ALABAMA
MUSEUM
of Natural History

Bulletin

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BULLETIN
ALABAMA MUSEUM OF NATURAL HISTORY

The scientific publication of the Alabama Museum of Natural History. Richard L. Mayden, Editor, John C. Hall, Managing Editor.

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The BULLETIN is devoted primarily to scholarship and research concerning the natural history of Alabama and the Midsouth. It appears irregularly in consecutively numbered issues.

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When citing this publication, authors are requested to use the following abbreviation: **Bull. Alabama Mus. Nat. Hist.**

ISSN: 0196-1039

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THE UNIVERSITY OF ALABAMA
TUSCALOOSA, ALABAMA

May 1, 1995

Etheostoma (*Ulocentra*) *scotti* (Osteichthyes: Percidae), a new darter from the Etowah River system in Georgia.

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ABSTRACT: Bauer, Bruce H., David A. Etnier, and Noel M. Burkhead. 1994. *Etheostoma* (*Ulocentra*) *scotti* (Osteichthyes: Percidae), a new darter from the Etowah River system in Georgia. Bulletin Alabama Museum of Natural History, Number 17:1–16 6 tables, 3 figures. *Etheostoma scotti*, a new darter of the subgenus *Ulocentra*, is described from the Mobile Basin, where it is endemic to the middle portion of the Etowah River system of north Georgia. It is one of three *Ulocentra* species that occurs in the Etowah system, with *E. brevirostrum* occurring in a few tributaries to the upper Etowah River and *E. coosae* occurring in the lower end of the system. *Etheostoma scotti* is a member of the *Etheostoma duryi* species group and is interpreted as being the sister species of *E. coosae*. It differs from *E. coosae* in having a broad brick-red band rather than a narrow red band in the spinous dorsal fin of nuptial males, in having 5 or 6 branchiostegal rays (typically 6 in *E. coosae*), and in having higher vertical scale counts. It differs markedly from *E. brevirostrum* in snout shape, lack of a red band in the anal fin, and in having 5 or 6 branchiostegal rays (consistently 5 on each side in *E. brevirostrum*).

Introduction

There are currently eighteen described species of the subgenus *Ulocentra* sensu Bouchard (1977) and Bailey and Etnier (1988) in addition to the species described herein (see recent papers by Boschung et al., 1992; Suttkus and Bailey, 1993; and Suttkus et al., 1994). The members of *Ulocentra*, commonly called the snubnose darters, are distributed in Gulf Coastal drainages from the Choctawhatchee west to the Mississippi River, the Cumberland and Tennessee rivers, and southern tributaries of the Ohio River.

While the status of the subgenus *Ulocentra* is controver-

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sial among students of darters (Page 1981; Bailey and Etnier 1988; Boschung et al. 1992), members of the group are easily recognized by a suite of physiognomic characters, and for many species, by the striking dichromatic coloration of nuptial males. The recent spate of descriptions of new species in the subgenus is largely the result of species long known to ichthyologists at last being formally described. That, however, is not the case for *Etheostoma scotti*; it was first recognized by one of us (BHB) in 1984 by unique aspects of its chromatic coloration.

It is likely that most of the remaining truly new species yet to be discovered will be cryptic and will have limited distributions, and that at least some will also merit conservation protection at the time of their description. It is a lamentable commentary on our societal stewardship of fluviatile aquatic ecosystems, that in North America, arguably the center of most intense study by systematic ichthologists in the world, scientific recognition of biodiversity is running neck-to-neck with its imperilment.

Methods

Except as noted, counts and measurements were made following methods defined by Hubbs and Lagler (1958). Proportional measurements are expressed as thousandths of standard length. Transverse body scales were counted from the origin of the anal fin diagonally upward to the base of the spinous dorsal fin. Gill rakers, counted on the anterior arch on the right side, include both dorsal and ventral rudiments. Measurements were made with needle-point dividers and a precision steel ruler and estimated to the nearest 0.1 mm. Trans-pelvic width was measured between the outer bases of the pelvic spines. The cephalic canals of the lateralis system were analyzed in accordance with the methods of Hubbs and Cannon (1935). Vomerine teeth were detected under magnification with the use of a fine stream of compressed air. The lower jaw was partially dissected away to better expose the teeth. The nape, cheek, opercle, prepectoral, and breast regions were examined for the extent of squamation. Values for the holotype appear in boldface in Tables 1–4. The equality of means for meristic characters from northern and southern tributary populations was tested with Student's t-test for unequal sample sizes (Steel and Torrie, 1980). Because the t-tests are not independent, the sequential Bonferroni technique (Rice, 1989) was used to determine critical values. However, exact Bonferroni P-values were not iterated; the results are only reported as not significant or significant at $P_{.05}$.

Physiographic province and subsection boundaries follow Wharton (1978); portions of these boundaries were checked against 7.5 minute U.S.G.S. topographic quadrangles. The Lake Allatoona map published by Atlantic Mapping, Inc., Marietta, GA, was very helpful in identifying small creeks and geographic names in the vicinity of Allatoona Reservoir. Observations and video recordings of spawning behavior were of fish housed in a 1.23 X 2.46-m (4 X 8-ft) plexiglass current tank. Current was generated in the tank with an electric 8.2-kg (18-lb) thrust trolling motor which propelled water in a circular fashion around a central divider in the tank.

Specimens of the new species and comparative material of *Etheostoma coosae* were received from the collections at Auburn University (AUM), Cornell University (CU), Tulane University (TU), University of Alabama (UAIC), University of Florida (UF), University of Georgia (UGAMNH), University of Michigan (UMMZ), and University of Tennessee (UT). In the listing of type material, each catalog number is followed by the number of specimens and range of standard length (SL) in millimeters, e. g., (10, 25–48). In addition to standard compass directions, the following abbreviations are used: Cr. = Creek, R. = River, mi. = mile(s), airmi. = airmile(s), trib. = tributary, Hwy. = Highway, Rd. = Road, Co. = County. In lists of materials not designated as types, the catalog number is followed by the number of specimens enclosed in parentheses. We include collection dates for all of the Cherokee darter material because the species has disappeared from numerous localities in the known and inferable portion of its very limited range.

***Etheostoma scotti*, new species**
Cherokee Darter
Figures 1 and 2

Ulocentra, undescribed species. Bailey and Etnier, 1988, p. 18, Etowah River system, 5 or 6 branchiostegal rays; Suttkus and Etnier, 1991, p. 2, middle Etowah River system.

Etheostoma (*Ulocentra*) sp., Cherokee darter. U.S. Federal Register 1989, 1991, Notice of Review, Category 2.

Cherokee darter. Burkhead et al., 1992, p. 15, imperiled aquatic fauna in Etowah River system, conservation.

Cherokee Darter (*Etheostoma* (*Ulocentra*) sp.). U. S. Federal Register, 1993, Volume 58(199), 50 CFR Part 17, pp. 53696–53702, proposed listing as threatened, distribution, threats to survival.

Etheostom (*Ulocentra*) sp. Cherokee darter. U.S. Federal Register, 1994, Volume 59(243), 50 CFR Part 17, pp. 65505–65512, listed as threatened.

Cherokee darter (*E. ulocentra*). Science 1995, 267; p. 1256, photograph.

HOLOTYPE—UMMZ 223256, adult male, 47.2 mm SL, McCannless Creek, trib. to Shoal Cr., above GA Hwy. 108, at jct. GA 108 and Darby Rd., 1.75 airmi. S of center of Waleska, Cherokee Co., GA, 3 May 1990. N. M. Burkhead, B. J. Freeman, C. R. Gilbert, S. J. Walsh, J. D. Williams (Figure 1).

PARATOPOTYPES—Collected with the holotype are UF 84842 (12, 34–48).

A

B

C

Figure 1.—Nuptial *Etheostoma coosae* and *E. scotti*. A. *E. coosae*, peak nuptial 58-mm SL male, Mosely Spring, Chattooga County, Coosa River system (UF 99854); B. *E. scotti*, peak nuptial 55-mm SL male, Shoal Creek, Dawson County (UF 99855): C. *E. scotti*, gravid 39-mm SL female, Rock Creek, Pickens County.

Table 1. Frequency distribution of lateral-line scale counts in *Etheostoma scotti* and *E. coosae* (count for holotype in boldface).

	Lateral Line Scale Rows																	
	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	N	$\overline{X}$	SD
Etheostoma coosae	2	5	3	22	27	50	38	47	35	19	14	8	4	3	2	279	50.4	2.51
Etheostoma scotti																		
Northern Tributaries		1	6	8	18	20	24	25	**16**	12	8	4	2	1		145	50.4	2.37
Southern Tributaries			6	4	17	19	20	44	30	15	13	11	10	2	1	192	51.3	2.51
Total		1	12	12	35	39	44	69	**46**	27	21	15	12	3	1	337	50.9	2.49

PARATYPES—*Northern tributaries to Etowah River, GA:* **Shoal Creek System, Cherokee Co.**—UF 89756 (2, 40–46), Shoal Cr. at GA Hwy. 108, 4.5 airmi. SSW of Waleska, 9 July 1991; UF 93512 (3, 35–43), Shoal Cr. at Pleasant Arbor Rd., 1.5 airmi. N of Waleska, 18 October 1989; UF 93510 (3, 20–39), Shoal Cr. at Co. Rd. 35, 0.7 airmi. NW of Waleska, 9 July 1991; UGAMNH 2466 (14, 27.5–47), Little Shoal Cr. at GA Hwy. 108, 6.3 airmi. SW of Waleska, 24 January 1992; UT 91.4353 (18, 35–55), same site, 4 May 1993; UGAMNH 645 (9, 37–52), Schoolhouse Cr., trib. to Shoal Cr., at GA Hwy. 140, N of Waleska, 26 April 1959. **Sweetwater Creek System, Cherokee Co.**—UGAMNH 280 (8, 35–42), 3 April 1953. **Stamp Creek System, Bartow Co.**—UF 93516 (7, 30–47), Stamp Cr. at GA Hwy. 269, 17 October 1989; UF 93508 (14, 34–50), same site, 21 September 1990; UT 91.4153 (2, 47–49), Stamp Cr. ca. 1.6 mi. above GA Hwy. 20, 18 October 1991; UT 91.4205 (1, 30) and UT 91.4206 (2, 30–43), Stamp Cr. 0.8 airmi. below GA Hwy. 269, 15 November 1992; UT 91.4357 (2, 38–40), Boston Cr. above Stamp Creek Rd., 6 May 1993. **Jug Creek System, Cherokee Co.**—UT 91.4347 (4, 35–51), Jug Cr. at crossing of unnamed logging rd., 4 May 1993. **Puckett Creek System, Cherokee Co.**—UT 91.4362 (4, 37–45), Puckett Cr. at private continuation of Old Shoal Creek Rd., 6 May 1993. **Hickory Log Creek System, Cherokee Co.**—UT 91.4350 (13, 35–55), Hickory Log Cr. at I-575 Canton Exit, 4 May 1993; UT 91.4363 (11, 35–49), Hickory Log Cr. at end of Vandiver Rd., 3 May 1993. **Sharp Mountain Creek System, Cherokee and Pickens Cos.**—American Museum of Natural History 98094 (3, 37–54), United States National Museum 325063 (4, 45–57), and University of Kansas 23134 (4, 43–59), all from Sharp Mountain Cr. at ford 0.3 rd. mi. NNW of Co. Rd. 774 bridge, Cherokee Co., 19 September 1990; CU 73724 (3, 40–45), Sharp Mountain Cr. at GA Hwy. 108, Pickens Co., 25 June 1991; INHS 29644 (13, 35–54), Sharp Mountain Cr. at Co. Rd. 307, 3.7 airmi. SSW of Jasper, Pickens Co., 21 January 1992; UF 84833 (11, 42–57), Rock Cr. at Co. Rd. 307, 5.25 airmi. W of Nelson, Pickens Co., 3 May 1990; UF 93511 (1, 33), Bluff Cr. at Co. Rd. 114, 4.4 airmi. W of Ball Ground, Cherokee Co., 18 October 1991. **Conn Creek, Cherokee Co.**—UF 93517 (4, 39–46), Conn Cr. at GA Hwy. 775, 3.9 airmi. E of Ball Ground, 13 October 1989. **Long Swamp Creek System, Pickens Co.**—UF 84810 (5, 30–42), Long Swamp Cr. at GA Hwy. 53, 3 May 1990; UGAMNH 816 (2, 33–34), East Branch Long Swamp Cr. near Tate, 20 October 1962; UF 84826 (5, 38–51), Norton Cr. 1.5 airmi. NE of Jasper, 3 May 1990; Illinois Natural History Survey 29400 (7, 30–55), Northeast Louisiana University 68475 (6, 41–46), Southern Illinois University at Carbondale 21123 (7, 39–46), and UAIC 10607.01 (7, 36–54), all from Four Mile Cr. at Co. Rd. 52, 3.9 airmi. SE of Tate, 21 November 1991. **Yellow Creek, Dawson Co.**—UGAMNH 2039 (4, 34–47), Yellow Cr. at Co. Rd. 192, 2 April 1990; UGAMNH 2043 (6, 32–54), Yellow Cr. 2 km. above Co. Rd. 192, 4 April 1990; UGAMNH 2044 (1, 54), Yellow Cr. 900 m. above Co. Rd. 192, 4 April 1990. **Shoal Creek System, Dawson Co.**—CU 19541 (19, 41–54), Etowah R. trib. (Shoal Cr.?) 2 mi. N of Dawsonville, 26 March 1951; UAIC 2911.06 (2, 42–43), Shoal Cr. 1 mi. W of Dawsonville at GA Hwy. 53, 18 April 1968; UF 84736 (9, 37–44), Shoal Cr. 1.2 airmi. NNW of Dawsonville, Howser Mill Rd., 4 April 1990; Academy of Natural Sciences of Philadelphia 169838 (2, 45–46), and Royal Ontario Museum 65966 (1, 52) and 65967 (1, 39), Shoal Cr. 2.2 airmi. NNE of Dawsonville at GA Hwy. 136, 21 November 1991; UMMZ 222932 (5, 47–54), Sweetwater Cr. at GA Hwy. 53, 19 November 1991; UF 93514 (1, 50), same site, 23 January 1992; UT 91.4335 (9, 38–44), Pigeon Cr. at Co. Rd. 6, 3.2 airmi. NNW of Dawsonville, 19 November 1991. **Lumpkin Co.**—UF 93518 (6, 35–47), unnamed trib. to Etowah R. at Co. Rd. 109, 6.0 airmi. SW of Dahlonega, 21 November 1991. ***Southern tributaries to Etowah River, GA:* Lumpkin Co.**—UMMZ 223258 (21, 25–46), Camp Cr. at Co. Rd. 1, 3.8 airmi. SSW of Dahlonega, 20 November 1991. **Dawson Co.**—UF 86085 (2, 40–48), Black Mill Cr. at GA Hwy. 318, 4.9 airmi. SSW of Dawsonville, 4 April 1990. **Cherokee Co., small tribs**—UF 93519 (2, 50–56), Smithwick Cr. at Co. Rd. 158, Lula Payne Trail, 4.2 airmi. SE of Ball Ground, 21 January 1992; UT 91.4232 (2, 46–47), Riggin Cr. 4.1 airmi. S of Ball Ground, 9 August 1992; UT 91.4196 (7, 28–43), Edward Cr. near mouth, 5.6 airmi.

Table 2. Frequency distribution of scale counts in *Etheostoma scotti* and *E. coosae* (counts for holotype in boldface).

	Scales Above Lateral Line							Scales Below Lateral Line								
	4	5	6	7	N	$\bar{X}$	SD	7	8	9	10	11	12	N	$\bar{X}$	SD
Etheostoma coosae	2	105	39	2	148	5.28	0.51		33	63	48	2	1	147	9.1	0.81
Etheostoma scotti																
Northern Tributaries		55	**88**	5	148	5.66	0.54	12	61	**56**	19	1		149	8.6	0.84
Southern Tributaries		31	171	16	218	5.93	0.46	4	36	95	68	11		214	9.2	0.85
Total		86	**259**	21	366	5.82	0.51	16	97	**151**	87	12		363	9.0	0.90

	Transverse Scale Rows											
	12	13	14	15	16	17	18	19	20	N	$\bar{X}$	SD
Etheostoma coosae	12	85	79	62	31	9	1	1		280	14.2	1.24
Etheostoma scotti												
Northern Tributaries		18	31	**50**	34	15	1			149	15.0	1.18
Southern Tributaries		23	39	32	51	53	17	1	1	217	15.6	1.53
Total		41	70	**82**	85	68	18	1	1	366	15.4	1.43

	Caudal Peduncle Scale Rows												
	15	16	17	18	19	20	21	22	23	24	N	$\bar{X}$	SD
Etheostoma coosae	1	10	53	65	74	55	17	4			279	18.6	1.35
Etheostoma scotti													
Northern Tributaries		1	11	21	**54**	30	17	4	3		141	19.3	1.32
Southern Tributaries			3	17	51	62	35	15	5	2	190	20.0	1.30
Total		1	14	38	**105**	92	52	19	8	2	331	19.7	1.35

Table 3. Frequency distribution of fin ray counts in *Etheostoma scotti* and *E. coosae* (counts for holotype in boldface).

	Dorsal Spines								Dorsal Rays						
	8	9	10	11	12	N	$\bar{X}$	SD	10	11	12	13	N	$\bar{X}$	SD
Etheostoma coosae		38	162	75	4	279	10.2	0.66	17	127	124	12	280	11.5	0.68
Etheostoma scotti															
Northern Tributaries	2	30	**94**	23		149	9.9	0.64	12	**108**	29		149	11.1	0.51
Southern Tributaries	1	17	129	46		193	10.1	0.57	7	141	44		192	11.2	0.48
Total	3	47	**223**	69		342	10.0	0.61	19	**249**	73		341	11.2	0.50

	Anal Rays						
	6	7	8	9	N	$\bar{X}$	SD
Etheostoma coosae	18	165	95	2	280	7.29	0.59
Etheostoma scotti							
Northern Tributaries	4	71	61	**8**	144	7.51	0.65
Southern Tributaries	1	111	75	2	189	7.41	0.52
Total	5	182	136	**10**	333	7.45	0.58

Table 4. Frequency distribution of fin ray and branchiostegal counts in *Etheostoma scotti* and *E. coosae* (counts for holotype in boldface).

	Left Pectoral Rays							Branchiostegals							
	12	13	14	15	N	X̄	SD	10	11	12	13	14	N	X̄	SD
Etheostoma coosae	1	104	161	13	279	13.7	0.57	20	24	251	2	1	298	11.8	0.57
Etheostoma scotti															
Northern Tributaries	1	19	**111**	11	142	13.9	0.49	15	14	**116**			145	11.7	0.65
Southern Tributaries		45	140	7	192	13.8	0.48	86	39	86	7		218	11.1	0.96
Total	1	64	**251**	18	334	13.9	0.49	101	53	**202**	7		363	11.3	0.90

S of Ball Ground, 14 November 1992; UF 93515 (3, 36–42), Canton Cr. at Co. Rd. 762, Upper Union Hill Rd., 6.7 airmi. NW of Holly Springs, 20 January 1992; UAIC 10737.01 (51, 35–52), Canton Cr. at Scott Rd., Co. Rd. 288, 1.9 airmi. SE of jct. GA Hwy. 20 and I–575, 25 June 1991; TU 167020 (10, 42–55), unnamed trib. to Canton Cr. at GA Hwy. 140, 0.25 rd. mi. E of jct. GA Hwy. 140 and I-575, Canton, 20 July 1992; UGAMNH 44 (4, 17–46), Owl Cr. 1 mi. SW of Victoria, 24 June 1948; UGAMNH 45 (7, 18–46), Kellog Cr. SSE of Canton, 24 June 1948. **Little River System, Cherokee Co.**—UT 91.4212 (2, 49–53), Little R. 0.7 airmi. W of Holbrook, 14 November 1992; UT 91.4361 (2, 45–46), Little R. below Wrights Mill Rd., 5 May 1993. **Allatoona Creek System, Bartow, Cobb, and Cherokee Cos.**—UGAMNH 46 (13, 32–46), Clark Cr. near Allatoona Reservoir, SE of Canton, Bartow Co., 24 June 1948; UGAMNH 48 (6, 20–48) and UGAMNH 47 (9, 18–53), same site, 25 June 1948; UGAMNH 52 (3, 36–44), Allatoona Cr. headwaters, 4 mi. SW of Acworth, Cobb Co., 26 June 1948; UMMZ 210243 (5, 31–46), Proctor Cr. 2 mi. NW of Kennesaw, 4 mi. SE of Acworth, Cobb Co., 9 July 1966; CU 17640 (15, 37–44), Butler Cr. at US Hwy. 41, 10 mi. NW of Marietta, Cobb Co., 30 March 1950; UT 91.2759 (3, 45–51), same site, 12 October 1984; UT 91.3247 (4, 42–48), same site, 26 April 1986; UT 91.2893 (27, 40–53), Butler Cr. at Mack Dobbs Rd., SW of Kennesaw, Cobb Co., 12 April 1985; UF 93509 (5, 39–49), same site, 17 October 1989; UF 84815 (5, 40–52), same site, 5 April 1990; TU 158326 (19, 17–43) and AUM 26548 (19, 17–45), same site, 20 June 1990; UT 91.3246 (15, 37–52), Butler Cr. at Jim Owens Rd., 1.3 mi. E of Acworth, Cobb Co., 15 March 1987; UT 91.3249 (8, 37–50), same site, 21 March 1987; UT 91.3248 (5, 40–55), same site, 10 April 1987; TU 158336 (18, 15–52) and AUM 26558 (17, 18–47), same site, 20 June 1990. **Pumpkinvine Creek System, Paulding Co.**—UF 93513 (3, 36–45), West Fork Cr. at Co. Rd. 94, 6.5 airmi. N of Dallas, 1 August 1991; UMMZ 223257 (8, 35–52) Possum Cr. at Co. Rd. 64, 5.5 airmi. NE of Dallas, 1 August 1991; UGAMNH 2458 (1, 48), Bluffy Cr. at GA Hwy. 468, 5.3 airmi. WSW of Dallas, 16 October 1989; UGAMNH 2467 (12, 22–52), same site, 1 August 1991; UGAMNH 2459 (2, 38–39), unnamed trib. to Pumpkinvine Cr. at GA Hwy. 464, 2.25 airmi. N of Dallas, 17 October 1989; TU 158354 (3, 37–42) and AUM 26577 (2, 36–39), Pumpkinvine Cr. at Hulseytown Rd., 6.2 mi. WSW of Dallas, 20 June 1990; UT 91.4368 (49, 33–44), Picketts Mill Cr. at GA Hwy. 92, 1 August 1991. **Raccoon Creek System, Paulding Co.**—UGAMNH 278 (14, 32–44), Pegamore Cr. 1 mi. above Raccoon Cr., 19 March 1953; UGAMNH 278a (5, 31–57), same site, 4 April 1953; UGAMNH 2460 (7, 31–45), Raccoon Cr. at Braswell Mountain Rd., 3.75 airmi. NE of Braswell, 17 October 1989; UF 84744 (5, 33–52), same site, 5 April 1990; TU 158369 (1, 41), same site, 20 June 1990; UGAMNH 2461 (1, 45), Raccoon Cr. at end of GA Hwy. 493, 4.9 airmi. S of Euharlee, 30 July 1991.

Additional Material Examined But Not Designated as Types—UGAMNH 174a(2), Allatoona Reservoir (presumed to be Allatoona Creek), Bartow Co.; UF 99855 (3, 49–55), Shoal Cr. at Co. Rd. 1 bridge (Howser Mill Rd.), 1.3 airmi. NW center Dawsonville, Dawson Co., 4 April 1995.

Diagnosis—*Etheostoma scotti* is a member of the subgenus *Ulocentra* as diagnosed by Bouchard (1977); it typically lacks a premaxillary frenum (or has a poorly developed one) and has vomerine teeth, as is typical of members of the *Etheostoma duryi* species group of Bailey and Etnier (1988). Within the *E. duryi* species group (*bellator, brevirostrum, chermocki, colorosum, duryi, etnieri, flavum, lachneri pyrrhogaster, ramseyi, raneyi,* and *tallapoosae*) it differs from *brevirostrum, etnieri,* and *pyrrhogaster* in lacking red pigment in the anal fin, and from all species except *coosae* in often (64%, calculated from data in Table 4) having six branchiostegal rays. The species is similar to *E. coosae,* from which it differs primarily in aspects of color patterns of nuptial and near nuptial males. In peak nuptial *Etheostoma scotti,* the spinous dorsal fin is entirely pigmented brick-red except for an irregular basal black band on the anterior two-thirds of the fin, or, if clear bands are present (pre-, post-, or non-nuptial males), dark pigment is evident within the clear bands when examined under magnification. In *E. coosae* the spinous dorsal fin

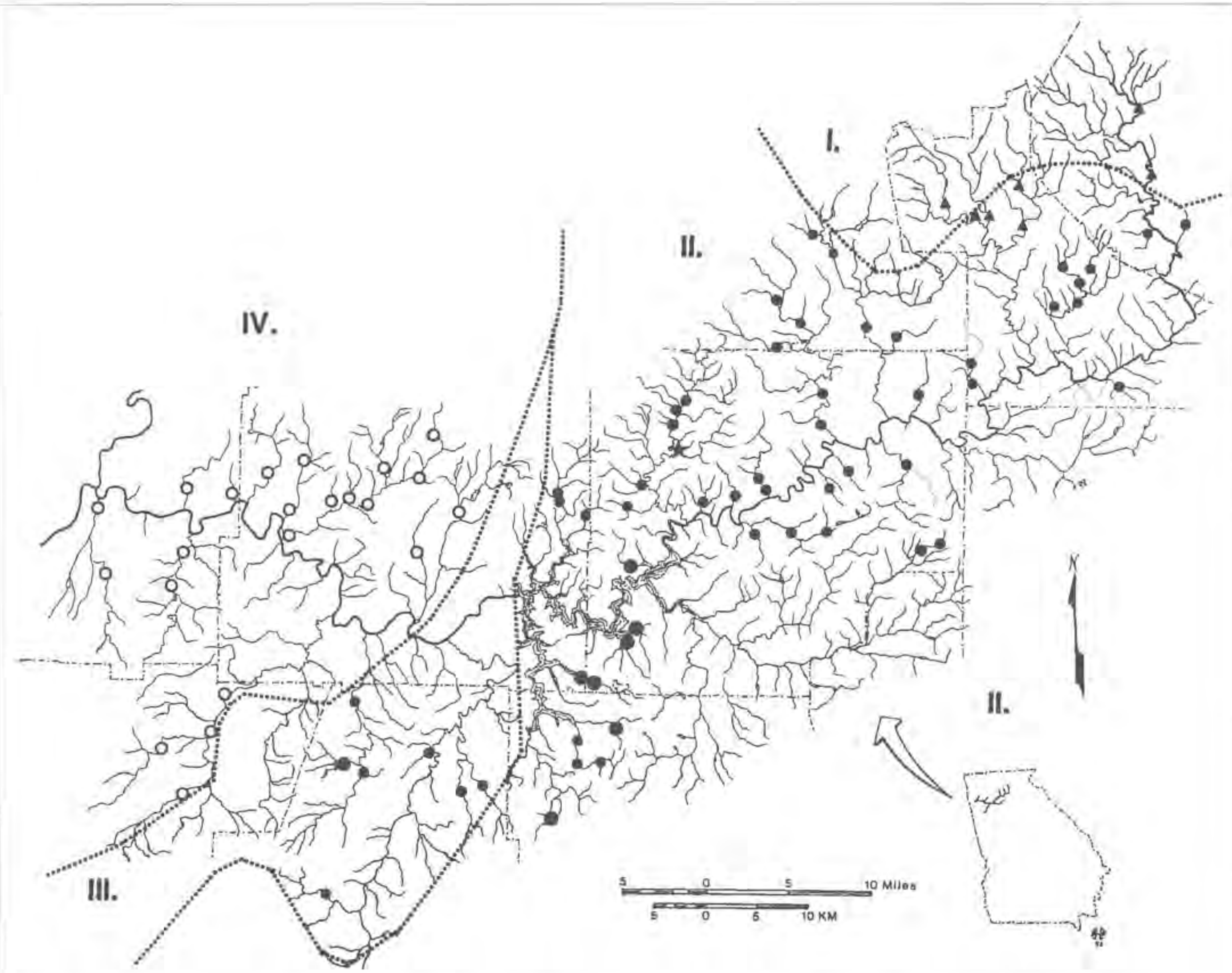

Figure 2.—Distribution of species of *Ulocentra* in the Etowah River system. Open circles are *Etheostoma coosae*; small closed circles are extant populations of *E. scotti*, large closed circles are extirpated populations of *E. scotti*, the star denotes type locality; triangles are *E. brevirostrum*. The bold dotted lines are boundaries to physiographic provinces and province subsections: I, Blue Ridge; II, Upland Subsection of the Piedmont; III, Talladega Upland subsection of the Blue Ridge; IV, Great Valley subsection of the Valley and Ridge. The large impoundment in the center of the Etowah River is Allatoona Reservoir.

has a narrow median red band occupying about one-fourth the height of the fin, and this band is bordered above and below by a clear band devoid of pigment. In small males the lateral bars on the posterior half of *Etheostoma scotti* are more narrow and vertically produced than in *E. coosae*, their width about one-third to one-half the width between bars in *E. scotti*; width of bars is equal to or slightly greater than interspaces in *E. coosae* (Fig. 1). In addition, *E. scotti* has slightly higher vertical scale counts than those of *E. coosae* (Table 2), and branchiostegal ray counts are lower in *E. scotti* (about 64% of counts are 6 rather than 5) than in *E. coosae* (6 in 88% of counts, Table 4).

DESCRIPTION—*Etheostoma scotti* reaches a maximum of 55.6 mm SL (females) to 59.1 mm (males). Frequency distributions of scale, fin ray, and branchiostegal ray counts are presented in Tables 1–4. Lateral line complete with 47–55 scales in 90% or more of specimens (range 45–58). Transverse scale rows 13–17 (13–20), with 5–7 scale rows above lateral line and 8–10 (7–11) scale rows below lateral line. Caudal peduncle scale rows 18–22 (16–24). Dorsal fin with 9–11 (8–11), modally 10 spines and 11–12 (10–12), modally 11 soft rays. Anal fin with 2 spines and 7–8 (6–9), modally 7 soft rays. Pectoral fin rays 13–14 (12–15), modally 14. Branchiostegal rays 5 (35% of counts), 6 (64%), or 7 (1%). Cephalic sensory canals typically complete. Lat-

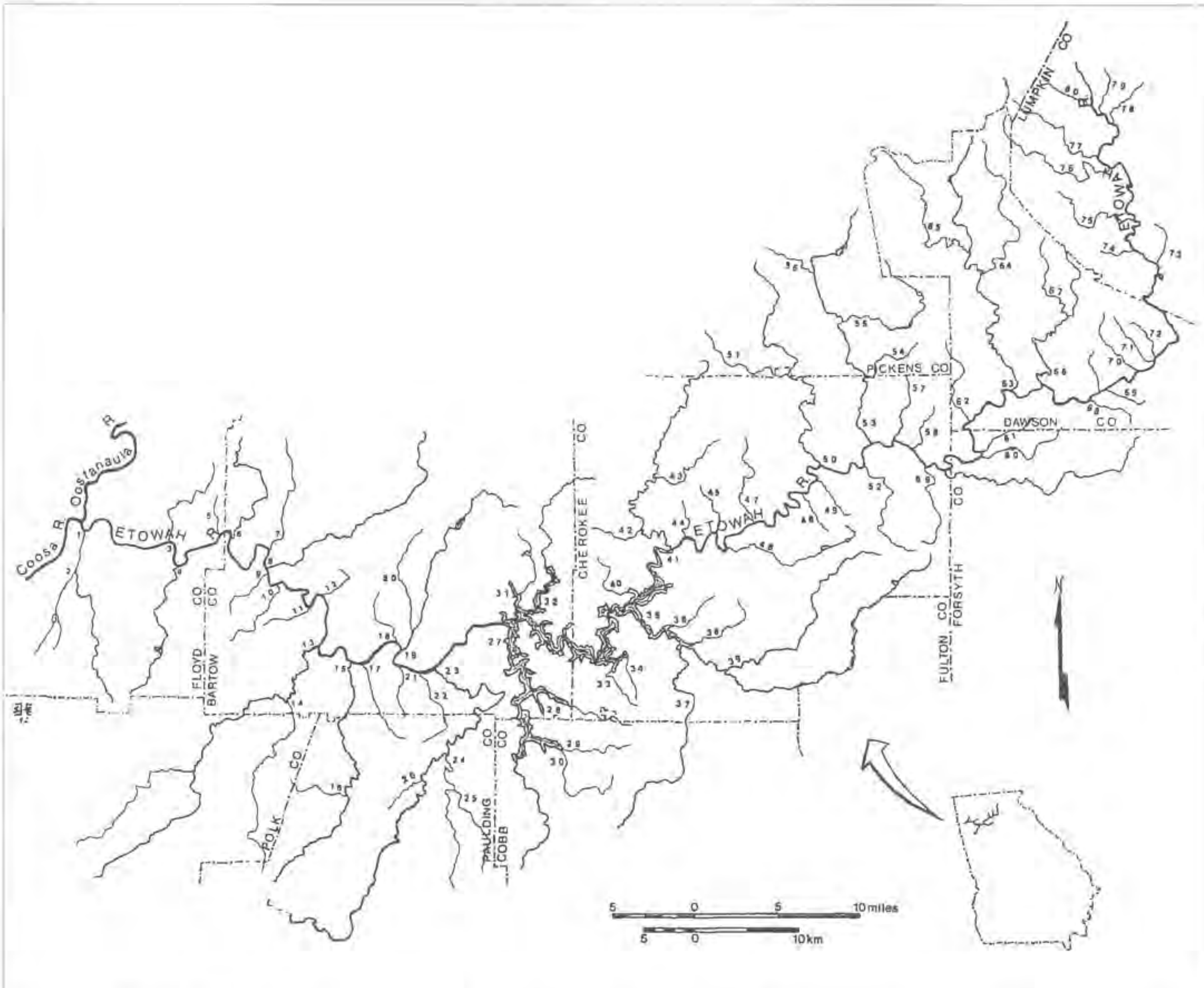

Figure 3.—Political boundaries and major tributary names of the Etowah River system; numbers refer to names listed in Appendix 1.

eral canal (5 pores per side) and supraorbital canal (4 pores per side plus single coronal pore) consistent in 56 specimens examined. Infraorbital canal complete with (sum of both sides) 15 (5 specimens), 16 (116), 17 (22) or 18 (10) pores; in 12 additional specimens this canal was narrowly interrupted at the suborbital bar. Preoperculomandibular canal complete with (sum of both sides) 17 (4), 18 (137), 19 (3), or 20 (1) pores. Supratemporal canal complete in 126 of 179 specimens (all except those in the Allatoona Creek system, see Geographical Variation). In this system the canal was complete in 33 of 36 specimens collected in 1948 and 1950 (UGAMNH 46, 48, 49, 52; CU 17640); in 13 of 29 specimens collected between 1984 and 1987 (UT 91.2759, 91.3246, 91.3247, 91.3248, 91.3249); and in only 5 of 68 specimens collected in 1990 (AUM 26548, 26558; TU 158326, 158336; UF 84815). Gill rakers 9 (1 specimen), 10 (7), 11 (8), 12 (3), or 13 (2); the lower limb with 4 to 7 rudiments and 3 to 4 developed rakers, with length of longest rakers 2 to 3 times their basal width; upper limb typically with three rudimentary rakers or with 2 rudiments and one developed raker. Vomerine teeth consistently present (21 specimens examined) and typically numbering 3 to 5. Belly, opercle, cheek, and nape typically covered with exposed scales. Some individuals have a mixture of exposed and embedded scales on the cheek. Scalation variable on prepectoral area; some specimens have only a few scales, whereas others have entire area covered with scales. The breast is typically naked; however, some individuals have up to 60% of the breast covered with exposed and/or embedded scales.

Selected measurements of males and females, ex-

Table 5. Measurements in thousandths of standard length for *Etheostoma scotti* and *E. coosae males.**

	E. scotti (N = 20)			*E. coosae* (N = 25)		
	Range	$\overline{X}$	S.D.	Range	$\overline{X}$	S.D.
Standard length (mm)	43.1–56.4	51	3.6	40.5–57.4	50.1	4.3
Caudal peduncle length	286–327	304	11.5	288–315	303	7.4
Caudal peduncle depth	99–125	116	6.3	98–114	106	4.6
Head length	238–273	251	8.0	244–269	254	7.1
Body depth at dorsal origin	164–198	183	9.4	190–221	207	9.2
Maximum body width	118–158	135	10.2	119–142	131	6.5
Snout length	56–77	64	4.9	62–74	69	3.3
Orbit length	50–67	58	4.3	59–71	66	2.6
Interorbital width	29–43	35	4.0	37–47	44	2.3
Spinous dorsal fin length	261–327	298	17.5	271–304	287	12.0
Longest dorsal spine length	126–171	151	10.9	107–143	130	8.4
Longest dorsal soft ray	154–182	166	7.6	148–204	176	15.5
Anal fin length	143–276	205	55.4	244–288	269	14.6
First anal spine length	70–99	81	7.6	53–84	72	8.4
Longest anal soft ray	142–166	153	6.3	121–179	146	13.1
Caudal fin length	210–231	218	6.6	193–241	221	12.5
Pectoral fin length	229–275	247	14.1	227–301	269	18.7
Pelvic fin length	178–218	200	10.5	191–247	216	14.5
Trans-pelvic width	71–86	76	4.0	72–86	79	3.1

* data for *E. coosae* taken from Suttkus and Etnier (1991)

pressed as thousandths of standard length, appear in Tables 5–6. Males appear to have longer spinous dorsal and anal fins, whereas females have greater body depth and body width, the latter presumably reflecting the gravid condition of some of the specimens.

Color in life—Chromatic pigmentation of four anesthetized (subdued for photography with MS-222) and three freshly preserved nuptial males, and of one anesthetized female is described from color transparencies. Variation of dark (melanophore) pigmentation of dorsal fins is augmented by detailed notes from four preserved gravid females. As with most species of *Etheostoma* and all species of *Ulocentra*, *E. scotti* exhibits pronounced sexual dichromatism. Male pigmentation is described first.

Males. Ground coloration of head pale straw yellow dorsally, white ventrally, and white on lower cheek and opercle. Dorsum of head dusky dark olive over occiput; snout dusky olive or brown, with oblique preorbital dark olive or black bar; cheek with narrow dark olive or black suborbital bar. Upper portion of cheek and opercle with irregular dark olive or black marks. Head ventrolaterally white or slightly opalescent (two males with a suffused turquoise wash). Body background coloration typically pale straw yellow; dorsum with usually eight dark olive saddles and pale yellow interspaces. Dorsal saddles of equal size and intensity, and located (1) immediately posterior to occiput, (2) under and slightly anterior to origin of spinous dorsal fin, (3) under middle of spinous dorsal fin, (4) under posterior base of spinous dorsal fin, (5) under anterior base of soft dorsal fin, (6) under posterior base of soft dorsal fin, (7) under depressed tips of posterior soft dorsal fin rays, and (8) centered on anterior procurrent caudal fin rays. Saddles typically 1.5 to 2 times wider than pale interspaces. Body pigmented dorsolaterally with combination of dark olive or black irregular diffuse marks and distinct to diffuse X- or Y-marks. Midlateral portion of body marked anteriorly with two or three separate dark blotches, and typically six dark bars, the first with its anterior margin just posterior to middle of spinous dorsal fin base and the last on narrowest portion of caudal peduncle. Anterior blotches black and most intense below lateral line. Lateral bars nearly vertical and black above lateral line, and slightly oblique (slanting down and back) with distinct to subdued turquoise to bluegreen cast below lateral line. The bars sometimes unite with dorsal saddles. Prepectoral area opalescent white or brassy. Remaining ventrolateral portion of body and areas between bars pale yellow. Venter

Table 6. Measurements in thousandths of standard length for *Etheostoma scotti* and *E. coosae females.**

	E. scotti (N = 20)			*E. coosae* (N = 10)		
	Range	X	S.D.	Range	X	S.D.
Standard length (mm)	39.1–49.7	45.5	3.6	42.7–50.2	45.0	2.1
Caudal peduncle length	296–322	304	6.5	295–306	302	3.7
Caudal peduncle depth	97–119	110	4.7	94–108	100	3.9
Head length	237–269	254	7.5	238–263	250	8.1
Body depth at dorsal origin	182–240	213	14.5	202–227	216	7.4
Maximum body width	142–192	170	12.8	137–166	150	9.0
Snout length	60–71	66	3.6	60–68	65	2.9
Orbit length	50–70	61	5.1	66–72	69	2.1
Interorbital width	26–42	34	3.6	42–47	45	1.5
Spinous dorsal fin length	254–296	277	10.5	244–285	262	10.8
Longest dorsal spine length	108–136	125	7.3	95–119	106	6.8
Longest dorsal soft ray	142–169	155	6.8	131–159	144	8.5
Anal fin length	235–270	254	10.3	220–244	231	9.1
First anal spine length	61–84	76	6.1	47–69	58	7.1
Longest anal soft ray	138–162	148	6.2	115–144	130	9.1
Caudal fin length	202–232	216	7.4	207–239	221	10.3
Pectoral fin length	238–286	258	12.6	254–295	273	12.9
Pelvic fin length	181–212	201	9.1	185–229	210	12.3
Trans–pelvic width	67–81	75	4.2	71–81	77	2.7

* data for *E. coosae* taken from Suttkus and Etnier (1991)

with slight yellow tinge. Pale ventral and ventrolateral areas of body, including breast, stippled with small brown chromatophores.

Spinous dorsal fin in peak nuptial males with narrow black basal band, wide suffused brick-red medial pigmentation occupying about three-fourths or more of height of fin, and sometimes a narrow turquoise or blue marginal band. First, second, and sometimes third membranes with bright orange-red ocellus within brick-red band. In nonnuptial males, the brick red medial band is subdivided by subdistal and epibasal clear bands; ocellus typically lacking; marginal band weakly defined dusky or gray rather than blue. Soft dorsal fin with basal black band; remainder of fin suffused brick red, usually less intense than in spinous dorsal fin. Margin of soft dorsal fin dusky, but not intensely so, not forming distinct band. Caudal fin backgound color pale olive yellow, with upper and especially lower procurrent rays suffused with turquoise to blue green; rays and interradial membranes streaked with dark olive and progressively darker toward posterior margin. Anal fin with dark olive interradial streaks extending nearly to margin; distal one-third of rays pale to brilliant turquoise to blue green; entire fin turquoise in one male. Pelvic fins with thickened white leading rays and black interradial membranes; middle of fin suffused with turquoise to blue green. Pectoral fins with clear membranes and rays narrowly bordered with black; dusky yellow olive pigment present on basal two-thirds of rays.

Females. Females with life colors different from those of males as follows. Head and body ground color similar to that of males except ventrolateral portion of abdomen with distinct gold luster. Side of body marked with eight or nine olive black to dark brown subquadrate blotches located just below lateral line; blotches never vertically produced to form bars. Dorsolateral body pigmentation variegated, often with mixture of X- to Y-shaped olive to black marks formed by darkened scale margins and with a few dark olive scales anterolaterally. Middle and posterior dorsolateral portion of body with subdued dark olive blotches directly above but separate from lateral blotches, suggesting interrupted bars. Ventral pale areas between lateral blotches usually with small central black X- or Y-mark, a pattern virtually diagnostic for females. Spinous dorsal fin of females largely transparent with scattered melanophores forming weak epibasal and submarginal bands or interrupted bands. Banding best developed in middle interspinous membranes. First and occasionally second membrane with small red ocellus; last membrane often entirely black. Soft dorsal fin also largely transparent, with rays weakly tessellated; membranes with weakly expressed basal concentrations of melanophores and occasional dark pigment more centrally located. Caudal fin rays prominently tessellated with olive brown bands, an additional distinctive feature of females. Anal, pectoral, and pelvic fins transparent and immaculate.

Color in preservative—Melanophore patterns correspond to dark olive, brown, and black pigmentation described above. Here we note pigment patterns on non-nuptial adults after color has been lost in preservative. Males with midlateral and posterior portion of body marked with dark irregular blotches, vertical bars usually absent. Abdomen and ventrolateral portion of caudal peduncle peppered with tiny melanophores, but breast nearly immaculate. Spinous dorsal fin appearing six-banded, with clear band basally and above and below median dark band in addition to three pigmented bands of nuptial males. Under magnification, small melanophores always present in these clear bands, especially in middle portion of fin. Area of anterior portion of fin where ocellus occurred clear to opaque white and roughly outlined with melanophores. Caudal fin weakly tesselated.

Females with midlateral dark blotches small and subquadrate; bars never present, but ventral edge of blotches often narrowed. Dorsolateral portion of body occasionally with dark and pale irregular wavy lines. In darkly pigmented specimens, ventrolateral pale areas between lateral blotches may have more dark markings than single central mark. Venter immaculate. Caudal fin strongly tessellated.

Temporal Variation—In males, the non-nuptial spinous dorsal fin pattern is typically present from the end of May to late August or September. Filling out of the wide median brick-red band begins in late September to early October. Clear bands in the spinous dorsal fin of fall and winter specimens are finely punctated (under magnification) with few to numerous melanophores. Males from January through April and May exhibit near peak nuptial coloration, with clear bands of the spinous dorsal fin absent, or nearly so.

In Butler Creek, Allatoona Creek system, Cobb County (Figures 2 and 3) we have uncovered evidence of a surprising and alarming teratological phenomenon. The supratemporal canal of the cephalic lateralis system is typically a very conservative and constant character, varying little within species, and typically constant within subgenera of darters. The canal is consistently complete throughout the subgenus *Ulocentra*. In *Etheostoma scotti* collected recently (1990) from Butler Creek, 63 of 68 specimens available had this canal interrupted on the midline. In 29 specimens collected in Butler Creek from 1984 through 1987, 16 had interrupted supratemporal canals. The supratemporal canal was incomplete in only 1 of 15 specimens collected in Butler Creek during 1950 (CU 17640), and in only 3 of 26 specimens collected elsewhere in the Allatoona Creek system in 1948 (UGAMNH 46, 48, 49, 52) and 1966 (UMMZ 210243). *Etheostoma scotti* has been extirpated from the Allatoona Creek system except for Butler Creek, and it seems likely that the failure of the supratemporal system to close normally in this creek is an early warning of the imminent demise of that population. We suspect that the abnormality is environmentally induced and non-genetic, perhaps caused by chemical pollutants entering the system. We think it possible that this is a phenomenon caused by genetic drift subsequent to isolation of the entire Allatoona Creek system by an embayment of Allatoona Reservoir, but this seems far less likely as populations in Butler Creek continued to be large (surely several thousands of individuals) during 1984 and 1990. A special note of thanks is extended to past and present representatives of the research collections of fishes of Cornell University, the University of Georgia, and the University of Michigan, for having the foresight and initiative to maintain these valuable historic collections.

Comparison—*Etheostoma scotti* is compared to species of *Ulocentra* of the Alabama River drainage portion of the Mobile Basin. *Etheostoma scotti* is most similar to, and may be confused with *E. coosae*, but it is relatively easily distinguished from *E. brevirostrum, E. ramseyi*, and *E. tallapoosae* by the absence of oblique median orange or red bands in the soft dorsal and anal fins, and by the lack of orange or red on the body. The most facile characters for separating *E. scotti* from *E. coosae* are chromatic pigmentation of near nuptial and nuptial males (see Diagnosis and Fig. 1). Small modal differences exist in meristic characters between *E. scotti* and *E. coosae* in scales above lateral line (modally 6 in *E. scotti*; 5 in *E. coosae*) (Table 2), transverse scale rows (Table 2) (modally 16 in *E. scotti*; 13 in *E. coosae*), and dorsal soft rays (Table 3) (modally 11 in *E. scotti*; 11 or 12 in *E. coosae*).

Geographic Variation—The following seven of 10 meristic characters had means that were significantly different between northern and southern tributary populations of *E. scotti* (at P.05, df for all characters > 120): branchiostegal rays $t = 6.598$; scales below lateral line $t = 6.627$; scales above lateral line $t = 5.143$; caudal peduncle scale rows $t = 4.886$, transverse scale rows $t = 4.028$; lateral line scales $t = 3.337$; dorsal spines $t = 3.057$. These results seem counterintuitive because the differences between character means of northern and southern populations are small (Tables 1–4); however, the significance of small mean differences in this case is explained by the small variance in large sample sizes.

While these comparisons are not conclusive, they do suggest that the main channel of the Etowah River is a dispersal barrier to the creek-dwelling *E. scotti*. Seven of the 10 characters exhibited the trend for southern populations to average slightly higher character values (Tables 1–

4). Geographic variation in darters at the relatively small scale of the Etowah River system is unusual.

The differences in meristic characters between northern and southern tributary populations, and the supratemporal canal abnormalities (page 11) have conservation implications. If populations of *E. scotti* exhibit significant differences in character expression across a presumably passable river channel, it is anticipated that differences would be exacerbated when populations are isolated by relatively permanent barriers such as Allatoona Dam and Reservoir, or by chronic degradation of stream reaches such as the main channel of the Little River (Fig. 3). The fragmentation of the species range by Allatoona Reservoir has rendered each population fragment more vulnerable to localized threats and subsequent decline or extirpation.

Distribution and Comparative Biogeography—*Etheostoma scotti* is endemic to the upland portions of the middle Etowah River system (Fig. 2) in two physiographic provinces: the Talladega Upland subsection of the Blue Ridge, and the Upland subsection of the Piedmont. Most populations of *E. scotti* occur in the Piedmont Upland subsection (Fig. 2). The Talladega Upland and Piedmont subsections are topographically more similar than the adjacent Valley and Ridge or the Blue Ridge provinces (Fig. 2). Although the Talladega Upland subsection is allied with the Blue Ridge lithologically, Wharton (1978) noted that it was not a part of the Blue Ridge proper. Rather, it is an outlying mosaic of lower elevation, often isolated ridges and rolling hills at the eastern boundary of the Valley and Ridge province.

All species of *Ulocentra* in the Etowah River system demonstrate remarkable fidelity to physiographic provinces, or conversely, avoidance of others. In the Etowah River, *E. brevirostrum* is restricted to the extreme upper system in the Blue Ridge proper and at the base of the Blue Ridge in the Upland subsection of the Piedmont. In all respects, *E. brevirostrum* is a true montane darter. Conversely, *E. coosae* exclusively occurs in the lowland section of the river where it is restricted to the Great Valley subsection of the Valley and Ridge province. The Great Valley subsection is the widest valley segment of the Valley and Ridge province in Georgia. *Etheostoma scotti* is the widest ranging species of *Ulocentra* in the Etowah River system, and, insofar as known, it is allopatric with *E. brevirostrum* and *E. coosae*. *Etheostoma brevirostrum* occurs elsewhere in the Coosa River system, although it too has a limited distribution (Suttkus and Etnier, 1991; our data).

A prominent feature of the Etowah River is Allatoona Reservoir, a large 4,800-ha hydroelectric/flood control impoundment completed in 1949 (Martin and Hanson, 1966; see Fig. 3 for numbered features and Appendix 1 for associated geographic names). Most populations of *E. scotti* are found upstream from Allatoona Dam. Virtually all tributaries draining the northern portion of the Etowah River system above Allatoona Dam harbor *E. scotti*. The two western-most tributaries of these systems (Stamp and Shoal creeks) are truncated in their lower reaches by Allatoona Reservoir (Fig. 2). McCannless Creek, a tributary of Shoal Creek, was selected as the type locality because the section above the State Route 108 bridge is in relatively good condition and contains a healthy population of *E. scotti*. The upper section of Long Swamp Creek in Pickens County slips off the Blue Ridge and holds the most upland populations of *E. scotti* (Fig. 2). Amicalola Creek is the only sizable northern tributary of the Etowah River apparently lacking a population of *E. scotti*, but this system is populated by *E. brevirostrum* in its headwaters. We floated the lower Amicalola Creek and sampled it at two sites, but captured no *E. scotti*.

Populations of *E. scotti* in southern (or eastern) tributaries of the system above Allatoona Reservoir are discontinuously distributed within and between most tributary systems (Fig. 2). *Etheostoma scotti* is absent, or nearly so, from the two largest tributaries: Settingdown Creek in the upper system, and the Little River in the middle system. Only two populations of *E. scotti* are known from the Little River system in its headwaters. It is possible that other equally isolated populations may occur elsewhere in the Little River system. Given the overall poor quality of this tributary, however, it is unlikely that any undetected large concentrations of *E. scotti* are sequestered in this system. All tributary systems below Little River, but above Allatoona Dam, are inundated in their lower reaches by the reservoir. Here, *E. scotti* persists only in Butler Creek, Cobb County, but is known to have occurred in at least six other tributaries prior to impoundment and extensive sedimentation of these streams. This region of Georgia is one of the fastest growing areas in the country; urbanization has contributed significantly to the degradation of the streams through increased runoff, sedimentation, and numerous point and nonpoint sources of pollution.

Below Allatoona Dam, only Raccoon and Pumpkinvine creeks contain *E. scotti*, both of these creeks mostly drain the Talladega Upland subsection of the Blue Ridge province (Fig. 2). In Pumpkinvine Creek, *E. scotti* is unknown from the main channel, but probably occurred there prior to extensive sedimentation of that system. *Etheostoma scotti* occurs in the main channel of Raccoon Creek, but a tributary population in Pegamore Creek may have been extirpated by construction of a small impoundment.

The influence of physiographic provinces on species of *Ulocentra* distributions is further illustrated in Euharlee Creek (Fig. 2). Euharlee Creek drains both the Talladega Upland and the Great Valley subsections, but harbors only *E. coosae*. The latter is restricted to the portion of Euharlee Creek occurring within the Great Valley subsection and its distribution conforms to the boundary of the two subsections. Hills Creek, a tributary of Euharlee Creek situated between Euharlee Creek (with *E. coosae*) and Raccoon Creek (with *E. scotti*) would be the logical place for sympatry of E. *coosae* and *E. scotti*, but no species of *Ulocentra* have been collected therein. The intriguing question is, What are the attributes of the physiographic provinces that promote or maintain parapatry, or otherwise profoundly affect distributions of similarly adapted fishes? Where the provinces abut, certainly the micro- and mesohabitats that are important to each species are found in streams draining each province, and certainly over recent geologic time each species has had ample opportunity to disperse across these boundaries.

In general, members of the subgenera *Ulocentra* and *Catonotus* share the propensity to become isolated in tributary systems and allopatrically speciate (for *Ulocentra* see Page and Burr, 1982; Bailey and Etnier, 1988; Suttkus and Etnier, 1991; Suttkus and Bailey, 1993; Suttkus et al., 1994; for *Catonotus* see Page et al., 1992). We interpret this to imply that these subgenera have a "high" intrinsic rate of speciation, and that bottlenecked populations at least sometimes speciate rather than become extirpated. If we are correct in deducing *E. scotti* and *E. coosae* to be sister species, their distributions are parapatric and apparently conform to physiographic boundaries and subsections thereof.

The simplest allopatric speciation model explaining present distributions is that some vicariant event isolated an upland population segment of an *E. coosae*-like ancestor that gave rise to *E. scotti*. The area of the Etowah River near Allatoona Dam is geologically and topographically complex, and provides a potential theater for a vicariant mechanism. Allatoona Dam is located in a relatively narrow gorge on the Etowah River near the boundary of the Talladgea Upland—Piedmont Upland subsections; the Great Smoky fault forms the boundary of these subsections (Cressler et al., 1979). In fact, the Etowah River in the vicinity of Allatoona Dam is crossed by five major faults in less than 10-air km, and is bounded to the south by another major fault, the Emerson (Cartersville) fault (Cressler et al., 1979). Major faults often produce zones of fracture concentration, areas which tend to exhibit increased weathering and cause localized valley formation. Perhaps the gorge/fault area was the site of a geologically temporary water fall, or more likely, a series of low falls that effectively isolated upstream populations of a precursor to *E. scotti*. The subsequent weathering of this hypothetical barrier could have allowed *E. scotti* to invade Talladega Upland streams (Pumpkinvine and Raccoon creeks, and probably others) southwest of the gorge area.

The fact that three nominal species of *Ulocentra* occur allopatrically in the relatively small Etowah River system is noteworthy but not unique. Three species of *Ulocentra* occur in the Black Warrior system of the Tombigbee River drainage (*E. bellator, E. chermocki,* and *E. zonistium*), three occur in the Duck River system of the Tennessee River drainage (*E. duryi, E. flavum,* and *E. simoterum*), and four occur in the Indian Creek system, a direct tributary to the Tennessee River (*E. duryi, E. flavum, E. simoterum,* and *E. zonistium*) (Bailey and Etnier, 1988; Etnier and Bailey, 1989; Boschung et al., 1992).

Habitat and Biology—*Etheostoma scotti* inhabits small to medium size creeks, approximately 1 to 15-m width, with moderate gradient and predominantly rocky bottoms. It is usually found in shallow water, ca. 0.1 to 0.5-m depth, in sections of reduced current, typically runs above and below riffles and at the ecotones of riffles and backwaters. *Etheostoma scotti* is associated with large gravel, cobble, and small boulder substrates, and is uncommonly or rarely associated with extensive areas of bedrock, fine gravel, or sand (it occurs in mosaic mixtures of the latter substrates). It is most abundant in stream sections with relatively clear water and clean substrates (little silt deposition). *Etheostoma scotti* is relatively intolerant of moderate to heavy silt deposition and impoundment. The common associates of *E. scotti* are *Campostoma oligolepis, Cyprinella callistia, C. trichroistia, Notropis xaenocephalus, Hypentelium etowanum,* juvenile *Micropterus coosae,* and *Percina nigrofasciata.*

Nothing is known about the diet, longevity, growth, or fecundity of *E. scotti*, but its life history is probably similar to that which has been described for *E. coosae* (O'Neil, 1981). One of us (NMB) observed and video recorded spawning behavior of *E. scotti* in the laboratory. Consistent with other species of *Ulocentra, E. scotti* belongs to the egg-attaching guild of darters (Page, 1985) and its spawning behavior is similar to that described for other *Ulocentra* (O'Neil, 1981; Keevin et al., 1989; Weddle, 1990). We provide a summary description of the spawning behavior of *E. scotti*; a detailed analysis will appear elsewhere.

Nuptial male *E. scotti* actively solicit and court gravid females by constantly following them. Nonreceptive females typically only tolerate a few solicitous advances by a courting male before abruptly swimming away from the male (approximately 0.5 m or more). Receptive females allowed courting males to approach and contact them laterally, head-to-head, or head-to-tail. Receptive females then initiate an "investigative" slow swim among rocks with the courting male closely following and generally mirroring the females swim-and-stop movement patterns. Receptive females appeared to visually scrutinize their immediate environment during this phase of the courtship. This inference is based on the constant eye movements females exhibited during the swim-and-stop movement patterns. The courting males did not perform this behavior. Courting males frequently interrupted courtship to chase any male conspecifics that approached the courting pair. We interpret this as defense of a roving territory and the defended space is some relatively small space around the receptive female.

Spawning usually occurred when the female assumed a vertical or near vertical position on cobble or small boulder but, occasionally, a horizontal position was assumed on large gravel. Prior to spawning, the male laterally contacted the female and sometimes stimulated her nape with short duration lateral quivering movements of the lower portion his head. At spawning, the male mounted the female head-to-head with both sexes arching dorsally and briefly quivering. The end of spawning act was usually marked by a distinct short forward lunge or dragging movement of the female. We interpret this movement as a functional behavior of the female to attach the oviposited egg to the substrate. Usually one egg is deposited per spawning act.

CONSERVATION—Although *E. scotti* is widespread in the middle Etowah River system, numerous populations appear to persist in low abundance and threats to the species are numerous and will likely increase. We concur with the federal listing of *E. scotti* as threatened. We further recognize that *E. scotti* is perilously close to meriting downgrading of conservation status to endangered because of the imminent likelihood of additional population decline and localized extirpation. This concern is based on a litany of recent and ongoing biologically adverse conditions: known extirpation of eight populations, inferred extirpation of many populations by Allatoona Reservoir, the ubiquitous system-wide degradation and destruction of benthic habitat by sedimentation, fragmentation of the species' range (promoting loss of genomic heterogeneity and increasing the probability of localized extirpation), ubiquitous point source and non point source pollution, and imminent threats from a proposed quarry, landfills, off-river water supply impoundments, major transportation bypasses, and perhaps most insidiously, rapid urbanization from the greater Atlanta metropolitan area. These threats are discussed in more detail in Burkhead et al. (1992) and Burkhead (1993).

The Etowah River system is clearly an imperiled river system. The Etowah River harbors two endangered fishes, the amber darter *Percina antesella*, and the Etowah darter *Etheostoma (Nothonotus) etowahae*. The blue shiner *Cyprinella caerulea*, a federally threatened species, apparently has been extirpated from the system. Other Mobile basin endemic fishes have declined in the Etowah River or are very localized. In addition, five mussels that occur or occurred in the Etowah River system are listed, four as endangered (upland combshell, *Epioblasma metastriata;* southern clubshell, *Pleurobema decisum;* ovate clubshell, *P. perovatum;* triangular kidneyshell, *Ptychobranchus greeni*), and one as threatened (Alabama moccasinshell, *Medionidus acutissimus)*. One mussel (Tennessee heelsplitter, *Lasmigona holstonia*), three snails (spindle elimia, *Elimia capillaris;* coldwater elimia, *E. gerhardti;* rough hornsnail, *Pleurocera formani*), and one mayfly (Berners two-winged mayfly, *Heterocleon berneri*) are on the federal list as Category 2 species (species that may merit listing, but for which there is insufficient data to presently list). It is estimated that as many as 35 of the 51 mussels that probably occurred in the Etowah River are now extirpated from the system (Burkhead et al., 1992).

The Etowah, Conasauga, and Coosawattee rivers still retain a significant fraction of the aquatic biodiversity of the beleaguered Coosa river system. It appears, however, that these systems are slipping closer to a critical threshold beyond which a spate of extinctions may occur. We can no longer afford to practice ineffective single species recovery programs; rather, we must focus on ecosystem recovery, and in this case, a practical definition of a river ecosystem would be any of the above river systems.

ETYMOLOGY—The epithet *scotti* is a patronym for Donald C. Scott, emeritus professor of Zoology, University of Georgia, who established the ichthyological collection of the University of Georgia Museum of Natural History and made many significant early collections of fishes from the Etowah River system. We suggest the common name of Cherokee darter, in reference to the county that includes the type locality and many other localities for this geographically restricted species.

Acknowledgments

Study materials and distributional records of the Cherokee darter have resulted primarily due to the efforts of the National Biological Service, Southeastern Biological Science Center, Gainesville, Florida. Funding for the research of this laboratory was provided by the Jacksonville office of the U. S. Fish and Wildlife Service. The numerous collection trips were coordinated by one of us (NMB) and included the following people, listed in alphabetical order: Michael M. Bentzien, Richard T. Bryant, John H. Chick, Robert S. Cowles, Gerald R. Dinkins, Byron J. Freeman, Mary Freeman, Carter R. Gilbert, Andrew G. Haines, Dennis C. Haney, M. H. Hughes, Tracie Jones, P. W. Parmalee, Jessica Peterkin, C. E. Skelton, Tracey Smith, William Smith-Vaniz, Louis A. Somma, Jay Troxel, Stephen J. Walsh, Douglas C. Weaver, and James D. Williams. R. C. Lattimore drafted the maps. We are appreciative of the loan of material, collection data, and courtesies extended to us by Herbert T. Boschung, Richard L. Mayden, and Bernard R. Kuhajda, University of Alabama; Julian M. Humphries and Charles Dardia, Cornell University; Byron J. Freeman and Tracie Jones, University of Georgia; Carter R. Gilbert and Steve Walsh, University of Florida; Doug Nelson, University of Michigan; and Henry L. Bart and Royal D. Suttkus, Tulane University. We thank the three peer reviewers for excellent criticisms of the manuscript.

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Appendix 1.-Names of streams numbered in Figure 3.

1. Silver Creek
2. Prentis Creek
3. Dykes Creek
4. Spring Creek
5. Youngs Mill Creek
6. Toms Creek
7. Connesena Creek
8. Two Run Creek
9. Unnamed Creek
10. Macedonia Creek
11. Unnamed Creek
12. Ashpole Creek
13. Euharlee Creek
14. Hills Creek
15. Raccoon Creek
16. Pegamore Creek
17. Richland Creek
18. Unnamed Creek
19. Pettit Creek
20. Nancy Creek
21. Pyle Creek
22. Word Creek
23. Pumpkinvine Creek
24. Possum Creek
25. Picketts Mill Creek
26. West Fork Creek

27. Allatoona Creek
28. Tanyard Creek
29. Proctor Creek
30. Butler Creek
31. Carter Creek
32. Stamp Creek
33. Kellogg Creek
34. Owl Creek
35. Little River
36. Blankets Creek
37. Noonday Creek
38. Toonigh Creek
39. Mill Creek
40. Sweetwater Creek
41. Shoal Creek
42. Little Shoal Creek
43. McCanless Creek
44. Jug Creek
45. Puckett Creek
46. Canton Creek
47. Hickory Log Creek
48. Edward Creek
49. Riggin Creek
50. Sharp Mountain Creek
51. Rock Creek
52. Smithwick Creek
53. Long Swamp Creek
54. Fourmile Creek
55. Long Swamp Creek
56. Norton Creek
57. Conn Creek
58. Bryant Creek
59. Board Tree Creek
60. Brewton Cogburn Creek
61. Bannister Creek
62. Yellow Creek
63. Amicalola Creek
64. Cochran Creek
65. Amicalola Creek
66. Shoal Creek
67. Pigeon Creek
68. Black Mill Creek
69. Unnamed Creek
70. Palmer Creek
71. Russell Creek
72. Proctor Creek
73. Camp Creek
74. Unnamed Creek
75. Mill Creek
76. Nimblewill Creek
77. Jones Creek
78. Two Run Creek
79. Unnamed Creek
80. Montgomery Creek

Present and Recent Historic Habitat of the Alabama Sturgeon, *Scaphirhynchus suttkusi* Williams and Clemmer, in the Mobile Basin

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ABSTRACT: Burke J. S. and J. S. Ramsey. 1993. Present and recent historic distribution of the Alabama sturgeon, *Scaphirhynchus suttkusi*, Williams and Clemmer, in the Mobile Basin. Bulletin Alabama Museum of Natural History, Number 17.17–24. 3 tables, 2 figures. Field sampling and interviews of experienced watermen were conducted to determine the conservation status and distribution of the Alabama sturgeon, *Scaphirhynchus suttkusi*, a rare large-river fish of the Mobile Basin. Information on historical distribution and trends were obtained from retired watermen using oral history recording techniques. Interviews indicated that the historical range of the sturgeon included 1,020 miles of main channel riverine habitat in the Mobile drainage. A stratified random survey of commercial fishermen was employed to determine the present distribution of the species. Distributional data obtained from the survey of commercial fishermen were subsequently supported by field sampling. Results of the survey suggest that a viable population of the species is restricted to 15% (152 miles) of the historical habitat with an additional 24% (240 miles) of marginal value as Alabama sturgeon habitat. This range contraction may have been caused by flow changes in Mobile Basin rivers due to dam construction for navigation and hydroelectric power generation. This hypothesis is supported by the present distribution of the species, which is most successful in those reaches of river with most natural flow.

Introduction

Three species of sturgeon are known from the Mobile Basin; the Alabama sturgeon, *Scaphirhynchus suttkusi*, Atlantic sturgeon, *Acipenser oxyrynchus*, and the lake sturgeon, *Acipenser fulvescens*. All have been reduced in abundance probably because of habitat alteration associated with the impoundment of rivers. The Alabama sturgeon, a recently described species inhabiting the Mobile Bay drain-

Bull. Alabama Mus. Nat. Hist. 17:17–24

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age system, is morphologically similar to the more widespread shovelnose sturgeon, *Scaphirhynchus platorynchus* of the Mississippi Basin (Williams and Clemmer, 1991). Though there is little information on the life history of the Alabama sturgeon it appears to be strictly a freshwater species preferring riverine habitat. An early documentation of the occurrence of the species appeared in Alabama Game and Fish News (Anonymous, 1930) which describes the Alabama sturgeon as "not uncommon in Alabama though it is more abundant further north." The presence of *Scaphirhynchus* in rivers of the Mobile Drainage was first reported in the scientific literature by Chermock (1955). Subsequent records of Alabama sturgeon from the basin are rare (Ramsey, 1976; Deacon et al., 1979) and Williams and Clemmer (1991), in their description of the species, listed only 27 specimens in museum collections (of these four were collected during this study).

Though perhaps never a common fish, the Alabama sturgeon appears to have become increasingly rare in recent years. Clemmer (1983) recommended that the Alabama sturgeon be listed as an endangered species and that studies of its current status and life history be initiated as soon as possible. The Alabama sturgeon is under review for endangered or threatened status by the U.S. Fish and Wildlife Service and is considered endangered by the American Fisheries Society (Williams et al., 1989). Our study was designed to delineate the recent historic and present range and status of the Alabama sturgeon in the Mobile Bay drainage. Because of the size of the study area and the rarity of this species we interviewed experienced watermen to define the recent range and sampled those areas where the probability of capture was highest.

Figure 1. Map of the Mobile Basin showing the major rivers and the position and purpose of dams. Dam reference numbers refer to Table 1.

The Study Area

The Mobile Drainage covers some 43 thousand square miles primarily in Alabama but extending into northwest Georgia, southeast Tennessee and northeast Mississippi (Figure 1). This area is drained by seven major rivers representing 1709 miles of large river channel. The drainage has been transformed by construction of 21 hydroelectric and navigation dams (Table 1) so that most of the major rivers in the state flow through a series of reservoirs. Hydroelectric dams often lack an absolute minimum flow and may operate to maintain zero flow between periods of power generation creating lentic conditions in rivers. In contrast navigation impoundments may be more lotic in nature as their dams generally have a minimum flow requirement to maintain the navigation channel down stream.

For purpose of a distributional analysis the study area was divided into major drainage and river sections. The Coosa and Tallapoosa rivers were divided into upper and lower sections (at or near the fall line), separated by Jordan and Thurlow dams, respectively. The Tombigbee River was divided into upper and lower sections by the confluence of the Black Warrior River and Demopolis Lock and Dam. The Alabama River was divided by the respective Army Corps of Engineers dams (Jones Bluff, Millers Ferry, and Claiborne) into two hydroelectric reservoirs, a navigation impoundment, and one free flowing section. The later is here referred to as the lower Alabama River. The other major rivers, Cahaba, Black Warrior, and Mobile Delta, which includes the Mobile, Tensaw and Middle rivers, were considered as discrete units for this analysis. Only the portion of the Mobile Basin within the state of Alabama was considered in this study.

Materials and Methods

Directed Interviews

Interviews with commercial fishermen, conservation officers, and state fisheries biologists were conducted to identify drainage and river sections from which Alabama sturgeon had been caught. Interviews with experienced commercial fishermen were tape recorded when possible and were valuable in selecting sampling areas, discerning historical trends, and providing insight into biology of the fish. Alabama sturgeon were distinguished from the other two sturgeon species that occur in Alabama using the following criteria: size (adult Atlantic and lake sturgeon are larger than Alabama sturgeon), shape of the tail (fisherman often noted the exceptionally slender, heavily armored caudal peduncle of Alabama sturgeon), caudal filament (de-

Table 1. Dams of the major rivers of the Mobile Basin, Alabama, and key characteristics (N=navigation, P=hydropower). Reference numbers refer to Figure 1.

Reference Number	Dam	Year Completed	Miles from Mouth	Depth of Lake at Dam (ft)	Area of Impoundment (acres)	Function
Tombigbee River						
1	Aliceville	1979	333	30	8300	N
2	Gainesville	1978	284	51	6400	N
3	Demopolis	1954	218	54	10000	N
4	Coffeeville	1960	120	34	8500	N
Black Warrior River						
5	Bankhead	1915	365	75	8730	NP
6	Holt	1966	347	72	6400	NP
7	Oliver	1940	338	36	675	N
8	Warrior	1959	261	31	7800	N
Coosa River						
9	Weiss	1961	585	62	30200	P
10	Neely Henry	1966	507	53	11200	P
11	Logan Martin	1964	459	69	15263	P
12	Lay	1914	411	88	12000	P
13	Mitchell	1923	397	90	5850	P
14	Jordan	1928	378	110	6800	P
Tallapoosa River						
15	Harris	1982	498	118	10660	P
16	Martin	1926	420	155	40000	P
17	Yates	1928	412	47	2000	P
18	Thurlow	1930	409	54	574	P
Alabama River						
19	Jones Bluff	1971	290	61	12300	NP
20	Millers Ferry	1968	187	56	17200	NP
21	Claiborne	1968	126	33	5800	N

scribed as bristly and like a whip), common name (often "hackleback" or "sand sturgeon" in the case of the Alabama sturgeon), and color (usually a sand or light brown color in the case of a Alabama sturgeon) (Figure 2).

Stratified Random Interviews

A telephone survey of licensed commercial fishermen was conducted to expand on information obtained during the directed interviews, and to determine the present distribution of the Alabama sturgeon. The study area was stratified by the river sections described above. Names of commercial fisherman were picked at random from commercial license receipts of key counties adjacent to each river section. We interviewed a minimum of five experienced fishermen (those who had fished for at least 10 years) from each river section. Fishermen were questioned on what areas they fished, how long they had been fishing there, what type of gear they used and how often it was employed, target species, whether they had heard of or caught a sturgeon and if so for a description of the fish and details of it's capture.

Fish Sampling

Sampling was conducted from fall 1984 through spring of 1985 in river sections which had been identified as probable sturgeon habitat: the Cahaba River, the four sections of the Alabama River, and the lower sections of the Coosa and Tallapoosa near their confluence at the Alabama River. Although limited, our sampling effort was directed specifically at Alabama sturgeon; the place and time of fishing was based on reports from individuals who had caught Alabama sturgeon, and the gear utilized was that proven successful for Alabama sturgeon or for shovelnose sturgeon in the Mississippi Basin. A variety of proven gear types were used; gill nets (Durkee et al, 1979; Berg, 1981), stationary and drifting trammel nets (Helms, 1974; Hurley,

Figure 2. Alabama sturgeon (416 mm FL) captured with a gill net in the lower Alabama section of the Alabama River on April 17, 1985.

1983), trotlines (Carlson and Pflieger, 1981), hoopnets (Berg, 1981), and electro-fishing (Christenson, 1975). Choice of gear type depended on the river section being sampled. For instance, in the relatively shallow Cahaba River electrofishing had proved effective in the past while in the deep areas of the Alabama River gill, trammel, and hoop nets could be used effectively. In most areas a variety of gear was tried and care was taken to sample all potential habitats in the river. All fish were identified to species in the field and released (except for voucher specimens deposited at the Auburn University fish collection).

Results—Interviews

Directed interviews of conservation officers and state fisheries biologists reinforced the reports that the Alabama sturgeon is extremely rare. Many fisheries professionals had never seen an Alabama sturgeon. Those who had were senior personnel who maintained that the species must be rare due to the few encountered in the Mobile Basin.

Interviews of experienced commercial fisherman indicated that the Alabama sturgeon was extremely rare or absent from the Coosa River, Tallapoosa River, and the Jones Bluff Reservoir of the Alabama River, but was still present in the rest of the Alabama River. Fishermen reported that in recent years catches of Alabama sturgeon in Millers Ferry section had declined considerably. In Claiborne navigation impoundment they were reported present, and occasionally captured in large numbers during the spring and summer by certain fishermen. In the lower Alabama, fishermen reported that Alabama sturgeon were caught annually, however, in small numbers. Fishermen from the Cahaba reported catching Alabama sturgeon infrequently. Alabama sturgeon were not caught by fishermen of the Mobile and Tensaw rivers of the Mobile Delta

Table 2. Results of stratified random phone interviews, conducted during 1985, of commercial fishermen using selected river sections in the Mobile Basin, Alabama. Sturgeon species indicated are A=Atlantic sturgeon, L=lake sturgeon, S=*Scaphirhynchus*.

River Section	Number of fishermen who caught sturgeon *pre–1975*	*post-1975*	Number of negative responses	Sturgeon species indicated
Alabama River				
Jones Bluff	1	0	4	A
Millers Ferry	2	2	1	A,S
Claiborne	2	3	1	A,S
Lower Alabama	1	0	4	A,S
Tallapoosa River				
Upper	0	0	5	—
Lower	1	0	5	A
Coosa River				
Upper	1	0	4	L
Lower	1	0	4	A
Cahaba River	1	1	3	A,S
Tombigbee River				
Upper	1	0	10	S
Lower	2	1	10	A,S
Black Warrior River				
	0	0	10	—
Mobile Delta	5	0	5	A,S

although most fishermen had caught an Atlantic sturgeon at some time. Fishermen from the Tombigbee and Black Warrior Rivers reported catching Alabama sturgeon from the lower portion of the Tombigbee only.

Reports of all three species of sturgeons found in the Mobile Basin were received during the stratified random phone survey (Table 2). Reports of adult Atlantic sturgeon capture, easily distinguished from those of the Alabama sturgeon by the size of the fish, were received from all rivers except the Black Warrior. Reports of capture of sturgeon from the upper Coosa described as having very dark coloring with a rounded nose, were considered to be lake sturgeon. An isolated population of lake sturgeon was reported from the upper Coosa by Scott (1951). Alabama sturgeon were reported captured throughout the Alabama River sections, in the Cahaba River, upper and lower Tombigbee River, Black Warrior River, and in the Mobile River. Recent captures (after 1975) were reported in the Alabama River and in the Cahaba River. Captures of Alabama sturgeon in the Black Warrior and lower Tombigbee were reported from the early 60's. One fisherman on the lower Tombigbee reported catching a sturgeon in the early 70's which fit the description of an Alabama sturgeon.

Results—Fish Sampling

During our sampling six Alabama sturgeon were examined and their presence in the Alabama River (lower Alabama, Claiborne and Millers Ferry sections) and the Cahaba River verified. Sampling conducted to try to verify reports of Alabama sturgeon resulted in the capture of 2735 fish of 37 species including three Alabama sturgeon (Table 3). Other uncommon species that occurred with Alabama sturgeon included: paddlefish, *Polyodon spathula*, in both Claiborne and the lower Alabama, blue sucker, *Cycleptus elongatus*, and striped bass, *Morone saxatilis* in the lower Alabama. The effective gear types for sturgeon were: three inch stretch gill nets (two fish) and electrofishing (one fish). One sturgeon was caught in the Claiborne Reservoir section (a gravid female, 532mm FL) and one in the Lower Alabama River section (416mm FL) both in 3 inch stretch gill nets set from steep sand and gravel bars in swift current. At both sites the river was approximately 30 ft deep with a flat bottom that rose steeply at the banks. One sturgeon was shocked with electrofishing gear in the Cahaba River in swift turbulent water, approximately 10 ft deep, at the tail end of a large gravel bar. Although this fish was not netted due to the swift current it was seen clearly by fisheries biologists who were certain that it was a Alabama sturgeon. In addition we examined three Alabama sturgeon captured by commercial fishermen. Two were caught in the lower Alabama (including one gravid female 658mm FL, and a small and presumably young specimen 359mm fL) and one in the Millers Ferry section near the confluence with the Cahaba River (555mm FL).

Confirmed captures of Alabama sturgeon (identified by fisheries professionals) and reports from directed and random interview indicate the historical range and the last reported capture times of Alabama sturgeon for the various river sections as follows: upper Tombigbee River in Mississippi and Alabama (153 river miles; Alabama sturgeon last reported capture in the 1960's), lower Tombigbee River (180 miles; ca. 1975), lower Black Warrior River (115 miles; ca. 1960), lower Coosa River (10 miles; ca. 1970), lower Tallapoosa River (50 miles; ca. 1960), upper Cahaba River (10 miles; ca. 1960), lower Cahaba River (81 miles; 1985), upper Alabama River above Jones Bluff Dam (78 miles; ca. 1984), Millers Ferry Reservoir of Alabama River (103 miles; 1985), Alabama River above Claiborne Lock and Dam (91 miles; 1985), lower Alabama River (91 miles; 1985), and the Mobile-Tensaw Delta (ca. 90 miles; ca. 1965) (Fig. 3). Of the 1020 miles of historic habitat the Alabama sturgeon are known, from recent confirmed captures (Fig. 3) to survive in four of the 13 river sections totaling 346 miles; the Cahaba River, Millers Ferry Reservoir, Claiborne Impoundment, and the lower Alabama River.

Discussion

Based on studies of other sturgeon we expect that alteration of riverine habitat may have a detrimental impact on Alabama sturgeon. Sturgeon species world wide are threatened by man's alterations of their riverine habitat (Rochard et al, 1990). Russian studies of reproductive success of sturgeons in their regulated rivers (Khoroshko, 1972; Zakharyan, 1972; Veshchev, 1982; Veshchev and Novikova, 1983) found that effectiveness of natural reproduction is directly proportional to flow regimes. Low flows lead to a deterioration in reproductive conditions, a curtailment of the spawning areas, and silting and death of eggs deposited in the beds (Veshchev and Novikova, 1983). Flow may be important to all sturgeon species whose demersal adhesive eggs may take 5–8 days to hatch.

Species of the genus *Scaphirhynchus* may be particularly vulnerable to river modifications as their entire life history is completed within rivers. Alteration of river flow may negatively impact shovelnose sturgeon, *Scaphirhynchus platorynchus*, as successful feeding (Elser et al., 1977) and reproduction (Berg, 1981) appears to be dependant on current. The shovelnose sturgeon is most abundant in channel habitats of the Mississippi, Missouri and Ohio Rivers, and in impounded sections of rivers are usually restricted to the more lotic areas (Held, 1969; Helms, 1974). Clearly flow patterns in rivers of the Mobile Basin have been extensively modified due to dam construction (Fig. 1) and these modifications may have caused a decline in the Alabama sturgeon population.

Results of interviews and confirmed captures of Alabama sturgeon show similar patterns (Fig. 3) and indicate that Alabama sturgeon are restricted primarily to the most lotic habitat of the Alabama and Cahaba Rivers. In more lentic habitats of the Alabama River Alabama sturgeon

Table 3. Effort (number of net nights and 30 minute electrofishing runs) and catch listed by river section.

	Jones Bluff	Millers Ferry	Claiborne lake	Lower Alabama	Lower Cahaba River	Tallapoosa	Lower Coosa
				Effort			
Hoop nets	4	6	2	0	12	4	0
Gill and Trammel nets	8	15	4	12	7	4	0
Electrofishing	0	2	0	0	32	0	2
				Catch			
Scaphirhynchus suttkusi	0	0	1	1	1	0	0
Polyodon spathula	0	5	1	1	2	0	0
Lepisosteus osseus	0	4	7	5	86	0	0
Lepisosteus oculatus	0	1	0	5	38	0	2
Amia calva	0	1	0	0	2	0	0
Anguilla rostrata	3	0	0	1	3	0	0
Dorosoma cepedianum	36	14	25	16	694	0	33
Dorosoma petenense	0	0	1	12	238	0	0
Alosa chrysochloris	1	18	0	5	6	0	0
Hiodon tergisus	0	5	0	1	4	0	0
Cyprinus carpio	13	1	1	0	41	1	1
Carpiodes cyprinus	0	4	8	2	20	6	0
Carpiodes velifer	2	19	19	2	229	0	4
Ictiobus bubalus	37	9	9	2	233	2	6
Cycleptus elongatus	0	0	0	4	0	0	0
Minytrema melanops	0	0	0	0	6	0	0
Moxostoma carinatum	0	0	0	0	36	0	1
Moxostoma poecilurum	0	55	0	3	160	1	5
Moxostoma duquesnei	0	0	0	0	10	0	5
Moxostoma erythrurum	1	0	0	0	0	0	0
Ictalurus furcatus	5	16	9	15	7	0	4
Ictalurus punctatus	0	10	7	11	26	0	3
Pylodictis olivaris	15	7	2	2	6	0	0
Strongylura marina	0	0	0	0	0	0	0
Morone chrysops	0	2	0	0	3	0	0
Morone saxatilis	0	0	0	4	0	0	0
Ambloplites ariommus	0	0	0	0	1	0	0
Lepomis macrochirus	5	0	2	2	15	0	11
Lepomis megalotis	0	0	0	0	12	1	8
Lepomis microlophus	1	0	0	0	1	0	3
Micropterus punctulatus	0	2	1	0	22	1	10
Micropterus salmoides	0	2	1	0	3	0	0
Pomoxis annularis	5	7	1	0	11	0	0
Pomoxis nigromaculatus	0	0	1	1	2	0	0
Crystallaria asprella	0	0	0	0	32	0	0
Percina caprodes	0	0	0	0	0	0	4
Aplodinotus grunniens	34	49	17	21	40	0	2

populations appear to be declining. Despite a confirmed and reported captures in these habitats in the 1980's interviews of all experienced commercial fishermen and biologists indicated that sturgeon abundance had declined in Jones Bluff and Millers Ferry in recent years. This may be due to the relatively recent impoundment of the Alabama River (Table 1) which established intermittent flows and blocked free movement of fish to and from the lower river. We were unable to capture an Alabama sturgeon in these more lentic pools of the Alabama River (Table 3). One of our contacts did capture a single Alabama sturgeon in Millers Ferry; however, as a full time commercial fisherman his effort was considerable and a recent discussion (1993) indicated that this was the last sturgeon he caught. In the Claiborne impoundment which is more riverine and the free flowing lower Alabama reports of large or regular catches suggest the presence of a more viable population. We were able to capture Alabama sturgeon in Claiborne (catch per unit effort=0.3/net night) and the lower Alabama River (cpue=0.12/net night) with relative ease. All of the capture sights were associated with sand and gravel bars and swift current. These two river section, representing about 15% of the historic range, may support currently reproducing populations as gravid females were caught in both in 1985.

The Alabama sturgeon is a big river species so that in addition to river flow, river size may be important. Despite free flow in the Cahaba River fishermen reported that catch of Alabama sturgeon had declined there. The Cahaba River is small compared to others in the state and may provide spawning habitat for sturgeon that inhabit the Alabama River. The largest catalogued collection of Alabama sturgeon (12) came from the confluence of the Alabama and Cahaba Rivers in late March of 1969 (Williams and Clemmer, 1991) and Alabama sturgeon were regularly electroshocked in the Cahaba in the 1960's during studies of the river redhorse, *Moxostoma carinatum*, spawning (Peter Hackney, pers. comm.). According to Hackney the blue sucker, another big river fish, was common in the Cahaba River in the 60's. During our electrofishing efforts in the Cahaba River we did shock a single Alabama sturgeon; however, blue suckers were not captured (Table 3).

The hypothesis that Alabama sturgeon are dependant on riverine habitat suggests that the Coosa, Tallapoosa, Black Warrior, and the upper sections of the Tombigbee and Alabama Rivers, which have been transformed into series of reservoirs, would not support populations of Alabama sturgeon. Other factors may limit Alabama sturgeon distribution such as channel modification and salt water intrusion. Interviews suggested that Alabama sturgeon are rare or absent from the free-flowing sections of the Mobile Delta and the lower Tombigbee. We suspect that interviews correctly classify these river sections as marginal habitat and that factors such as salt water intrusion during periods of low flow and reduction in gravel substrates, may be limiting the use of this area by Alabama sturgeon.

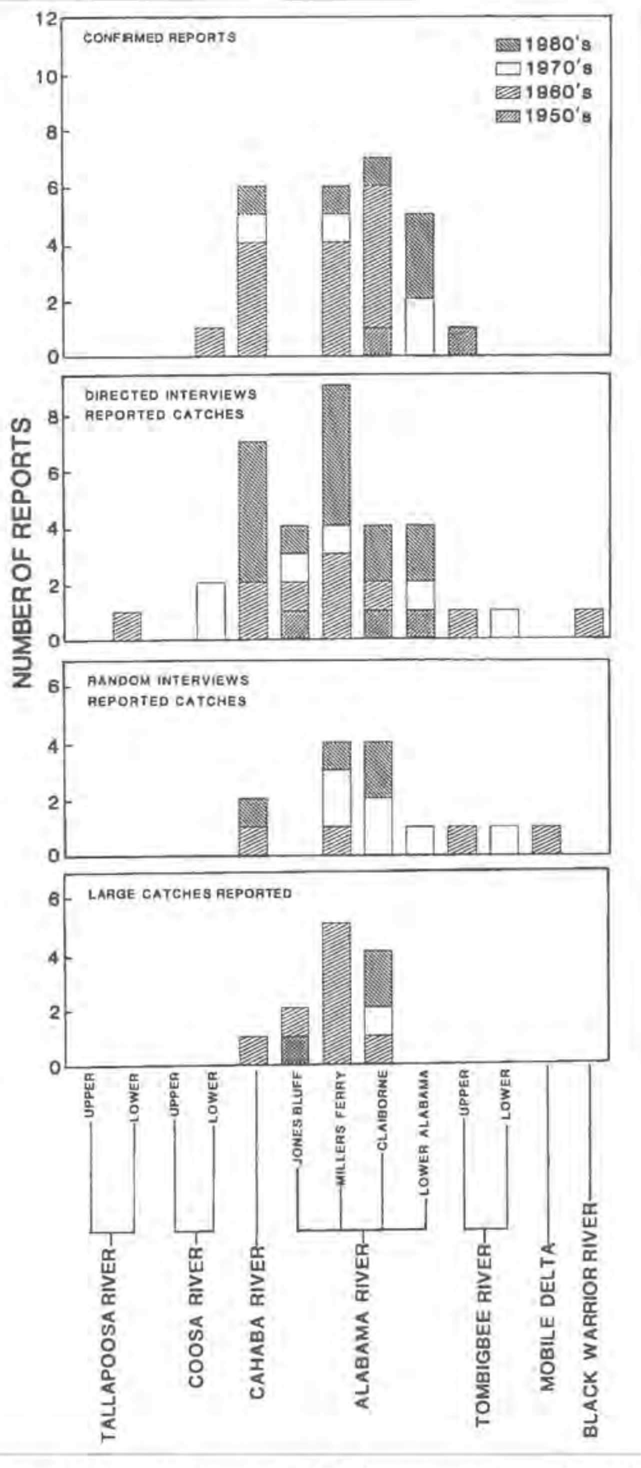

Figure 3. Four indicators of Alabama sturgeon, *Scaphirhynchus suttkusi*, distribution and status. Confirmed reports refer to reports from fishery professionals able to positively identify the catch to genus. Directed interview reports come from individuals chosen because of their extensive experience on Mobile basin rivers. Random interview reports come from the stratified random sample of licensed commercial fishermen. Reports of large catches refer to catches of at least five Alabama sturgeon and are drawn from the other three categories of reports.

Habitat management in the Mobile Basin could substantially alter conditions for Alabama sturgeon. Since this sturgeon appears to be dependant on the main channel of large rivers, practices that significantly alter this habitat may impact this species. For instance, gravel bars appear to be an important habitat for sturgeon and the mining of gravel from the rivers may impact sturgeon feeding and reproduction. Changes in instream flow requirements for dams to increase water quality and the amount of lotic habitat would be expected to increase the river areas that Alabama sturgeon could utilize.

Acknowledgments

The data for this paper was collected while the authors were members of the Alabama Cooperative Fish and Wildlife Research Unit, Auburn University, Auburn, Al. The study was funded by the Endangered Species Field Office, U.S. Fish and Wildlife Service, Jackson, Ms. We especially wish to thank James Smith of Cahaba, Jerry Brannon of Claiborne, and Amos Taylor of Pine Hill, Alabama. Dr. James Williams, Glenn Clemmer, Malcolm Pierson, Barry Smith, Clem Parnell, Bill Tucker, Tom Holman and many other individuals helped with their guidance and many courtesies. We are grateful to personnel of the Game and Fish Division, Alabama Department of Conservation and Natural Resources, who supported our efforts in many ways. A special permit to take sturgeon was issued by Sam L. Spencer. Much valuable information was contributed through the experience and expertise of conservation officers and district biologists.

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Roland Harper, Alabama Botanist and Social Critic: A Biographical Sketch and Bibliography

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Introduction

Roland Harper (1878-1966) was botanist for the Geological Survey of Alabama from 1905 until his death (Figure 1). An innovative—albeit controversial—early worker in the field of plant geography, Harper was also one of the last botanists privileged to visit and describe the original vegetation of the Southeast. But his interests were far from confined to plant geography and plant ecology, and also included systematic botany; soils, crops and weeds; forestry and controlled burning; demography; biostatistics; railroading; "booster literature" and urban problems; conservation; photography; race relations; eugenics; communism; and tobacco smoking. Harper published his findings and opinions on these matters in over 600 works, ranging from his early scholarly tomes in botany to impassioned letters-to-the- editor railing against modern urban life.

Harper's botanical knowledge and writings met with near-universal praise; indeed, he was the quintessential field botanist, and well respected by his peers. With nearly seventy years of botanizing under his belt, Harper "probably had the greatest store of field experience of any botanist of his day in the Southeast" (Core 1970). Not only was Harper tireless in effort and critical in observation, but he was renowned for his ability to recall decades later the places, plants, and individuals he had encountered.

But Harper's later writings—many of them protesting social change or delineating preposterous cultural relationships—have lessened his reputation among succeeding scientists. These writings, however, should be considered more sympathetically. In many respects Harper was a nineteenth-century man, sharing a belief in the power of quantitative evidence to explain natural as well as cultural phenomena. At the same time, Harper deplored the obliteration of a rural culture, especially when it was done in the name of "progress." He found the construction of hydroelectric dams, for example, to be doubly irritating, for it simultaneously obliterated the pristine habitats of rare Southeastern plants and, by introducing electricity, contaminated the simple ways of unspoiled agrarian people.

Because Harper's interests were so intertwined, we

Bull. Alabama Mus. Nat. Hist. 17:25–45

May 1, 1995

Figure 1. Harper making some of his "car window" observations, 1 Aug 1940. (Harper s.n.)

have found it impossible to split either his accomplishments or his published works into neat categories. Instead, what we have produced is an introduction to the accomplishments of a very complex and prodigious man. We have relied primarily on the half-million Harper items in the William Stanley Hoole Special Collections Library of the University of Alabama. These items include his diaries, field notes, publications (especially reprints), an extensive photographic collection, as well as the inevitable "miscellaneous." Lesser collections may be found in the Alabama Museum of Natural History and the Geological Survey of Alabama.

Biographical Sketch

Roland McMillan Harper was born in Farmington, Maine, on August 11, 1878. His father, William, was originally from Ontario, and had been a farmer and Methodist preacher before studying science in Munich. His mother, Bertha, was the daughter of a German portrait painter. At the time of Roland's birth—he was the oldest of five children—the father was a teacher of science at the State Normal School in Farmington.

In 1885, William Harper became superintendant of schools in Southbridge, Massachusetts, to which the family moved. The stay in Massachusetts was a short one, though, due to Roland's health. Roland had developed a persistent cough, and Mr. Harper—fearing the onset of tuberculosis—looked for a position in a warmer climate. Within two years the family moved to Dalton, Georgia, where the boy's health improved. It was here, too, that many of Roland's basic interests developed: "Like several of my boy friends, I collected stamps and [railroad] timetables in those days; and that may have given me a taste for classification, which I developed later in botany" (Harper 1954a).

The family moved to Americus, Georgia, in 1892, where the father again served as school superintendant. Since Harper had already completed the 11 school grades available, he worked as an office boy for two railroad companies. His father was able to add a twelfth grade to the high school curriculum, and Harper graduated in 1894.

At that time, the twelfth year of high school was roughly equivalent to the first year of college, so Harper entered the University of Georgia as a sophomore engineering student. Much to his annoyance, he was required to take a beginning botany course: "I did not see any sense in making engineering students study botany, but there was no escape from it" (Harper 1967). Harper thrived on the field work and identifications, setting what was thought to be a "record" of 140 species collected—but he still intended to be an engineer.

Although he received his Bachelor of Engineering in 1897, Harper never worked a day as an engineer. The economic times were tough—his father was also unemployed—and no engineering positions developed, so Harper moved with his family back to Southbridge. There he took a job in an optical factory, working 58 hours per week. He used evenings, Sundays and holidays to botanize, familiarizing himself with the local flora. He also visited the Gray Herbarium at Harvard, where he introduced himself to such stalwart botanists as B. L. Robinson, J. M. Greenman, and M. L. Fernald. He joined the New England Botanical Club and published his first botanical paper ("Additions to the Flora of Worcester County, Massachusetts") in the first volume of the Club's journal,

Figure 2. "*Taxodium imbricarium* [pond cypress] in pond about five miles west of Vernon; largest one about ten feet in diameter at base." Washington County, Florida, 7 May 1914, 3:35 PM. (Harper 260.3)

Figure 3. "Buhrstone chimney of H. Stanley, about two miles east of Silas." Choctaw County, Alabama, 18 Jul 1911, 5:07 PM. (Harper 161.6)

Rhodora.

During this time, Harper apparently stayed in contact with his engineering professors as well. One of these men, while traveling in Europe, met L. M. Underwood of the botany program at Columbia University, and this chance meeting led to Harper's interest in Columbia and the New York Botanical Garden. In 1899, Harper secured a scholarship to Columbia and set off for the big city. The Botanical Garden was just opening, and Harper was soon in contact with the major botanical "players" of that time: "It was certainly a stimulating environment for a young botanist, which can hardly be matched anywhere today" (Harper 1954a).

Intending to write a flora of Georgia for his dissertation, Harper spent the early months of 1900 preparing for the first of his yearly field trips "back home." A number of his preparations and activities that summer would greatly influence his later works: a growing interest in geology, to note the rock formations on which plants were found; the starting of a diary, such that "every day of the 20th century so far is accounted for" (Harper 1967); and the purchase of a camera. Harper relied increasingly on his cameras. In 1909 he purchased a folding Kodak Autograph, which he found ideal, for it allowed him to identify the shot directly on the negative. In his usual fashion, Harper meticulously numbered and organized his photographs until at his death he had over 7000 shots arranged in scrapbooks. These photographs were overwhelmingly devoted to recording botanical and geological scenes and to documenting the passing of traditional material folk culture. Representative photographs are included in this paper. During that first season—September 19th, to be precise—he first viewed the Altamaha Grit Region of Georgia, whose vegetation would become the focus for his dissertation.

Figure 4. "Georgia RR mixed train crossing trestle (about fifty feet high) in Athens." Clarke County, Georgia, 21 Nov 1928, 1:54 PM. (Harper 624.3)

Figure 5. "Spider lilies [*Hymenocallis coronaria*, Cahaba lilies] on Squaw Shoals, in water about a foot deep." Tuscaloosa County, Alabama, 4 Jun 1913, 9:26 AM. (Harper 232.9)

Figure 6. "Raft going down Ohoopee River, just below bridge." Tattnall County, Georgia, 24 June 1903, 2:25 PM. (Harper 75.8)

While at Columbia, Harper assumed a number of tasks and projects outside his formal studies. During the spring of 1901 he took a six-week leave of absence in order to work with J. N. Rose at the National Herbarium in Washington. There he met a number of government botanists, including F. V. Coville:

> At that time Dr. [Charles] Mohr"s monumental *Plant Life of Alabama* was going through the press, as a National Herbarium publication; and Mr. Coville, knowing of my interest in such work, gave me a copy of the regional map that formed the frontispiece, and a set of page proof[s] of the introductory part, which dealt with regional classification, etc. And I took that with me to Georgia the following summer, for frequent reference . . . (Harper 1967).

Thus were added two more major interests to Harper's store: regional classification of vegetation, and the Alabama flora.

Harper received his Ph.D. in 1905. In the fall of that year, he joined the staff of the Geological Survey of Alabama, "to continue the work of the late Charles Mohr . . . on the economic botany of the state, particularly trees and shrubs" (Harper 1967). Harper remained associated with the Geological Survey for the rest of his career, while occasionally assuming short-term duties elsewhere. During part of 1917-18, Harper worked on a regional map o the United States for the Department of Agriculture; he had ready access to census reports, and it was at this time that his interest in demographics began. In 1925, Harper was placed in charge of the Florida state census. And during 1928-29, he served as research professor of economics at the University of Georgia, and was presented with an honorary Sc.D. After 1931, Harper was employed continuously by the Geological Survey of Alabama.

Harper remained a bachelor until the age of 65. In 1943 he married Mary Susan Wigley of Dawson, Alabama, who was fifteen years his junior; they lived in a small house near the University of Alabama campus. Joseph Ewan visited the eighty-five-year-old Harper in 1963:

> . . . I found him proud, confident, and critical. Of good eyesight—he had only recently forsaken his ten-cent store spectacles for prescription lenses—he spoke softly, his blue eyes closely watching my response . . . . He took keen satisfaction in his age, ticking off the deceased botanists that he had known (Ewan 1968).

Harper died three years later—April 30, 1966—and was buried in Tuscaloosa.

Figure 7. "Interior of dense cane-break on Big Creek, about four miles west of Northport. Largest canes about one inch by twenty feet." Tuscaloosa County, Alabama, 4 Mar 1913, 10:59 AM. (Harper 214.4)

Harper's Writings

By any standard, Harper was a prolific writer, with his "life list" of publications surpassing 600. His father must have been a major influence in this area, since the elder Harper himself published over 100 works, mostly of a religious, scientific, and educational nature (Anonymous 1907).

Roland Harper's first published writing was on the children's page of the *Michigan Christian Advocate* when he was but six-and-a-half years old (Harper 1954a). His first botanical works appeared in *Rhodora* in 1899, following graduation from college and removal to Massachusetts. These works were mainly "Additions to" or "Notes on" various floras, descriptions of collecting trips and the plants collected, nomenclatural problems and common names of plants, or discussions of individual species and their habitats or biology. [See Figure 8 for a graphical synopsis of his works.]

Included in these early works is Harper's first "car-window" observation—a glimpse of *Sarracenia flava* in the sand hills of North Carolina (Harper 1967). These observations, from notes taken during train rides across the countryside, compose Harper's unique contribution to the young science of plant geography. Harper justified this "hasty" technique in a 1914 paper on the pine barrens of Mississippi:

> One of the objects of this paper is to show how a botanical reconnaissance survey of an essentially homogeneous area of 13,000 square miles can be made in less than a week . . . . Even such hasty work brings out some fundamental and significant facts not previously known, and if more time can be devoted to it the results of course are still more satisfactory. (In view of these possibilities it looks like misdirected energy to spend months or years, as many botanists have done, in trying to make a complete collection of the plants of a single county or other restricted area, and publishing a list of them, which usually establishes no general principles and is therefore of very little scientific value.)

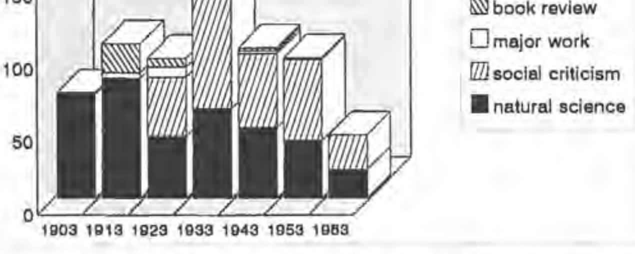

Figure 8. Graphical synopsis of Harper's papers; dates represent mid-points of decades.

Figure 9. "No-Tobacco League picnic in front of northern Methodist church, Wedowee." Randolph County, Alabama, 5 Jul 1936, 12:25 PM. (Harper 734.5)

While criticized for this practice, Harper was fully aware of the sources of bias and error and continued to defend his method, claiming that the "general principles" gained from such a survey were worth any loss of detail.

Until the end of World War I, Harper's writings were exclusively botanical or geographical. But after reviewing census reports while working in Washington, he became captivated by demographics and statistics and began to write letters-to-the-editor based on statistical comparisons. Harper often gleaned his statistics from newspapers and booster literature, or what Harper described as "a neglected source of geographical information" (Harper 1916). Harper used these statistics to examine a multitude of "problems," often arriving at startling conclusions: e.g., appendicitis lowers the birth rate (Harper 1938), and "the proportion of spinsters . . . is a pretty good index of culture" (Harper 1939). While today these claims sound totally absurd, Harper was simply reflecting the nineteenth-century trust in the application of statistics and the scientific method to social phenomena.

An examination of Harper's writings reveals two other themes of the early- to mid-twentieth century: the promise of eugenics and the specter of communism. Eugenics—with its emphasis on the application of natural laws, the conservation of resources, and strict standards for "clean living"—was quite an attractive force for Harper, and its basic philosophy shows up in many of his writings. Unfortunately, he also fully embraced the social Darwinism and racism intrinsic to the movement. Eugenics continued to be a powerful force in American social thinking (and in Harper's writings) until the Great Depression and the revealed horrors of Nazism.

With eugenics dying, Harper turned to McCarthyism. He found communism everywhere he looked: in the

Figure 10. "Turpentine still among pine hills between Brookwood and Tidewater; said to be about five years old." Tuscaloosa County, Alabama, 15 Apr 1911, 2:50 PM. (Harper 141.1)

sameness of tombstones, in the American public school system, in woman suffrage, and in the integration of churches (Harper 1953, 1954b). Basically, any movement that led to the breakdown of class, gender, or racial distinctions was deemed to be "communist," and he insisted on bringing it to the attention of the reading public.

Early in his career, Harper developed a simple system to keep track of his rapidly increasing publications. He numbered his reprints in pencil in the upper right-hand corner, with the number circled. The first 59 papers were numbered sequentially; after that point, special systems were added. Book reviews were given an "R" prefix, and major works were prefixed with "P". The latter, however, were not always so major; for example, P22, "Some Economic Features of the Pensacola Terrace in Florida," was but seven pages long. Occasionally, Harper gave a paper a number ending in "½," as if he had delayed in inserting it into the sequence. Others have multiple designations (e.g., 318a and 318b) for different reprint versions. Harper often supplied alternative titles for his reprinted articles, especially his letters-to-the-editor; in the following list of his works, these alternative titles have been placed in brackets.

The first person to produce a formal list of Harper's papers was Jack McCormick. This list was put together in the mid-1950s as part of a graduate student seminar project at Rutgers University; Harper contributed an autobiographical sketch to the project, and McCormick compiled a list of Harper's writings (Harper 1967). McCormick's list was necessarily incomplete, since about 10 productive years remained of Harper's life, and a number of errors and omissions occur. The following list—based on McCormick's but updated and corrected—contains nearly all of Harper's writings, with each citation followed by a number. The numbers assigned by Harper are included in parentheses; brackets enclose any numbers that we have added to his system.

List of Publications by Roland Harper

1899

Additions to the flora of Worcester County, Massachusetts. I. Rhodora 1:42–43. [1]

A new station for *Potentilla tridentata*. Rhodora 1:90–91. [2]

The pteridophytes of Georgia. Fern Bull. 7:65–67. [3]

Additions to the flora of Worcester County, Massachusetts. II. Rhodora 1:201–205. [4]

1900

Further additions to the flora of the Amherst region. Rhodora 2:68–70. [5]

Notes on the distribution of some of the rarer plants of central Massachusetts. Rhodora 2:119–123. [6]

Notes on the flora of Middle Georgia. Bull. Torrey Bot. Club 27:320–341. (7)

Notes on the flora of South Georgia. Bull. Torrey Bot. Club 27:413–436. (8)

Figure 11. Harper's plant press propped against a longleaf pine trunk, about four miles south of Moultrie, Georgia. (Harper 33.2)

1901

Synonymy of *Burmannia* and *Gyrotheca*. Torreya 1:33–34. [9]

Additions to the flora of Worcester County, Massachusetts. III. Rhodora 3:185–186. [10]

On a collection of plants made in Georgia in the summer of 1900. Bull. Torrey Bot. Club 28:454–484. (11)

Some popular plant names used in Georgia. Torreya 1:115–117. [12]

1902

Ilex myrtifolia with yellow fruit. Torreya 2:43–44. [13]

Notes on *Lycopodium clavatum* and its variety *monostachyon*. Rhodora 4:100–102. [14]

Notes on *Elliottia racemosa*. Plant World 5:87–90. [15]

Taxodium distichum and related species, with notes on some geological factors influencing their distribution. Bull. Torrey Bot. Club 29:383–399. (16)

Notes on the Lafayette and Columbia formations and some of their botanical features. Science (ser. 2) 16:68–70. [17]

A visit to Okefinokee Swamp in southern Georgia. Torreya 2:156–158. (18)

1903

A unique climbing plant. Torreya 3:21–22. [19]

Exploration of Okefinokee Swamp. Science (ser. 2) 17:508. [20]

Two new stations for *Elliottia*. Plant World 6:60. [21]

Botanical explorations in Georgia during the summer of 1901. Bull. Torrey Bot. Club 30:282–295, 319–342. (22)

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