life history of *P. cymatotaenia* including color photographs of spawning and sexual dimorphism in the development of the caudal keel. As judged from males with well developed caudal keels and females ripe with ova, the breeding season of *P. stictogaster* peaks from mid-March through mid-April.

Thirteen young-of-the-year from July collections range in SL from 26.2 to 33.0 mm ($\bar{x}$ = 29.5). Judging from the adult size reached by other darters (Page, 1983), *P. stictogaster*, which grows to at least 73 mm, probably lives a maximum of about 3 years.

RELATIONSHIPS AND BIOGEOGRAPHY.—In two studies of relationships among species of *Percina* using morphological data (Page, 1974; 1981), *P. stictogaster* and *P. cymatotaenia* clustered together no matter how the characters were analyzed. Species showing frequent and close clustering to *Odontopholis* in the phenetic analyses (Page, 1974) were *P.* (*Hypohomus*) *aurantiaca* and *P.* (*Alvordius*) *macrocephala*. In a cladistic analysis of 52 morphological characters, *Hypohomus* was the sister group to *Odontopholis* (Page, 1981); however, many meristic and mensural characteristics which appear to be homoplasies (Page and Swofford, 1984) were used in the cladistic analysis, and it is our opinion that relationships among subgenera of *Percina* are not adequately hypothesized. Data on the modified midventral scales of *Percina*, a character set unique to the genus, suggest that *Odontopholis* is the sister to *Hypohomus* plus all other subgenera of *Percina* (Fig. 5). *Odontopholis* and *Hypohomus* possess modified scales on the breast as do all other *Percina* but *Odontopholis* lacks distinctly modified scales on the belly. However, in *Hypohomus* and other *Percina*, but not in *Odontopholis*, midbelly scales are slightly larger and more strongly toothed than scales in adjacent rows (Page, 1976).

The inherently interesting disjunct distribution of species of *Odontopholis*, and its similarity to the distribution of the subgenus *Litocara* of *Etheostoma* (also with only two species) has been discussed by Pflieger (1971), Page and Burr (1982), Page (1983), Wiley and Mayden (1985), Burr and Page (1986), and Burr and Warren (1986). *Litocara*, containing *Etheostoma nianguae* and *E. sagitta*, and

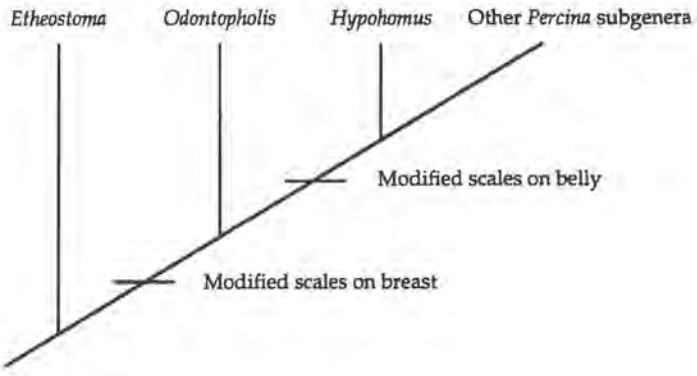

Figure 5. Phylogenetic relationships among subgenera of *Percina*.

Odontopholis each have one member restricted to tributaries of the Missouri River in the Ozarks of Missouri and one member in Ohio River tributaries in central and eastern Kentucky (and barely into northern Tennessee). Of further interest is the fact that just as *Odontopholis* is the basal clade of *Percina*, *Litocara* may be the basal clade, or close to the base, of *Etheostoma* (Page, 1983; Bailey and Etnier, 1988). It is unclear why the basal clades (i.e., subgenera) of these two large genera of darters should have the distributions shown by *Odontopholis* and *Litocara*, but the correlation is interesting and warrants additional study.

Dispersal hypotheses have been offered to explain the distributions of *Odontopholis* and *Litocara* (Pflieger, 1971; Page, 1983; Burr and Page, 1986). Two vicariant hypotheses were discussed by Wiley and Mayden (1985). One, termed the "Pleistocene hypothesis" by Wiley and Mayden (1985) was discussed previously by Pflieger (1971), Page (1983), Burr and Page (1986), and Burr and Warren (1986) and assumes that the ancestor of each pair was widespread in the preglacial Mississippi River system and that the central portion of the range of the ancestor was eliminated during glaciation, leaving two widely disjunct populations that subsequently speciated. If the Illinoian glacial advance (the most southern advance east of the Mississippi River) eliminated the connection between the eastern and western populations, they have been isolated from one another about 100,000 years. An alternative explanation, the "pre-Pleistocene hypothesis" (Wiley and Mayden, 1985), is that the species observed today were present at the beginning of the Pleistocene but speciated in a drainage pattern subsequently replaced by the present-day pattern. The latter hypothesis suggests an even greater age for the species.

Conservation Status.—In the summer of 1890, Albert J. Woolman and his assistant, Hiram W. Monical, collected specimens of *P. stictogaster* from several localities in the Green and Barren River systems of Kentucky (Woolman, 1892); they reported the species to be "a very rare darter." In the 1960s, William R. Turner and Eugene Whitney, with the Kentucky Department of Fish and Wildlife Resources, made numerous collections from the upper Green and Barren rivers using an ichthyocide (viz., rotenone); some of their collections contain more than 15 specimens of *P. stictogaster*, an unusually large number for the species. Although the habitat of *P. stictogaster* is difficult to collect using conventional seining methods, the species does not appear to be as abundant in the Green River system as it was in the 1960s. Kuehne and Barbour (1983) found the species to be more difficult to obtain in the upper Green River in the last 10 years covered in their report than it had been previously. *Percina stictogaster* is more common in the Kentucky River system, especially middle Red River, Red Bird River, and Station Camp Creek.

Branson et al. (1981) recommended that the species be considered for threatened or special concern species status in Kentucky, and that it be continually monitored for population reductions, presumably because of its restriction to only a few rivers and its vulnerability to decimation through environmental perturbations such as strip mining (Branson, 1977). The species was not included in the most recent list of endangered, threatened, and rare animals in Kentucky (Warren et al., 1986), principally because Burr and Warren (1986) recommended delisting in light of its relative abundance in the Kentucky River system. *Percina stictogaster* is of special concern and has protected status in Tennessee (Starnes and Etnier, 1980; Johnson, 1987; Etnier and Starnes 1991) where stream channelization projects threaten available habitat.

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Systematics of the *Etheostoma jordani* Species Group (Teleostei: Percidae), With Descriptions of Three New Species

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ABSTRACT: Wood, Robert M., and Richard L. Mayden. 1993. Systematics of the *Etheostoma jordani* species group (Teleostei: Percidae), with descriptions of three new species. Bulletin Alabama Museum of Natural History, Number 16:31–46, 5 tables, 6 figures. Members of the *Etheostoma jordani* species group are endemic to and distributed throughout the Mobile Basin, largely above the Fall Line. Variation in 22 standard and truss measurements, 18 meristic characters, and coloration was examined throughout the range of this species group. Analysis of these characters supports the recognition of four distinct and allopatrically distributed species. The four species are endemic to the: 1) Black Warrior River System; 2) the Cahaba, Coosa, and lower Tallapoosa river systems; 3) the Etowah River System; and 4) the upper Tallapoosa River System. State and Federal protection is recommended for each of the three species from the Black Warrior, upper Etowah, and upper Tallapoosa rivers.

Introduction

Rivers of the Mobile Basin contain one of the most distinctive ichthyofaunas in North America, characterized by at least 40 endemic species (Swift et al., 1986; Burr and Mayden, 1992). Faunal diversification within this basin has followed from a long history of drainage exchange and isolation of gene pools, combined with a limited impact of the detrimental processes associated with Pleistocene glaciation (Swift et al., 1986; Wiley and Mayden, 1985; Mayden, 1988).

The greenbreast darter, *Etheostoma jordani* Gilbert, endemic to the Mobile Basin primarily above the Fall Line, has long been considered a single species (Zorach, 1969). Evaluation of variation in morphology and color in the greenbreast darter from throughout its range has revealed that in reality four distinct species are represented. The focus of this paper is to describe variation within this group of darters, redescribe *Etheostoma jordani* Gilbert, and present formal taxonomic descriptions of the three new species.

Methods

Variation within the *Etheostoma jordani* species group was explored using standard meristic and morphometric characters following Hubbs and Lagler (1974) and truss variables sensu Humphries et al. (1981) except as follows. Transverse scale rows were counted from the anal fin origin to the first dorsal fin. A total of 18 meristic variables were examined including: lateral line scale rows, transverse scale rows above and below lateral line, caudal peduncle scale rows above and below lateral line, dorsal fin spines, dorsal fin rays, anal fin spines, anal fin rays, pelvic fin rays, pectoral fin rays, caudal fin rays, branchiostegal rays, and breast, opercle, cheek, and nape squamation. Caudal fin rays include principal rays plus two. Body measurements were generated using electronic calipers (nearest 0.01 mm) and were input directly into a computer data base. All body lengths reported are standard lengths. A total of 22 standard and truss measurements were examined (Fig. 1). Standard measurements included standard length (SL:D1–15), head length (HL:D1–8), head depth

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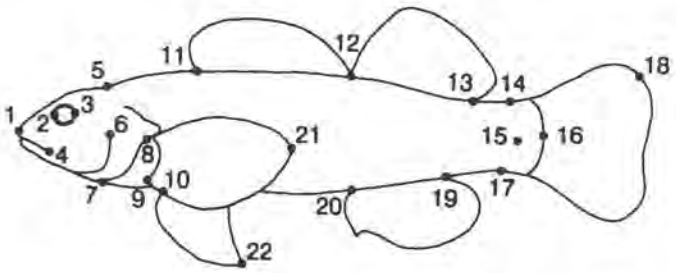

Figure 1. Numbered points indicate landmarks from which corresponding measurements below were taken. When a number is duplicated in a measurement this indicates that the second landmark was in the same position as the first on the opposite side of the fishes body from that shown.

Landmarks

D1	**Anterior-most tip of snout**
D2/D3	**Greatest bony distance of orbit**
D4	**Posterior-most point of closed mouth**
D5	**Occiput**
D6	**Dorsal-most point of preopercular margin**
D7	**Breast posterior to isthmus**
D8	**Posterior-most margin of opercle below opercular spine**
D9	**Insertion of pectoral fin**
D10	**Insertion of pelvic fin**
D11	**Origin of spinous dorsal fin**
D12	**Origin of soft dorsal fin**
D13	**Insertion of posterior-most ray of soft dorsal fin**
D14/D17	**Least depth of caudal peduncle along line through hypural plate**
D16	**Insertion of medial caudal ray**
D18	**Tip of longest caudal ray**
D19	**Insertion of posterior-most anal fin ray**
D20	**Insertion of first anal fin spine**
D21	**Tip of longest pectoral ray**
D22	**Tip of longest pelvic ray**

(HD:D5–7), head width (HW:D6–6), snout length (SN:D1–2), predorsal length (PL:D1–11), eye diameter (ED:D2–3; 2 and 3 being at greatest bony distance), gape width (GW:D4–4), pectoral fin length (PT:D9–21), pelvic fin length (PV:D10–22), spinous dorsal fin base length (DIL:D11–12), soft dorsal fin base length (DIIL:D12–13), anal fin base length (AL:D20–19), caudal fin length (CL:D16–18), caudal peduncle width (CW:D15–15), and caudal peduncle depth (CD:D14–17); truss measurements included spinous dorsal origin to pelvic fin origin (D11–10), spinous dorsal origin to anal fin origin (D11–20), spinous dorsal insertion to anal fin origin (D12–20), soft dorsal fin origin to anal fin insertion (D12–19), soft dorsal fin origin to pelvic fin origin (D12–10), anal fin origin to soft dorsal insertion (D20–13).

Characters derived from coloration included head, body, and fin pigmentation patterns. Details of coloration patterns were obtained from live specimens and color transparencies of live and recently preserved specimens. Consistency of these traits was verified by the examination of live and freshly preserved breeding and non-breeding adult specimens throughout the Mobile Basin over a four year period.

Statistical analysis of morphometric variables included Student's t-test ($P<0.05$) for comparisons of males and females for sexual dimorphism within each species and sheared principal component analysis for differences among species (SAS code for running sheared PCA provided by D. L. Swofford). Because males and females were divergent for some body measurements, sexes were evaluated separately for principal component analysis of morphometric variables. Principal component analysis of meristic variables employed a correlation matrix; analysis of morphometric variables employed a covariance matrix.

Etheostoma jordani species group

DIAGNOSIS.—Members of subgenus *Nothonotus* as diagnosed by Zorach (1972) and Page (1981). Distinguished from other members of *Nothonotus* by lack of dark horizontal lines between scale rows, presence of a partially scaled nape [only found elsewhere in *E.* (*Nothonotus*) *bellum*], presence of dark mottling on side of body forming 3 to 11 weak vertical bars, presence of broad subdistal red band in caudal fin of males. Distributed widely throughout the Mobile Basin, primarily above the Fall Line.

Etheostoma jordani Gilbert
Greenbreast Darter
Figures 2 and 3A

LECTOTYPE.—USNM 125110, adult male, 48 mm, Choccoloco Creek at Oxford, Coosa River System, Calhoun County, Alabama, 23 May 1889, P. H. Kirsch, W. M. Andrews, and E. O. Jones. Designated by Collette and Knapp (1967).

DIAGNOSIS.—A member of the *Etheostoma jordani* species group of the subgenus *Nothonotus*. Distinguished from other members of the species group by presence of red spots without dark halos on side of body, olivaceous lips, blue-turquoise anal fin, and exposed scales on opercles.

DESCRIPTION.—Morphometric measurements and some diagnostic meristic variables are reported in Tables 1 and 2. General head and body shape and pigmentation are shown in Figures 2 and 3a.

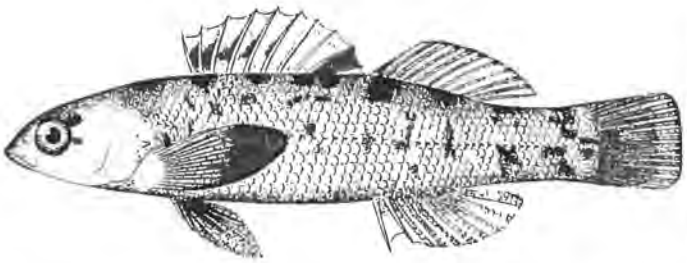

Figure 2. Original illustration of *Etheostoma jordani* (Gilbert, 1891).

Dorsal spines 9(5 specimens), 10(129), 11(86), 12(5); $\bar{x}$=10.4, SD = 0.58. Soft dorsal rays 10(2), 11(29), 12(169), 13(25); $\bar{x}$ = 11.9, SD = 0.52. Anal fin rays 6(4), 7(81), 8(134), 9(6); $\bar{x}$ = 7.6, SD = 0.57. Pectoral fin rays 12(51), 13(168), 14(6); $\bar{x}$=12.8, SD=0.46. Caudal fin rays 16(6), 17(215), 18(4); $\bar{x}$=16.1, SD=0.21. Scale rows above lateral line 6(70), 7(144), 8(11); $\bar{x}$=6.7, SD=0.54. Scale rows below lateral line 6(2), 7(160), 8(63); $\bar{x}$=7.3, SD=0.47. Scale rows above lateral line at caudal peduncle 7(38), 8(118), 9(67), 10(2); $\bar{x}$=8.2, SD=0.69. Scale rows below lateral line at caudal peduncle 8(6), 9(140), 10(74) 11(5); $\bar{x}$=9.4, SD=0.57. Branchiostegal rays 5(2), 6(222), 7(1); $\bar{x}$=6.0, SD=0.12. Nape squamation 0% (6), 10% (11), 20% (6), 30% (41), 40% (13), 50% (111), 60% (10), 80% (21), 90% (4), 100% (2); $\bar{x}$=0.5, SD=0.19. Cheek without scales, opercle with scales, breast generally without scales (217) occasionally 1–4 embedded scales (8).

Male genital papilla is a broad based, shortened conical structure. Female genital papilla is a thick elongate conical structure.

Preoperculomandibular canal pores 10(10). Infraorbital canal pores 6(1), 7(2), 8(7); $\bar{x}$=7.6, SD=0.66. Lateral canal pores 4(10). Supratemporal canal pores 2(5), 3(5); $\bar{x}$=2.5, SD=0.50. Supraorbital canal pores 3(2), 4(8); $\bar{x}$=3.8, SD=0.40. Coronal pore 1(10).

Males were found to possess significantly greater head depth, gape width, caudal peduncle depth and caudal peduncle width than females, while females possessed a significantly larger eye diameter than males ($P<0.05$, Table 1). No other significant differences were found in either morphometric or meristic traits.

Coloration.—Males and females are dichromatic; males being more brightly colored than females throughout the year, dichromatism reaching its peak during the spring. Coloration of a male in breeding condition is depicted in Figure 3A.

Breeding males. Body olivaceous with concentrations of melanophores forming pattern of 3–11 weakly defined vertical bars along flanks. Flanks with red spots, lacking dark halos typical of other *Nothonotus*; spots equally distributed above and below lateral line, more concentrated from distal tip of pectoral fin posteriorly. Dorsum with 8–9 distinct olivaceous to brown quadrate blotches, most prominent blotch lying across anterior portion of nape. Head olivaceous dorsally, slightly turquoise on ventral surface. Lips olivaceous. Sub-orbital bar weak, extending from eye toward ventral-most portion of cheek. Post-orbital bar distinct, extending from eye to one-half distance across dorsal margin of opercle. Breast and branchiostegal rays and membranes turquoise. Caudal peduncle at caudal fin insertion with four brown to black spots; two at midline may coalesce to form a single spot, one at dorsal-most and one at ventral-most portions of caudal peduncle.

Spinous dorsal fin with thin clear to white margin followed proximally by intense red band (1.0–2.0 mm in width); red band most prominent anteriorly, becoming thinner posteriorly. Basal four-fifths of spinous dorsal fin olivaceous with black elliptical blotches in membranes between first 3–7 spines; anterior two blotches most intense. Soft dorsal fin with narrow turquoise to black margin followed proximally by thin clear to yellow band, followed proximally by red band (2.0–4.0 mm). Basal one-half of soft dorsal fin olivaceous. Distal one-half of caudal fin with turquoise band (1.0–2.0 mm) at fin margin followed proximally by broad red band (3.0–5.0 mm). Proximal one-half of caudal fin with yellow to clear membranes and black rays. Pelvic fins white at margin, followed proximally by broad turquoise band becoming black toward insertion. Pectoral fins clear; occasional orange chromatophores near insertion. Distal one-half of anal fin turquoise; basally, fin olivaceous to black.

Breeding females. Body brown and mottled with 3–11 weakly defined vertical bars along flanks, more pronounced along and below lateral line. Sub-orbital bar prominent, extending from eye to ventral-most portion of cheek; post-orbital bar distinct, extending from eye to one-half width of opercle. Breast and branchiostegals may have faint turquoise cast. Four distinct spots at caudal fin insertion as in males.

Spinous dorsal fin, olivaceous to black basally; distally, fin with thin red marginal band. Soft dorsal fin mottled basally; thin black band at margin. Caudal fin mottled, yellow to orange in color, with black marginal band. Anal fin with prominent black wash on basal one-half to two-thirds of fin, becoming clear at margin. Pelvic fins clear to faintly mottled on rays and membranes. Pectoral fins clear, occasionally with some yellow to orange pigment on membranes near insertion of fin rays.

Coloration of preserved males.—Body tan to olivaceous. Along flanks, melanophores forming pattern of 3–11 weakly defined vertical bars; melanophores more prominent just below lateral line generally coalescing to form distinct spot. Body scales with concentration of melanophores at margins forming a black marginal band on each

Table 1. Proportional measurements of the *Etheostoma jordani* species group. * Indicates significant differences between the sexes at P < 0.05 level.

Etheostoma jordani

	Males (N=102)			Females (N=90)		
	Range	$\bar{x}$	SD	Range	$\bar{x}$	SD
SL (mm)	33.690–52.360	43.036	4.012	31.390–54.370	38.205	4.328
HL	9.360–15.310	12.470	1.150	8.880–15.430	11.157	1.306
HL/SL	0.268–0.312	0.290	0.010	0.254–0.330	0.291	0.014
HD/HL*	0.521–0.774	0.610	0.042	0.514–0.764	0.597	0.045
HW/HL	0.386–0.591	0.468	0.040	0.383–0.574	0.462	0.041
SN/HL	0.196–0.282	0.239	0.017	0.199–0.282	0.234	0.017
GW/HL*	0.171–0.299	0.224	0.027	0.146–0.271	0.208	0.025
EY/HL*	0.173–0.245	0.210	0.015	0.165–0.258	0.221	0.016
PL/SL	0.340–0.392	0.360	0.010	0.333–0.402	0.362	0.012
PT/SL	0.191–0.281	0.242	0.017	0.184–0.285	0.241	0.018
PV/SL	0.175–0.236	0.207	0.013	0.168–0.236	0.206	0.014
CL/SL*	0.124–0.210	0.168	0.019	0.134–0.212	0.172	0.018
CD/SL	0.105–0.142	0.121	0.007	0.097–0.134	0.114	0.007
CW/SL*	0.025–0.046	0.034	0.004	0.025–0.043	0.033	0.004

Etheostoma douglasi

	Males (N=31; includes holotype)			Females (N=30)		
	Range	$\bar{x}$	SD	Range	$\bar{x}$	SD
SL (mm)	32.290–63.270	46.271	8.401	31.780–54.570	39.923	6.084
HL	10.330–18.110	13.681	2.168	9.800–16.330	12.056	1.518
HL/SL	0.265–0.323	0.297	0.012	0.274–0.333	0.303	0.013
HD/HL	0.496–0.732	0.610	0.050	0.520–0.645	0.589	0.035
HW/HL	0.392–0.623	0.490	0.043	0.410–1.009	0.488	0.103
SN/HL	0.214–0.276	0.234	0.015	0.208–0.272	0.236	0.016
GW/HL*	0.191–0.301	0.229	0.022	0.179–0.255	0.215	0.019
EY/HL*	0.180–0.239	0.214	0.014	0.183–0.263	0.225	0.022
PL/SL*	0.331–0.387	0.367	0.015	0.351–0.406	0.380	0.013
PT/SL	0.183–0.285	0.244	0.022	0.222–0.288	0.251	0.018
PV/SL	0.172–0.236	0.214	0.015	0.187–0.237	0.214	0.013
CL/SL	0.151–0.205	0.182	0.015	0.135–0.226	0.186	0.019
CD/SL*	0.116–0.145	0.128	0.008	0.106–0.133	0.123	0.007
CW/SL	0.027–0.042	0.034	0.004	0.026–0.038	0.033	0.003

Table 1. continued

Etheostoma chuckwachatte

	Males (N=15; includes holotype)			Females (N=15)		
	Range	$\bar{x}$	SD	Range	$\bar{x}$	SD
SL (mm)	35.520–44.250	39.484	2.821	33.500–41.980	37.781	2.751
HL	10.590–12.950	11.589	0.690	9.630–12.790	11.038	0.946
HL/SL	0.276–0.311	0.294	0.009	0.269–0.315	0.292	0.012
HD/HL	0.546–0.640	0.594	0.025	0.534–0.640	0.586	0.033
HW/HL	0.439–0.520	0.480	0.023	0.407–0.532	0.478	0.033
SN/HL	0.214–0.255	0.231	0.011	0.221–0.272	0.234	0.013
GW/HL	0.203–0.275	0.235	0.019	0.196–0.268	0.227	0.021
EY/HL*	0.206–0.244	0.224	0.011	0.211–0.284	0.236	0.019
PL/SL	0.350–0.386	0.372	0.010	0.351–0.397	0.370	0.012
PT/SL	0.213–0.275	0.236	0.019	0.222–0.268	0.243	0.014
PV/SL	0.195–0.226	0.208	0.010	0.186–0.233	0.207	0.012
CL/SL*	0.127–0.160	0.146	0.010	0.135–0.181	0.154	0.012
CD/SL	0.105–0.135	0.118	0.008	0.103–0.123	0.113	0.006
CW/SL	0.026–0.042	0.034	0.005	0.028–0.038	0.032	0.003

Etheostoma etowahae

	Males (N=7; includes holotype)			Females (N=16)		
	Range	$\bar{x}$	SD	Range	$\bar{x}$	SD
SL (mm)	43.350–47.240	44.664	1.266	30.130–46.370	39.964	5.070
HL	12.080–13.860	12.871	0.567	8.680–13.590	11.486	1.388
HL/SL	0.271–0.300	0.288	0.009	0.273–0.305	0.288	0.009
HD/HL	0.559–0.653	0.591	0.029	0.522–0.642	0.578	0.040
HW/HL	0.402–0.492	0.442	0.031	0.408–0.501	0.448	0.030
SN/HL*	0.234–0.290	0.268	0.025	0.217–0.262	0.239	0.016
GW/HL	0.188–0.232	0.211	0.014	0.168–0.241	0.199	0.022
EY/HL	0.200–0.227	0.214	0.011	0.183–0.236	0.218	0.014
PL/SL	0.347–0.381	0.360	0.012	0.335–0.385	0.357	0.013
PT/SL	0.237–0.282	0.250	0.015	0.197–0.257	0.236	0.017
PV/SL	0.194–0.234	0.210	0.016	0.175–0.251	0.203	0.017
CL/SL	0.140–0.174	0.164	0.012	0.146–0.193	0.171	0.015
CD/SL	0.107–0.124	0.113	0.006	0.098–0.120	0.108	0.007
CW/SL	0.027–0.038	0.033	0.004	0.025–0.036	0.032	0.003

Table 2. Variation in some meristic characters in the *Etheostoma jordani* species group.

Lateral Scale Rows

	42	43	44	45	46	47	48	49	50	51	52	53	54	55	N	$\bar{x}$	SD
Etheostoma jordani																	
Coosa River				8	4	8	19	30	21	32	21	12	3	6	164	50.2	2.3
Cahaba River				3	1	3	7	4	10	1		1			30	48.6	1.8
Lower Tallapoosa River			1	1	4	5	5	3	7	3	1				30	48.3	2.0
Etheostoma douglasi			1	4	5	3	6	6	13	9	5	5	2	1	60	49.5	2.5
Etheostoma etowahae	2	2	5	11	4	7	7	2	1	1					35	45.5	1.8
Etheostoma chuckwachatte			1	1	8	8	9	10	9	4	2				52	48.3	1.8

Transverse Scale Rows

	11	12	13	14	15	16	17	N	$\bar{x}$	SD
Etheostoma jordani										
Coosa River				38	77	40	9	164	15.1	0.82
Cahaba River				19	7	3	1	30	14.5	0.81
Lower Tallapoosa River				12	8	10		30	14.9	0.86
Etheostoma douglasi			2	26	16	13	3	60	14.8	0.98
Etheostoma etowahae	5	7	16	6	1			35	12.7	1.01
Etheostoma chuckwachatte			3	22	16	11		52	14.6	0.87

Caudal Peduncle Scale Rows

	15	16	17	18	19	20	21	22	23	24	N	$\bar{x}$	SD
Etheostoma jordani													
Coosa River			5	31	62	30	33	1	2		164	19.4	1.18
Cahaba River				1	14	7	8				30	19.7	0.90
Lower Tallapoosa River			1	1	12	10	5	1			30	19.6	1.02
Etheostoma douglasi				5	15	7	18	11	3	1	60	20.4	1.46
Etheostoma etowahae	1	7	16	8	3						35	17.1	0.94
Etheostoma chuckwachatte			8	7	26	7	3	1			52	18.8	1.13

Percent Squamation on Opercle

	0.0	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.75	0.80	1.00	N	$\bar{x}$	SD
Etheostoma jordani															
Coosa River			1	1	14	2	6	111	2	25		2	164	0.5	0.14
Cahaba River						5	1	19	3	2			30	0.5	0.11
Lower Tallapoosa River					5			25					30	0.4	0.09
Etheostoma douglasi	60												60	0.0	0.00
Etheostoma etowahae	2	1	1	9	5	8	7	2					35	0.3	0.12
Etheostoma chuckwachatte				2	1	4	13	29			3		52	0.4	0.12

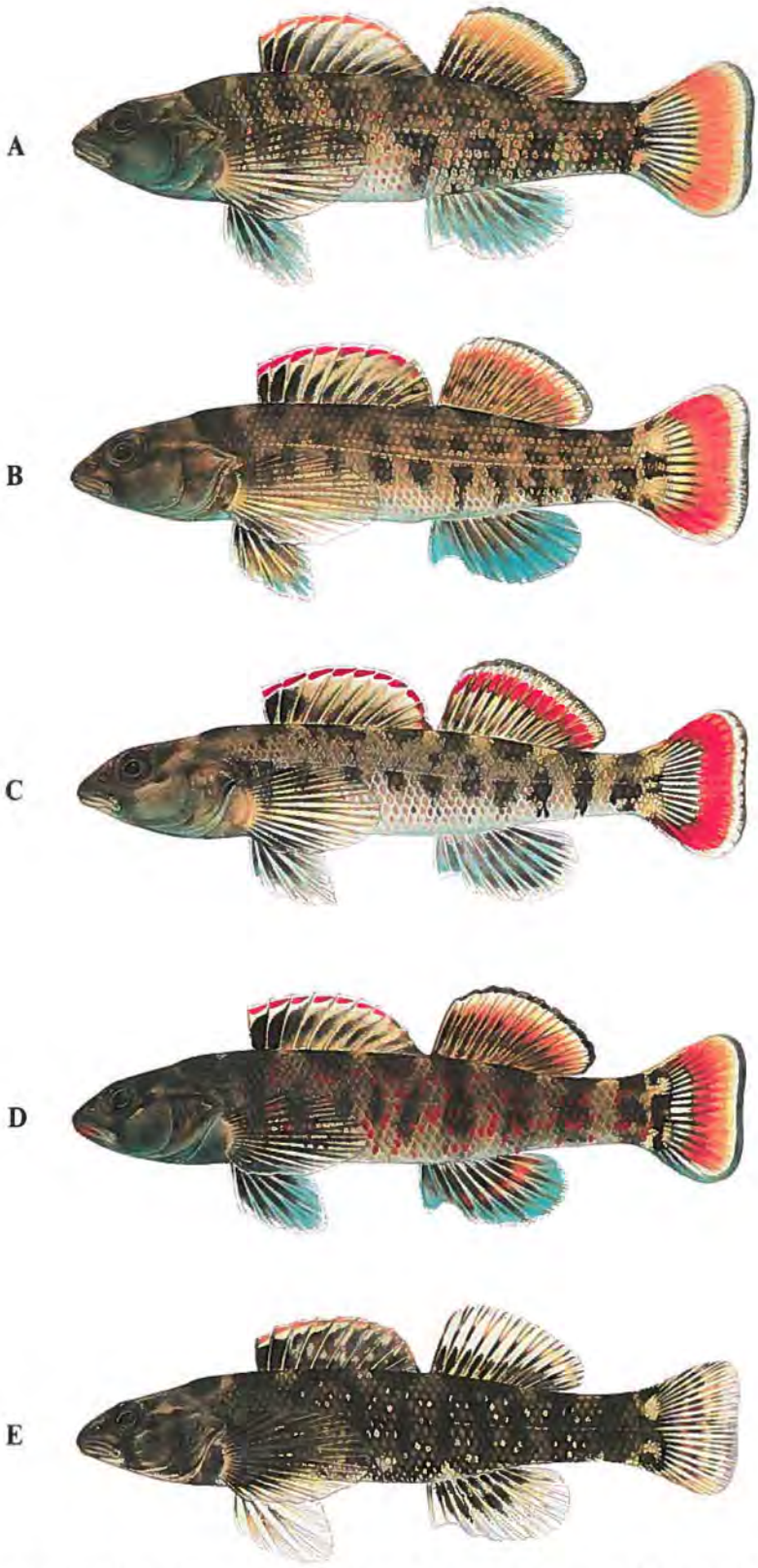

Figure 3. A. Breeding male *Etheostoma jordani*, Cahaba River, Jefferson County, Alabama (UAIC 10286.01). B. Breeding male *Etheostoma douglasi*, West Fork Sipsey River, Winston County, Alabama (UAIC 10273.01). C. Breeding male *Etheostoma etowahae*, Amicalola Creek, Dawson County, Georgia (UAIC 10471.01). D. Breeding male *Etheostoma chuckwachatte*, Hillabee Creek, Tallapoosa County, Alabama (UAIC 10284.01). E. Female *Etheostoma chuckwachatte* (same collection data as male).

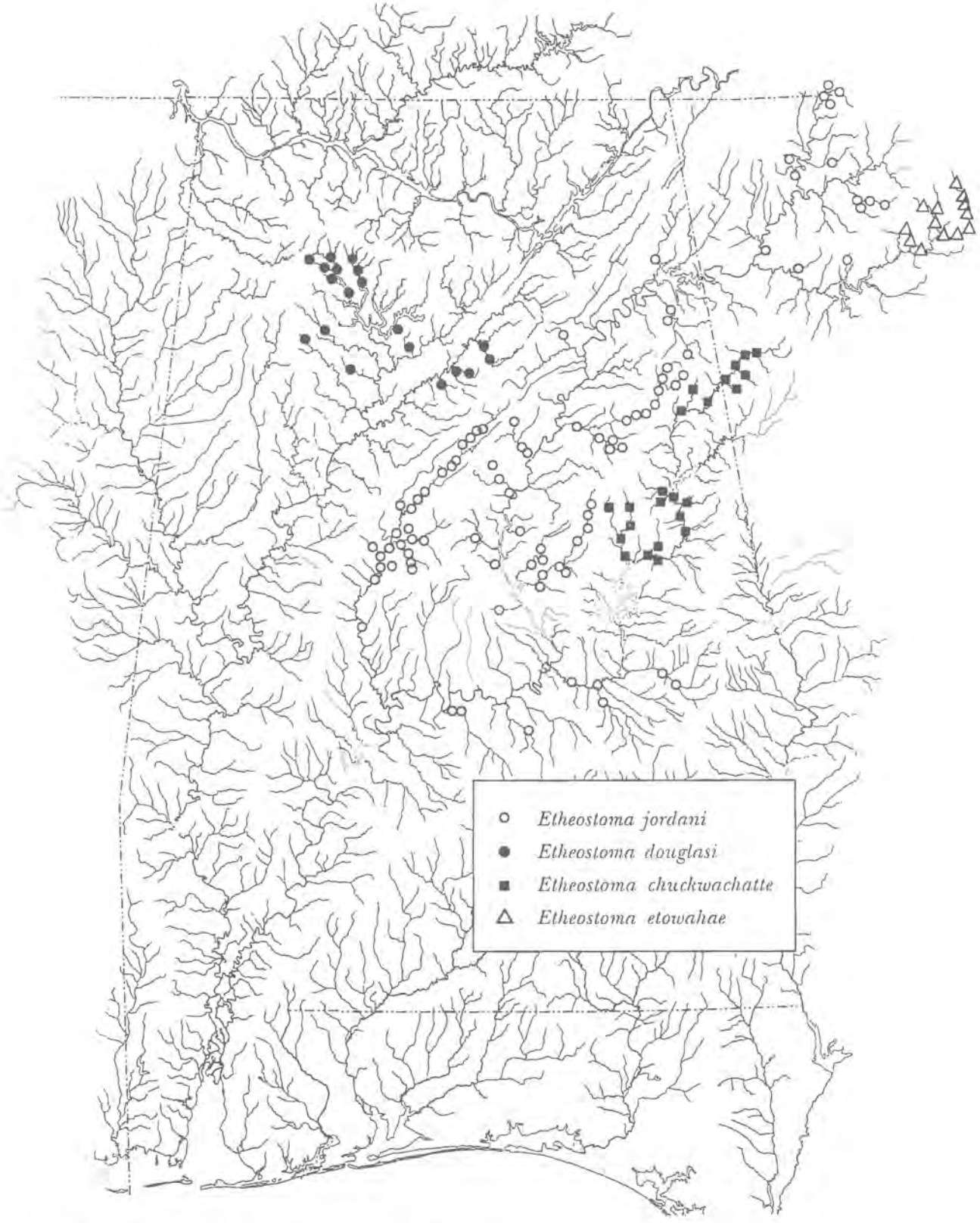

Figure 4. Map of known localities of members of *Etheostoma jordani* species group.

scale. Dorsum crossed by 8 quadrate blotches, generally not extending ventrally more than 4 scale rows; first immediately posterior to the occiput, second at insertion of spinous dorsal fin, third near middle of spinous dorsal fin base, fourth at termination of spinous dorsal fin, fifth at insertion of soft dorsal fin, sixth near end of soft dorsal fin base, seventh posterior to end of soft dorsal fin base and underlying rays of soft dorsal fin, eighth at caudal peduncle. Head olivaceous dorsally; cheek olivaceous. Sub-orbital bar distinct; extending from eye toward ventralmost margin of cheek. Postorbital bar dusky; pre-orbital bar present but may be obscured by overall head pigmentation in darker individuals. Black humeral spot present.

Spinous dorsal fin olivaceous basally, with thin white marginal band; basally membranes between first three spines with black elliptical spots. Soft dorsal fin olivaceous basally, followed distally by narrow white band and narrow olivaceous band at fin margin. Caudal rays olivaceous in basal three-fourths of fin; membranes white; distally, fin with narrow white band followed by narrow olivaceous margin. Four distinct black spots present at insertion of caudal fin; two spots immediately posterior to hypural plate at midline, one at insertion of dorsal procurrent caudal rays, one at insertion of ventral procurrent caudal rays. Anal fin membranes dusky basally; color fades toward margin of fin. Anal fin rays overlain by melanophores; generally bordered by membrane void of any pigment. Distal margin of anal fin with melanophores coalescing to form band; band best developed posteriorly, fading anteriorly. Pelvic fins dusky basally and medially; melanophores fade at margin giving appearance of white marginal band. Pectoral fin rays overlain with melanophores; membranes white.

Coloration of preserved females.—Body tan to olivaceous as in males except with much more speckled appearance. Head as above; cheek tan but with slight concentration of uniformly scattered melanophores. Sub-orbital and post-orbital bars as in males, pre-orbital bar more distinct than in male. Dorsum of head, lips, cheeks, branchiostegals, breast, and belly heavily speckled with profusion of discrete melanophores. Black humeral spot present. Spinous dorsal fin heavily pigmented with discrete melanophores, giving overall speckled appearance; melanophores may coalesce near margin giving appearance of a dusky submarginal band. Soft dorsal fin olivaceous basally, followed distally by alternating patterns of unpigmented and pigmented zones, giving rise to a speckled appearance; melanophores on rays and membranes. Margin of soft dorsal fin with thin olivaceous band. Caudal fin membranes unpigmented; rays overlain by alternating areas with and without melanophores, creating speckled appearance. Margin of caudal fin with dusky brown band, bordered proximally by area more or less void of pigment, forming white band. Anal fin heavily speckled basally, fading toward margin where clear. Pectoral and pelvic fins as in males except more speckled in appearance.

DISTRIBUTION.—*Etheostoma jordani* is distributed throughout the Coosa River System, including the Conasauga and Coosawattee rivers, the Cahaba River System, and the Tallapoosa River System below the Fall Line. Known populations of *E. jordani* are depicted in Figure 4.

ECOLOGY.—Adults of *Etheostoma jordani* typically inhabit riffles with a moderate to strong current (Zorach, 1969; Orr, 1989) over gravel or cobble substrate. Orr (1989) reported that larvae of dipterans, ephemeropterans, and trichopterans accounted for the majority of the diet in *E. jordani* from Opintlocco Creek (Tallapoosa River System; Macon County, Alabama). Orr and Ramsey (1990) reported details of reproductive ecology for *E. jordani* from Opintlocco Creek. Based on mean gonadosomatic indices they found that the peak reproductive activity for *E. jordani* in 1986 occurred in the third week of April, females with ripe ova were found from 22 April through 3 June at water temperatures of 18.0–29.4 C (Orr and Ramsey, 1990). The smallest mature female of *E. jordani* captured during their investigation was 23.0 mm SL. In addition, they report that *E. jordani* spawns by burying its eggs in sand at a site selected by the female. O'Neil (1980) reported that females of *E. jordani* in Barbaree Creek (Coosa River System; Clay County, Alabama) were at a reproductive peak in mid to late May 1977 based on monthly gonadosomatic indices.

ETYMOLOGY.—The species epithet *jordani* is used in honor of David Starr Jordan. The common name greenbreast darter refers to the blue-green coloration on the breast and underside of head.

Etheostoma douglasi Wood & Mayden, new species
Tuskaloosa Darter
Figure 3B

HOLOTYPE.—UAIC 10345.02, adult male, 51.2 mm, West Fork Sipsey River at Lawrence Co. Rd. 6, Sipsey River Recreational Site, T9S, R8W, Sec. 8, Winston County, Alabama, 14 March 1991, R. M. Wood, S. R. Layman, and A. M. Simons.

PARATOPOTYPES.—NLU 66886 (5 specimens; 33.0–45.3 mm SL), UAIC 10345.01 (22; 26.9–48.5), USNM 31992.6 (5; 30.0–35.9), collected with the holotype. INHS 28458 (3; 33.4 to 45.3), SIUC 20338 (3; 32.5–40.8), UAIC 10273.01 (8; 21.6–36.9), UF 92303 (3; 29.7–36.2), UGAMNH 2432 (3; 30.6–37.0), UT 91.4171 (3; 31.8–35.5), 2 March 1992, R. L. Mayden and B. R. Kuhajda.

PARATYPES.—UAIC 3851.08 (14 specimens; 23–50 mm SL), Sipsey River, 4.0 km W of Grayson and 16.1 km NNE of Double Springs, T9S, R8W, Sec. 10, Winston County, Alabama, 29 October 1971, D. Dycus and D. Johnson; UAIC 3852.09 (18; 31–52), Sipsey River 2.8 km W of Hwy 242 and

6.4 km SW of Double Springs, T9S, R8W, Sec. 22, Winston County, Alabama, 3 November 1971, D. Dycus and D. Johnson; UAIC 3854.07 (4; 41–53), Sipsey River at low pressure bridge, 6.4 km E of Alabama Hwy 195 and 8.9 km NNE of Double Springs, T9S, R8W, Sec. 33, Winston County, Alabama, 8 November 1971, D. Dycus, W.M. Howell, and M. Hopiak; UAIC 3858.06 (10; 30–44), Sipsey River, 8.1 km W of Alabama Hwy 33 and 2.8 km NW of Sipsey River recreation area, T9S, R8/9W, Sec. 6/1, Winston County, Alabama, 17 November 1971, D. Dycus and M. Hopiak; UAIC 3868.06 (8; 37–54), Borden Creek on Bunyan Hill Rd., 4.8 km W of Alabama Hwy 33, T8S, R8W, Sec. 32, Lawrence County, Alabama, 22 August 1970, W. M. Howell, M. Hopiak, and J. Manasco; UAIC 4111.06 (4; 24–45), Sipsey River at low pressure bridge, 6.4 km E of Alabama Hwy 195 and 8.9 km NNE of Double Springs, T9S, R8W, Sec. 33, Winston County, Alabama, 15 October 1971, D. Dycus and M. Hopiak.

Diagnosis.—A member of the *E. jordani* species group, distinguished from other members by the combination of no red spots along flanks, no scales on the opercles, and no trace of red pigmentation on the lips or in the anal fin.

Description.—Morphometric measurements and some significant meristic variables are reported in Tables 1 and 2. General head and body shape and pigmentation are shown in Figure 3b.

Dorsal spines 10(41), 11(19); $\bar{x}$=10.3, SD=0.47. Soft dorsal rays 11(15), 12(40), 13(5); $\bar{x}$ =11.8, SD=0.56. Anal fin rays 7(23), 8(34); $\bar{x}$=7.7, SD=0.57. Pectoral fin rays 12(7), 13(52), 14(1); $\bar{x}$=12.9, SD=0.35. Caudal fin rays 15(1), 16(6), 17(53); $\bar{x}$=16.9, SD=0.39. Scale rows above lateral line 5(1), 6(32), 7(27); $\bar{x}$=6.4, SD=0.53. Scale rows below lateral line 6(2), 7(37), 8(18), 9(3); $\bar{x}$=7.4, SD=0.64. Scale rows above lateral line at caudal peduncle 7(7), 8(20), 9(29), 10(3), 11(1); $\bar{x}$=8.5, SD=0.83. Scale rows below lateral line at caudal peduncle 9(20), 10(24), 11(15), 12(1); $\bar{x}$=10.0, SD=0.81. Branchiostegal rays 6(59), 7(1); $\bar{x}$=6.0, SD=0.13. Nape squamation 20% (1), 30% (5), 40% (15), 50% (30), 60% (1), 80% (6), 90% (2); $\bar{x}$=0.5, SD=0.14. Breast generally without scales (58) occasionally 1–2 embedded scales (2). Cheek and opercle without scales.

Preoperculomandibular canal pores 9(2), 10(7), 11(1); $\bar{x}$=9.9, SD=0.54. Infraorbital canal pores 8(9), 9(1); $\bar{x}$=8.1, SD=0.30. Lateral canal pores 4(10). Supratemporal canal pores 2(10). Supraorbital canal pores 4(10). Coronal pore 1(10).

Males were found to possess a significantly greater gape width than females, while females possessed greater eye diameter, predorsal length, and caudal peduncle depth than males ($P<0.05$, Table 1). No other significant differences were found in either morphometric or meristic traits.

Coloration.—Males and females are dichromatic; males being more brightly colored than females throughout year, dichromatism reaching its peak during the spring. Males possess same coloration as in *E. jordani* with the exception that red spots along flanks are lacking. Coloration of a male in breeding condition is depicted in Figure 3b. Coloration of females same as in *E. jordani*.

Distribution.—*Etheostoma douglasi* is known from the upper Black Warrior River System in Alabama. Known populations of *E. douglasi* are depicted in Figure 4.

Ecology.—Adults of *E. douglasi* typically inhabit riffles in streams of moderate to strong current over gravel or cobble substrate. O'Neil (1980) reported females of *E. douglasi* in Gurley Creek (Black Warrior River System; Jefferson County, Alabama) with differentiating ova scattered throughout the ovary on 1 April 1966 and in Blackburn Fork (Black Warrior River System; Blount County, Alabama), females with fully differentiated ova scattered throughout the ovary and in oviducts on 24 May 1977.

Etymology.—Named for Dr. Neil H. Douglas, Director and Curator, Northeast Louisiana University Museum of Zoology, in recognition of his contributions to our understanding of the freshwater fish fauna of Louisiana and his dedication to teaching. The common name, Tuskaloosa darter, is in reference to the Mississippian chieftan met by Hernando de Soto and to the Choctaw Indian name for Black Warrior, the river system to which this species is endemic.

Etheostoma etowahae Wood & Mayden, new species
Etowah Darter
Figure 3C

Holotype.—UAIC 9169.14, adult male, 54.7 mm, Etowah River at Georgia Hwy 52, 13.7 km NNE of Dawsonville, Lumpkin County, Georgia, 5 April 1989, R. M. Wood, R. L. Mayden, B. R. Kuhajda, R. H. Matson, and M. T. Ferguson.

Paratopotypes.—INHS 28460 (2 specimens; 45.6–46.6 mm SL), NLU 66888 (2; 44.3–50.6), SIUC 20340 (2; 46.5–48.4), UAIC 9169.11 (6; 34.6–43.0), USNM 319924 (2; 44.5–50.7), collected with the holotype. UAIC 2912.03 (4; 40.9–43.2), 20 April 1968, J. D. Williams, E. Crowder, and H. Harima. UAIC 9811.08 (1; 44.7), 1 June 1990, R. L. Mayden, R. M. Wood, and R. H. Matson.

Paratypes.—UAIC 6219.04 (1 specimen; 45.5 mm SL), Etowah River at Co. Rd. 75, 3.2 km N of Georgia Hwy 52, Lumpkin County, Georgia, 31 May 1980, R. T. Bryant and J. A. Walton; UAIC 9822.10 (3; 38.2–54.4), Amicalola

Creek at Co. Rd. 25 and 26, Dawson County, Georgia, 1 June 1990, R. M. Wood, R. L. Mayden, and R. H. Matson; UMMZ 157952 (5; 41.9–46.7), Etowah River, 6.4 km SW of Dahlonega on US Hwy 19, Lumpkin County, Georgia, 25 August 1939, R. M. Bailey and M. K. Bailey; UF 84777 (8; 38.4–53.2), Amicalola Creek at Co. Rd. 25, 14.4 km NNW of Dawsonville, Dawson County, Georgia, 2 May 1990, N. M. Burkhead, C. R. Gilbert, J. D. Williams, S. J. Walsh, and B. J. Freeman.

Diagnosis.—A member of the *E. jordani* species group distinguished from other members of the group by the absence of red spots on flanks, lack of red pigment on lips, lack of a red band in anal fin, and presence of scales on opercle. Additionally, *E. etowahae* differs from remaining three members of the *E. jordani* species group in having a mean of 12.7 tranverse scale rows (versus a minimum mean of 14.5); 45.5 lateral line scales (minimum mean of 48.3); and a mean of 17.1 caudal peduncle scale rows (minimum mean of 18.8) (Table 2).

Description.—Morphometric measurements and some significant meristic variables are reported in Tables 1 and 2. General head and body shape and pigmentation are shown in Figure 3c.

Dorsal spines 10(18), 11(15), 12(2); $\bar{x}$=10.5, SD=0.61. Soft dorsal rays 11(1), 12(33), 13(1); $\bar{x}$=12.0, SD=0.24. Anal fin rays 7(9), 8(26); $\bar{x}$ =7.7, SD=0.44. Pectoral fin rays 12(3), 13(28), 14(4); $\bar{x}$=13.0, SD=0.45. Caudal fin rays 16(3), 17(29), 18(3); $\bar{x}$=17.0, SD=0.42. Scale rows above lateral line 5(11), 6(23), 7(1); $\bar{x}$=5.7, SD=0.52. Scale rows below lateral line 5(7), 6(20), 7(8); $\bar{x}$=6.0, SD=0.66. Scale rows above lateral line at caudal peduncle 6(3), 7(28), 8(4); $\bar{x}$=7.0, SD=0.45. Scale rows below lateral line at caudal peduncle 7(6), 8(19), 9(10); $\bar{x}$=8.1, SD=0.67. Branchiostegal rays 6(35). Nape squamation 10% (5), 20% (5), 30% (8), 40% (9), 50% (8); $\bar{x}$=0.3, SD=0.14. Cheek and breast naked, opercles scaled.

Preoperculomandibular canal pores 9(2), 10(7); $\bar{x}$= 9.9, SD=0.54. Infraorbital canal pores 8(8), 9(1); $\bar{x}$=8.1, SD=0.30. Lateral canal pores 4(9). Supratemporal canal pores 2(9). Supraorbital canal pores 4(9). Coronal pore 1(9).

Males of *E. etowahae* possessed a significantly greater snout length than females ($P<0.05$, Table 1). No other significant differences were found in either morphometric or meristic traits.

Coloration.—Males and females are dichromatic; males being more brightly colored than females throughout year, dichromatism reaching its peak during the spring. Coloration of males same as in *Etheostoma jordani* with the exception that there are no red spots along flanks. Coloration of a male in breeding condition is depicted in Figure 3C. Coloration of females same as in *E. jordani*.

Distribution.—*Etheostoma etowahae* is restricted to the Etowah River System of Georgia above Lake Allatoona. Known localities of *E. etowahae* are depicted in Figure 4.

Ecology.—Adults of *E. etowahae* typically inhabit riffles in streams of moderate to strong current over gravel or cobble substrate. Nothing has been reported on the diet or reproductive habits of this species.

Etymology.—The species epithet *etowahae* is an adjective referring to the Etowah River to which the new species is endemic. The common name, Etowah darter, also refers to the Etowah River.

Etheostoma chuckwachatte Mayden & Wood, new species
Lipstick Darter
Figures 3D and 3E

Holotype.—UAIC 9815.07, adult male, 45.5 mm, Hillabee Creek at Alabama Hwy 22, 11.7 km NE of Alexander City, T23N, R22E, Sec. 16, Tallapoosa County, Alabama, R. M. Wood, R. L. Mayden, B. R. Kuhajda, and S. R. Layman, 3 Feb. 1990.

Paratopotypes.—INHS 28459 (2 specimens; 37.5–39.7 mm SL), NLU 66887 (2; 34.5–41.7), SIUC 20339 (2; 37.4–38.8), USNM 319925 (2; 37.3–40.0), UAIC 9815.02 (7; 29.2–34.9), UF 92304 (2; 37.3–37.5), UGAMNH 2431 (2; 35.6–44.5), UT 91.4172 (2; 35.1–37.3), collected with the holotype. UAIC 6418.09 (26; 22.8–39.7), 16 November 1980, D. L. Nieland and R. A. Kasperzak; UAIC 10284.01 (5; 36.2–39.2), 6 March 1992, B. R. Kuhajda, R. L. Mayden, H. T. Boschung, and J. R. Tomelleri.

Diagnosis.—A member of the *E. jordani* species group distinguished from other members of the group by the presence of red lips, bright red spots along flanks, a broad red band in the anal fin of adult males, and scales on opercles.

Description.—Morphometric measurements and some meristic variables are reported in Tables 1 and 2. General head and body shape and pigmentation are shown in Figures 3d and 3e.

Dorsal spines 9(1), 10(19), 11(30), 12(2); $\bar{x}$=10.6, SD=0.50. Soft dorsal rays 10(2), 11(32), 12(17), 13(0), 14(1); $\bar{x}$ =11.4, SD=0.65. Anal fin rays 7(30), 8(22); $\bar{x}$ =7.4, SD=0.50. Pectoral fin rays 12(3), 13(45), 14(4); $\bar{x}$=13.0, SD=0.37. Caudal fin rays 17(52). Scale rows above lateral line 6(28), 7(24); $\bar{x}$=6.5, SD=0.50. Scale rows below lateral line 6(3), 7(35), 8(14); $\bar{x}$=7.2, SD=0.54. Scale rows above lateral line at caudal peduncle 7(12), 8(30), 9(10); $\bar{x}$=8.0, SD=0.66. Scale rows below lateral line at caudal peduncle

8(9), 9(38), 10(4), 11(1); $\bar{x}$=8.9, SD=0.57. Branchiostegal rays 6(52). Nape squamation 0% (4), 10% (5), 20% (4), 30% (7), 40% (5), 50% (18), 60% (3), 70% (4), 80% (1), 100% (1); $\bar{x}$=0.4, SD=0.22. Cheek and breast naked. Opercles scaled.

Preoperculomandibular canal pores 10(12). Infraorbital canal pores 7(1), 8(9), 9(2); $\bar{x}$=8.1, SD=0.49. Lateral canal pores 3(1), 4(11); $\bar{x}$=3.9, SD=0.28. Supratemporal canal pores 2(11), 3(1); $\bar{x}$=2.1, SD=0.28. Supraorbital canal pores 4(12). Coronal pore 1(12).

Males of *E. chuckwachatte* were found to have a significantly greater caudal fin length than females, while females possessed a larger eye diameter than males ($P<0.05$, Table 1). No other significant differences were found in either morphometric or meristic traits.

COLORATION.—Males and females are dichromatic; males being more brightly colored than females throughout year, dichromatism reaching its peak during the spring. Coloration of males same as in *E. jordani* with the exception that males of *E. chuckwachatte* have bright red lips and a broad red band through the anal fin. Coloration of females same as in *E. jordani*. Coloration of a male and female in breeding condition are depicted in Figures 3D and 3E.

DISTRIBUTION.—*Etheostoma chuckwachatte* is known from throughout the Tallapoosa River System above the Fall Line in Alabama and Georgia. Known localities of *E. chuckwachatte* are depicted in Figure 4.

ECOLOGY.—Adults typically inhabit riffles with a moderate to strong current (Zorach, 1969; Orr, 1989) over gravel and/or cobble substrate. Orr (1989) reported that larvae of dipterans, ephemeropterans, and plecopterans accounted for the majority of the diet in *E. chuckwachatte* from Hillabee Creek (Tallapoosa County, Alabama). Orr and Ramsey (1990) presented details of the reproductive ecology of *E. chuckwachatte* from Hillabee Creek. Based on mean gonadosomatic index, peak reproductive activity occurred in the first week of May. Females with ripe ova were found from 7 April through 30 June at water temperatures of 20.0-25.6 C. The smallest mature female captured during this investigation was 29.0 mm SL (Orr and Ramsey, 1990). While *E. chuckwachatte* has not been observed spawning, it is assumed to be an egg burier.

ETYMOLOGY.—*Etheostoma chuckwachatte* ('shŭck wə 'shä tē) is named from the anglicized version of the Creek Indian words for mouth, chuckwe; and red, chattee; and refers to the bright red lips on the mouths of breeding males of this species. The common name, lipstick darter, is also in reference to the bright red lips on breeding males.

COMPARISONS.—Species of the *Etheostoma jordani* group are easily distinguished from one another on the basis of squamation, meristic characters, general head and body shape, and pigmentation patterns (Table 3). *Etheostoma douglasi* is distinguished from other members of the species group, and all other members of *Nothonotus* except *E. acuticeps*, with its lack of exposed scales on the opercle (Table 2). While meristic characters among the species are similar, *E. etowahae* has fewer lateral line scales, fewer scale rows above and below lateral line at the caudal peduncle, and fewer transverse scale rows than the remaining three species in the group (Table 2). This pattern of interspecific variation is further summarized by principal component analysis of meristic variables for both males and females (Fig. 5; Table 4). *Etheostoma etowahae* is almost completely separated from the remaining three species along PCI. Meristic variables loading most heavily along PCI include scale rows above and below lateral line, caudal peduncle scale rows, and lateral line scale rows (Table 4).

General patterns of variation of head and body shape

Table 3. Characters useful in distinguishing species of the *Etheostoma jordani* species complex.

Characteristic	*E. jordani*	*E. douglasi*	*E. etowahae*	*E. chuckwachatte*
Transverse scale rows	14–16	14–16	11–14	14–16
Caudal peduncle scale rows	18–21	19–22	16–18	17–20
Red spots on side of body	present	absent	absent	present
Red stripe in anal fin	absent	absent	absent	present
Red pigment on lips	absent	absent	absent	present
Scales on opercle	present	absent	present	present

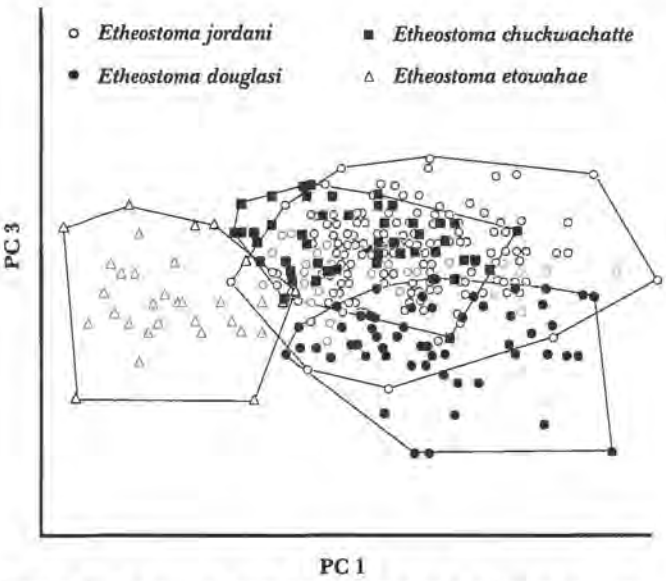

Figure 5. Principal component analysis of meristic variables for males and females of the *Etheostoma jordani* species group.

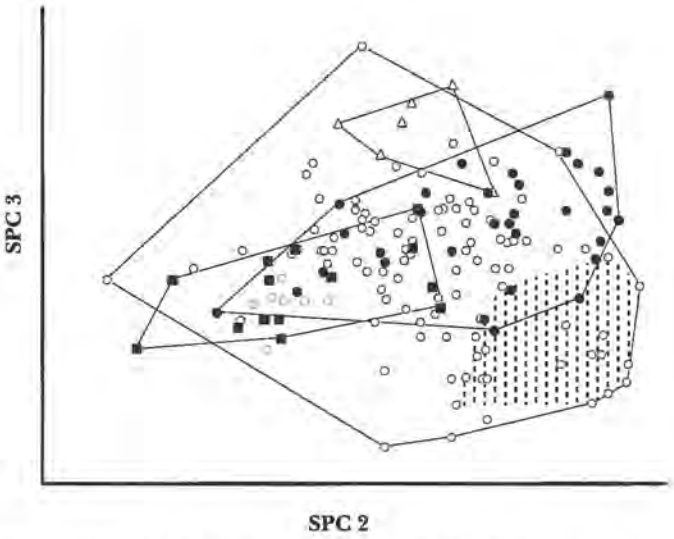

Figure 6. Principal component analysis of sheared morphometric variables for males of the *Etheostoma jordani* species complex. Shaded area represents the population of *E. jordani* below the Fall Line in the Tallapoosa River system.

differentiation are best summarized in sheared principal component analysis (Fig. 6; Table 5). While variation of mensural characters within *E. jordani* broadly overlap the remaining three species, *E. etowahae* is completely separated from *E. chuckwachatte* and almost entirely separated from *E. douglasi* in shape features summarized primarily by sheared PCIII. Along sheared PCII, *E. chuckwachatte* is completely separable from those populations of *E. jordani* in closest geographic proximity, namely populations in the Tallapoosa River below the Fall Line (the latter population highlighted by shading). Mensural variables loading heavily along sheared PCII include caudal fin length, pectoral and pelvic fin lengths, and head length; along sheared PCIII head length, snout length, pectoral fin length, and anal fin base length loaded most heavily. Generally *E. etowahae* has a shorter head, snout, and pectoral fins, and a longer anal fin base than the other three species in the group. *Etheostoma chuckwachatte* generally has a longer head, and shorter pectoral, pelvic, and caudal fins relative to populations of *E. jordani* in closest geographic proximity (Fig. 6; Table 5).

Table 4. Variance loadings for the principal components in the analysis of meristic variables for males and females of species of the *Etheostoma jordani* species group.

Variable	PC I
Lateral Line Scales (L.L.)	0.53173
Scale Rows Above L.L.	0.74112
Scale Rows Below L.L.	0.79677
Scale Rows Above L.L. at Peduncle	0.77490
Scale Rows Below L.L. at Peduncle	0.78444
Dorsal Fin Spines	-0.13191
Dorsal Fin Rays	0.05877
Anal Fin Rays	-0.01361
Pectoral Fin Rays	-0.04835
Caudal Rays	-0.06424
Percent Breast Squamation	0.13814
Percent Opercle Squamation	0.03977
Percent Nape Squamation	0.36931

Several pigmentation characters also serve to distinguish the four species in the group. Males of *Etheostoma jordani* and *E. chuckwachatte* are distinguished from those of *E. etowahae* and *E. douglasi* by the presence of red spots on the side of the body. Males of *E. chuckwachatte* are distinguished from all other members of *Nothonotus*, except *E. rufilineatum*, by the presence of red lips; they are further distinguished from all other members of the *E. jordani* group by this character and the presence of a broad red band through a typically blue—turquoise anal fin.

COMPARATIVE BIOGEOGRAPHY.—Within the Mobile Basin a number of other species possess geographic patterns of disjunction and endemism consistent with those exhibited by members of the *Etheostoma jordani* species group. The genus *Cyprinella* contains sister taxa that are congruent in distribution with *E. jordani* and *E. chuckwachatte*. *Cyprinella gibbsi* is restricted to the Tallapoosa River largely above Lake Martin (compare to *E. chuckwachatte*) while its sister species *C. trichroistia* is found in the Cahaba and Coosa River systems with a few reported populations in the Alabama River (compare to *E. jordani*) and upper Black War-

rior River *(E. douglasi)*. Within the topminnow genus *Fundulus* a biogeographic pattern emerges that is largely consistent with the distributions of *E. jordani* and *E. chuckwachatte*. *Fundulus bifax* is nearly restricted to the Tallapoosa River System (one population known from a tributary to the lower Coosa River), while *F. stellifer* is more wide ranging and found in the Cahaba, Coosa, and Alabama River systems as well as the Chattahoochee River System. While this pattern is not identical to that of *Etheostoma jordani* and *E. chuckwachatte*, the similarities are striking.

Within the genus *Etheostoma*, there are a number of species within the snubnose darter clade which exhibit distributional patterns consistent with those of the *E. jordani* species group. Within the range of *Etheostoma douglasi* there is currently at least one endemic species, the undescribed Warrior darter. Within the range of *E. jordani* and *E. etowahae*, *E. coosae* and *E. brevirostrum* are restricted to the Coosa River System (Suttkus and Etnier, 1991). The distribution of the Tallapoosa darter *E. tallapoosae* is almost identical with that of *E. chuckwachatte*, while the undescribed Cherokee darter is found within the same regions of the Etowah River System as *E. etowahae* although the two species are not known to be syntopic (N. M. Burkhead, pers. comm.).

Within the genus *Cottus*, Robins (1954) and Williams and Robins (1970) recognized that members of the *Cottus carolinae* complex from the Mobile Basin were distinct from other populations of *C. carolinae* and belonged to two distinct subspecies. One of these, *Cottus carolinae zopherus* is restricted to the Coosa River System and is distinct from forms in the upper Tallapoosa River, the upper Black Warrior River, and the upper Etowah River. This geographic pattern is once again quite similar to that exhibited by *Etheostoma jordani*, *E. chuckwachatte*, *E. douglasi*, and *E. etowahae*.

Table 5. Variance loadings for the principal components in the analysis of morphometric variables for males of species of the *Etheostoma jordani* species group.

Variable	Sheared PC II	Sheared PC III
SL	-0.07502	-0.16617
HL	-0.23828	-0.26374
HD	0.00162	0.07227
HW	-0.00034	0.14862
SN	-0.21025	-0.48111
PL	-0.13408	-0.22175
ED	-0.18404	-0.22324
PT	0.35903	-0.27995
PV	0.22997	-0.17345
DIL	-0.10372	-0.04041
DIIL	-0.13887	0.11064
AL	0.03278	0.52794
CL	0.78391	-0.13876
CD	-0.02959	0.01532
D10—11	0.01639	0.11432
D11—20	-0.08775	-0.09025
D12—20	-0.01702	0.11432
D12—19	-0.04800	0.18956
D10—12	-0.04383	-0.00001
D13—20	-0.01299	0.23299

CONSERVATION STATUS.—Based on the known distributional status of the four species contained within the *Etheostoma jordani* species group, three of the species are in need of special status by state and federal agencies. We recommend minimally according the status of threatened to *E. douglasi* and *E. chuckwachatte; E. etowahae* merits endangered species status. The wider distribution of *E. jordani* and its relative abundance in some streams in which it occurs prevent us from recommending protection until a thorough status survey has been conducted.

To date, a thorough status survey has only been conducted on one of these species, *E. etowahae* (Burkhead, 1992). In this study Burkhead recommended that *E. etowahae* be listed as Federally endangered due to its extremely restricted range and continuing habitat degradation. We fully agree with these conclusions and support his recommendation for endangered species status. Similar studies must be conducted on the remaining three members of the complex. *Etheostoma chuckwachatte* and *E. douglasi* have fragmented and restricted geographic distributions (Fig. 4) in watersheds that are also suffering from general habitat degradation and have recently been targeted for impoundments and/or proposals aimed at water removal for urban usage. In either case, habitats necessary for the continued existence of either species will be eliminated or severely jeopardized. While *E. jordani* is more widespread geographically than other members of the group, its range is fragmented (Fig. 4). Habitat degradation in any area inhabited by species in this group could result in permanant loss of a population or series of populations and their gene pools. Unfortunately, this has apparently already occurred at the type locality for *E. jordani*. Recent efforts to locate *E. jordani* near Oxford, Alabama and vicinity failed. In fact, no fishes were collected from the heavily polluted Choccoloco Creek near Oxford.

Because of the general predilection in this species group and other *Nothonotus* for high-gradient, clear

streams with silt-free gravel and cobble substrate, these species will be sensitive to both indirect and direct habitat degradation. These traits, combined with the general distribution of these fishes in the upper Mobile Basin, make them valuable indicator species of the general quality of many aquatic ecosystems in the basin. Their fragmented ranges, together with impending threats to aquatic and nearby terrestrial ecosystems warrant concern for their continued existence.

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Material examined not designated as types.

Etheostoma jordani. Etowah River: Bartow County, Georgia: UF 80098 (3), INHS 75088 (3), RMW-91-50 (4), Stamp Cr. at GA Hwy 269, 6.4 km SE of White; UAIC 9814.06 (1) Two Run Cr., S of Kingston off new US Hwy 411. Paulding County, Georgia: UF 80125 (25), UAIC 10103.11 (2), Raccoon Cr. at Braswell Mountain Road, 6.0 km NE of Braswell. Conasauga River: Bradley County, Tennessee: UAIC 3901 (42) Conasauga R. on TN Hwy 74, 1.6 km downstream from TN-GA state line; UAIC 5663.07 (11) Conasauga R. at TN Hwy 74. Polk County, Tennessee: UAIC 6768.05 (11) Ball Play Cr., 1.8 km NE of Conasauga; USNM 231368 (57) Minnewauga Cr. off of US Hwy 411. Murray County, Georgia: UAIC 6240.13 (25) Conasauga R. at Co. Rd. 173. Coosawattee River: Pickens County, Georgia: CU 53247 (13), CU 63900 (5) Talking Rock Cr. on GA Hwy 5, 18.4 km SSW of Ellijay; TU 40727 (16) Talking Rock Cr. on GA Hwy 5, 21.8 km S of Ellijay. Murray County, Georgia: CU 24938 (7) Unnamed tributary of Coosawattee R., 8.2 km S of Chatsworth on US Hwy 411. Oostanaula River. Whitfield County, Georgia: USNM 162367 (6) Tributary of Oostanaula R., 9.8 km S of Dalton on US Hwy 41; USNM 168011 (1) Triburary of Oostanaula R., 9.3 km S of Dalton on US Hwy 41. Murray County, Georgia: USNM 168037 (14) Tributary of Oostanaula R., 8.3 km SSE of Chatsworth on US Hwy 411. Coosa River. Clay County, Alabama: UAIC 5565.08 (11), UAIC 5814.09 (18), UAIC 5816.12 (22), Cheaha Creek; UAIC 5550.15 (10), UAIC 5566.12 (16), Threemile Creek; UAIC 8532.12 (3) 11.5 km WNW of Millerville at AL Hwy 7. Cleburne County, Alabama: UAIC 6626.09 (14), Shoal Creek at Forest Service Rt. 509, Choccoloco Wildlife Management Area; AU 385 (21) Hatchet Cr., 8.0 km N of Goodwater on AL Hwy 7. Coosa County, Alabama: UAIC 2174 (2) Tributary to Swamp Cr., 2.7 km ENE of Rockford; UAIC 8470.16 (3) Weogufka Ck., 1.3 km NW of Moriah; UAIC 8529.10 (10) Peckerwood Cr., 5.3 km NNE of Marble Valley; AU 1092 (7) Hatchett Creek, 8.3 km N of Goodwater on AL Hwy 7; AU 16780 (13) Weogufka Cr., 9.1 km SSE of Weogufka; AU 18581 (8) Hatchet Cr., 6.1 km N of Rockford on AL Hwy 231; AU 20083 (7) Peckerwood Cr., 3.4 km SSE of Talladega Springs; AU 20916 (14) Hatchett Creek, 6.6 km N of Rockford. Talapoosa River: Macon County, Alabama: UT 91.1911 (33), AU 5472 (10) Line Creek, 7.5 km WSW of Shorter on US Hwy 85; AU 6562 (22), AU 12159 (3), AU 21960 (9), Uphapee Ck., 5.6 km N of Tuskegee at US Hwy 85. Cahaba River: Bibb County, Alabama: UAIC 5576.09 (9), UAIC 5581.16 (16), UAIC 5604.25 (17), Little Cahaba River at Bulldog Bend; UAIC 5585.13 (30) Schultz Creek at AL Hwy 219, 6.4 km N of Centreville; UAIC 8339.15 (11) Cahaba River at AL Hwy 27 bridge. Shelby County, Alabama: UAIC 5593.05 (5) Cahaba River at AL Hwy 251.

Etheostoma douglasi. Sipsey River: Winston County, Alabama: UAIC 4329.15 (92) Sipsey River at Sipsey Fork Rec. Area; UAIC 6265.12 (49) Hubbard Creek at Sipsey River Rec. Area, AL Hwy 60 in Bankhead Natl. Forest. Jefferson County, Alabama: UAIC 1906 (31), UAIC 3305 (16), UAIC 3342 (19), Gurley Creek on AL HWY 79, 0.4 km S of Blount-Jefferson Co. line.

Etheostoma etowahae. Etowah River: Dawson County, Georgia: UF 15789 (2) Etowah R. 1.1 km NW of Landrum on GA Hwy 136; UT 91.1902 (4) Etowah R. at GA Hwy 53, 6.4 km SE of Dawsonville.

Etheostoma chuckwachatte. Tallapoosa River: Randolph County, Alabama: UAIC 8487.11 (7) Crooked Cr., 7.4 km NW of Malone; UAIC 8488.10 (6), UAIC 8489.14 (8)

Cornhouse Cr., 4.2 km NE of Malone. Tallapoosa County, Alabama: 8486.20 (20) Eumuckfaw Cr., 5.3 km SSE of New Site; UAIC 8476.15 (48) Tallapoosa R., 10.7 km SSW of Daviston.

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