



ALABAMA
MUSEUM
of Natural History

Bulletin

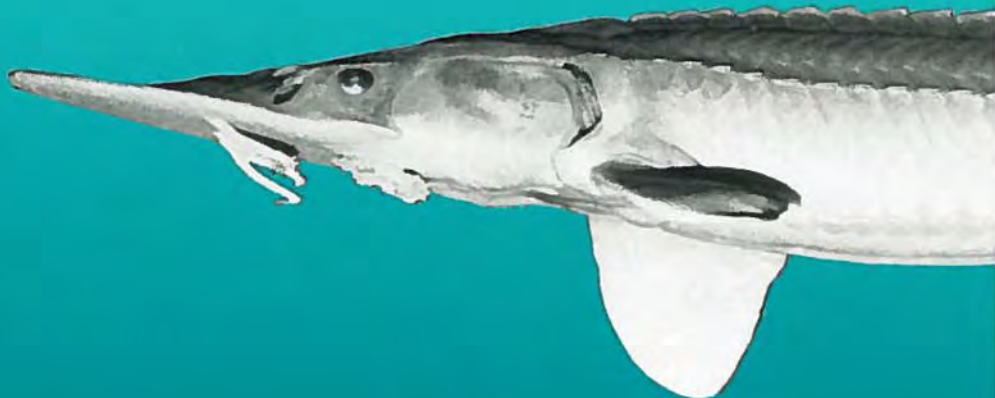
Number 10

June 1, 1991

Notropis rafinesquei,
a New Cyprinid Fish from the Yazoo River System in Mississippi

Reproductive Behavior of *Exoglossum* Species

Scaphirhynchus suttkusi,
a New Sturgeon from the Mobile Basin of Alabama and Mississippi



**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.

BULLETIN ALABAMA MUSEUM OF NATURAL HISTORY is published by the Alabama Museum of Natural History, a unit of The University of Alabama. The **BULLETIN** succeeds its predecessor, the **MUSEUM PAPERS**, which was terminated in 1961 upon the transfer of the Museum to the University from its parent organization, the Geological Survey of Alabama.

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.

Communication concerning manuscripts, style, and editorial policy should be addressed to: Editor, **BULLETIN ALABAMA MUSEUM OF NATURAL HISTORY**, The University of Alabama, Box 870340, Tuscaloosa, AL 35487-0340; Telephone (205) 348-7550. Prospective authors should examine the Notice to Authors inside the back cover.

Orders and requests for general information should be addressed to Managing Editor, **BULLETIN ALABAMA MUSEUM OF NATURAL HISTORY**, at the above address. Numbers may be purchased individually; standing orders are accepted. Remittances should accompany orders for individual numbers and be payable to The University of Alabama. The **BULLETIN** will invoice standing orders. Library exchanges may be handled through: Exchange Librarian, The University of Alabama, Box 870266, Tuscaloosa, AL 35487-0340.

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

ISSN: 1055-0240

Copyright, 1991 by The Alabama Museum of Natural History

Price this number: \$5.00



ALABAMA
MUSEUM
of Natural History

Bulletin

Number 10

June 1, 1991

Notropis rafinesquei,
a New Cyprinid Fish from the Yazoo River System in Mississippi
by Royal D. Suttkus

Reproductive Behavior of *Exoglossum* Species
by Eugene G. Maurakis, William S. Woolcott, and Mark H. Sabaj

Scaphirhynchus suttkusi,
a New Sturgeon from the Mobile Basin of Alabama and Mississippi
by James D. Williams and Glenn H. Clemmer

THE UNIVERSITY OF ALABAMA
TUSCALOOSA, ALABAMA

June 1, 1991

Notropis rafinesquei, a New Cyprinid Fish from the Yazoo River System in Mississippi.

Royal D. Suttkus

Museum of Natural History, Tulane University
Belle Chasse, Louisiana 70037

ABSTRACT: Suttkus, Royal D. 1991. *Notropis rafinesquei*, a new cyprinid fish from the Yazoo River System in Mississippi. *Bulletin Alabama Museum of Natural History*, Number 10:1-9, 4 tables, 3 figures. *Notropis rafinesquei*, a new shiner (Cyprinidae), is endemic to the Yazoo River system in Mississippi. It is related to *Notropis longirostris*, *N. sabiniae*, and *N. ammophilus*. The related three species occur in the Yazoo system and in numerous other river systems along the Gulf Slope. The four species comprise a species complex to themselves.

The Yazoo shiner, *Notropis rafinesquei*, is most similar to *N. ammophilus* in some body proportions and pigmentation but differs from *N. ammophilus* in details of the disposition of xanthic coloration, some body proportions, and fin-ray and scale counts.

Introduction

Recently, the orangefin shiner, *Notropis ammophilus*, was described (Suttkus and Boschung, 1990) and compared to *Notropis longirostris* and *N. sabiniae*. An undescribed form, mentioned as belonging to the same *longirostris* species complex, is the subject of this paper. All four species occur in the Yazoo River system of northern Mississippi. The form herein described is an endemic to the Yazoo River system whereas the other three species, *N. ammophilus*, *N. longirostris*, and *N. sabiniae* also occur in other river systems.

Methods

Counts and measurements follow those described by Hubbs and Lagler (1964). Measurements were taken with a dial caliper and were recorded to the nearest tenth of a millimeter. Lengths are in standard lengths (SL). Vertebral counts include four elements in the Weberian complex and the urostylar vertebra.

For type material and other material examined, numbers in parentheses following each catalog number indicate the number of specimens and the range of standard length in mm, e.g. (14, 15-36). In addition to standard compass directions the following abbreviations are used: Cr. =

Creek, mi = mile or miles, R. = River, trib = tributary, Miss Hwy = Mississippi Highway, US Hwy = United States Highway, Rd = Road, AUM = Auburn University, CU = Cornell University, TU = Tulane University, Museum of Natural History, UAIC = University of Alabama Ichthyology Collection, UF = University of Florida, Florida Museum of Natural History, UMMZ = University of Michigan, Museum of Zoology, USNM = National Museum of Natural History, and UT = University of Tennessee.

The 1980 Common and Scientific Names of Fishes (Robins, et al.) is followed with regards to generic groupings of the family Cyprinidae.

Notropis rafinesquei, new species
Yazoo Shiner
Figure 1

Notropis sp. Suttkus and Boschung, 1990 (reference to undescribed form).

The type material consists of 1838 specimens measuring from 18 to 43 mm SL collected from Teoc Creek system,

tributary to Yalobusha River. Other material examined (see below) consists of 7931 specimens in 92 collections from 75 additional sites in the Yazoo River system in Mississippi (Fig. 2).

HOLOTYPE.—TU 157264, adult tuberculate male 38.2 mm SL, from Teoc Cr., trib. to Yalobusha R. at Miss. Hwy 35, Carroll County, (T20N, R3E, Sec. 21), 12 May 1985, Royal D. Suttikus and Veronica Trau Colbert.

PARATYPES.—The 429 specimens (23-39) collected with the holotype are distributed as follows: TU 140774 (309), CU 71713 (20), UAIC 9102.01 (10), UF 78364 (20), UMMZ 214872 (20), USNM 301166 (10), and UT 44.4505 (20). Four other series collected at the same site on the following dates include: TU 139610 (750, 18-38), 17 February 1985; TU 150052 (97, 18-39), 27 September 1987; TU 155847 (165, 19-42), 8 August 1989; TU 158025 (346, 22-39), 17 May 1990. TU 141302 (50, 35-43), was taken from Aiken Cr., a small trib. to Teoc Cr. (T20N, R3E, Sec 17) on 22 June 1985.

DIAGNOSIS.—A species of the *Notropis longirostris* species group as defined by Suttikus and Boschung (1990). This species has 4-4 pharyngeal teeth and 7 anal fin rays, and is best distinguished from other members of the species group by the arrangement of coloration. Xanthic coloration concentrated at base of each fin. Unique xanthic cleithral bar extends from base of pectoral fin to upper end of opercular opening; in nuptial males, coloration extends forward from upper end of cleithral bar to posterior rim of orbit. Typically distinct dark basal-caudal spot (usually small, elongate blotch) separated from posterior end of lateral body stripe by pale area. Thin submarginal line of pigment on lateral line scales and two rows above, absent or poorly developed. Lowest number of pectoral fin rays (\bar{x} = 13.2) and highest number of lateral line scale rows (\bar{x} = 35.3) and predorsal diagonal scale rows (\bar{x} = 15.7) of species complex.

DESCRIPTION.—Proportional measurements are presented in Tables 1 and 2; meristic variation is presented in Tables 3 and 4; and general body shape and coloration are illustrated in Figure 1. The meristics not tabulated are as follows: dorsal fin rays 7 (13 individuals), 8 (97); anal fin rays 6 (5), 7 (102), 8 (3); pelvic fin rays 7-7 (21), 7-8 (13), 8-7 (6), 8-8 (70); principal caudal fin rays 17 (1), 18 (3), 19 (105), 20 (1); and caudal peduncle scale rows 11 (1), 12 (108), 15 (1). Fin ray and scale counts for the holotype are as follows: D 8, A 7, P 14-15, V 8-8, C 19, lateral line scales 36, caudal peduncle scales 12, body circumferential scales 24, and predorsal diagonal scale rows 16.

The pharyngeal teeth are 4-4 (30 individuals) and are moderately hooked; the edges of the grinding surface entire or weakly crenate.

The subrete body form, with an arched dorsal profile and a slightly curved venter, are adaptations for a benthic habitat. A similar body shape is exhibited by the other members of the species group. *Notropis rafinesquei* has a moderately slim, short body. The head is nearly conical in shape; proportional width and depth of the head being less than in other members of the species group (Table 1). The mouth is inferior and nearly horizontal to slightly curved and oblique. The dorsal fin is slightly elevated, and the anterior rays are usually slightly to decidedly longer than the posterior rays in the depressed fin position; the posterior margin is nearly straight. The anal fin is only slightly elevated. Sexual dimorphism of the anal fin is pronounced. The leading edge of the anal fin of the male is nearly straight to the tip of the first principal ray; the anterior rays are considerably longer than the posterior rays in the depressed fin. In nuptial females the anterior rays are flexed toward the body at their distal tips; the third or fourth or any ray thereafter to the last (seventh) may be the longest in the depressed fin position. The pectoral fins of males and females are about the same length; however, pelvic fins of males average somewhat longer than those of females.

Females occasionally with a scattering of minute tubercles on the top of the head but only males have well developed tuberculation. Moderately large tubercles are scattered over the top of the head from the occiput to the internarial area. Anterior to the internarial area the tubercles are smaller and more or less evenly spaced. The suborbital area, preopercle, and opercle are usually devoid of tubercles. Mandibular ridges with moderately large tubercles. Nuptial males possessing maximum tubercle development have tubercles along the anterior 11 or 12 pectoral fin rays. Typically, there is only a single row of small tubercles along the anterior pectoral ray and multiple rows of tubercles along the second to the eighth pectoral fin ray. Thereafter, there is a diminishing number of rows (usually a single row) and number of tubercles per row, from the ninth to the eleventh or twelfth ray. It is not uncommon for males in full tuberculation to have small tubercles along dorsal, anal, and pelvic fin rays. Nuptial males with tubercles along the margins of scales on the predorsal and anterior lateral body areas.

The lateral line sensory system is frequently incomplete. The pored scale count included those scales with a notch on the posterior margin as well as those with the typical elevated tubular ridge. A sample of twenty specimens was examined with the following results: 6 specimens had a complete lateral line system; 2 had a single unpored scale; 5 had two unpored scales; 3 had three unpored scales; 2 had four unpored scales; 1 had five unpored scales; and 1 had six unpored scales. Casual examination of several dozen additional specimens revealed one unusual individual. This specimen had 22 unpored scales in the left lateral series and 21 unpored scales in the right lateral series.

Gill rakers are small and spaced such that none are long



Figure 1. *Notropis rafinesquei*, new species. Lateral view of paratype, TU 155847, male 40mm SL, collected by R.D. Suttkus on August 8, 1989. Photo by P.E. O'Neil.

Table 1. Proportional Measurements (Expressed in Thousandths of Standard Length) for Males of *Notropis rafinesquei*, *N. ammophilus*, *N. longirostris*, and *N. sabiniae* from the Yazoo River Drainage in Mississippi. (N=25 for each species plus Holotype of *N. rafinesquei*).

Character	Holotype	<i>N. rafinesquei</i>			<i>N. ammophilus</i>			<i>N. longirostris</i>			<i>N. sabiniae</i>		
		Range	\bar{x}	SD	Range	\bar{x}	SD	Range	\bar{x}	SD	Range	\bar{x}	SD
Standard length (mm)	38.2	33.3-40.8	36.3	1.7289	37.0-44.6	40.6	1.8554	37.6-41.4	39.5	1.1570	34.9-40.9	37.4	1.6015
Dorsal origin to snout tip	515	494-524	511	0.0080	403-528	513	0.0084	491-529	511	0.0083	494-523	511	0.0081
Dorsal origin to caudal base	523	507-537	522	0.0064	505-555	526	0.0113	510-541	525	0.0086	513-538	524	0.0070
Dorsal origin to occiput	285	274-303	290	0.0083	275-310	292	0.0089	280-322	299	0.0112	278-301	290	0.0067
Pelvic insertion to snout tip	502	478-517	497	0.0097	492-523	511	0.0082	485-523	503	0.0103	467-512	486	0.0101
Anal origin to caudal base	369	343-390	362	0.0100	333-365	351	0.0089	321-367	346	0.0100	350-377	366	0.0067
Body, greatest depth	204	196-233	210	0.0084	208-240	226	0.0066	191-207	198	0.0051	207-234	222	0.0066
Body, greatest width	136	135-157	142	0.0063	140-165	151	0.0052	129-145	136	0.0035	145-161	153	0.0049
Caudal peduncle, length	249	239-272	254	0.0080	229-266	247	0.0087	239-267	252	0.0074	244-278	263	0.0100
Caudal peduncle, least depth	102	100-118	105	0.0040	103-122	114	0.0041	104-113	108	0.0024	117-127	123	0.0032
Head, length	267	249-283	264	0.0085	266-290	275	0.0066	248-284	263	0.0083	269-289	279	0.0048
Head, depth	160	157-175	163	0.0044	164-179	172	0.0038	148-165	159	0.0041	167-185	175	0.0043
Head, width	139	138-157	146	0.0052	143-158	152	0.0040	130-148	140	0.0045	152-171	162	0.0047
Interorbital, least fleshy width	89	82-92	88	0.0024	84-98	91	0.0040	78-88	83	0.0032	88-104	94	0.0039
Snout, length	86	78-94	88	0.0044	83-95	89	0.0031	75-90	84	0.0033	91-104	97	0.0032
Orbit, length	73	65-79	74	0.0035	69-77	73	0.0026	70-78	74	0.0015	66-72	70	0.0018
Upper jaw, length	86	84-93	89	0.0028	78-97	89	0.0047	73-90	82	0.0040	83-97	90	0.0039
Dorsal fin, length	212	210-232	221	0.0054	206-241	225	0.0085	199-232	216	0.0086	196-226	214	0.0075
Anal fin, length	178	177-203	191	0.0070	164-197	184	0.0074	168-193	178	0.0065	175-194	184	0.0052
Caudal fin, length	259	253-298	270	0.0099	269-303	284	0.0103	258-301	276	0.0097	262-299	281	0.0082
Pectoral fin, length	188	173-202	190	0.0064	169-192	184	0.0057	173-192	183	0.0052	167-200	181	0.0080
Pelvic fin, length	154	146-165	157	0.0051	128-163	151	0.0076	138-170	148	0.0070	148-175	156	0.0064

Table 4. Number of Vertebrae in *Notropis rafinesquei* and *Notropis ammophilus*.

Species and System	Number of Vertebrae					N	\bar{x}	S.D.
	33	34	35	36	37			
<i>N. rafinesquei</i>								
Yazoo River		5	68	54	4	131	35.43	0.6214
<i>N. ammophilus</i>								
Alabama River	1	51	54	3		109	34.54	0.5698

enough to overlap the next when depressed against the arch. The two or three rakers on the upper arm (epibranchial) are better developed than those on the lower arm (ceratobranchial) of the gill arch. Total gill rakers for twenty specimens are as follows: 6 (5 specimens); 7 (9); 8 (6).

COLORATION.—Coloration of the adults apparently is present throughout the year, however it is brightest during the breeding season. The xanthic coloration is concentrated at the bases of all fins and diminishes in intensity toward the middle and distal parts of each fin. The distal pigmentation fades rather rapidly after preservation, whereas the concentrated basal pigmentation may persist for several months after formalin preservation. In nuptial males the xanthic cleithral bar is continuous with a postorbital xanthic bar. This latter bar extends from the upper end of the cleithral bar forward to the posterior rim of the orbit (Fig. 1). Some individuals have xanthic coloration on the upper part of the iris. Nearly all individuals exhibit xanthic coloration along the lips.

In preservative *Notropis rafinesquei* is a pale, lightly pigmented fish and is quite similar to the orange-fin shiner, *Notropis ammophilus* (Suttkus and Boschung, 1990). The dark spots above and below each lateral line pore are usually prominent anteriorly but often blend with the lateral stripe on the caudal peduncle. There is little, if any, pigmentation on the scales below the lateral line row. Large adults typically have pigmentation on the first three to eight scales in the row below the lateral line; these scales are margined with melanophores. Frequently, the outline of the exposed part of the scale is incomplete; dorsal margins, nearest to the lateral line, are pigmented but ventral part is unpigmented. Below the lateral line the body usually is immaculate; posteriorly there is little, if any, pigmentation below the lateral stripe. The anterior end of the lateral stripe is slightly in advance of a vertical through the anterior insertion of the anal fin; posterior termination is at the caudal base. Black or dark brown basal-caudal blotch separated from the lateral stripe by a pale area (lightly pigmented or no pigmentation). The blotch, under magnification, is revealed as a single oval spot, a single slash of dark pigment, or two

closely approximated slashes of dark pigment. After years in preservatives the intensity of the blotch fades and can make identification more difficult. In general, the scales above the lateral line are margined with melanophores; exposed part of each scale with enclosed unpigmented area. The predorsal stripe partially obliterates the unpigmented central part of the predorsal scales. The postdorsal stripe or pigmentation is more intensive and extensive than predorsal pigment, and there is essentially no unpigmented areas remaining on the postdorsal scales. The central areas of postdorsal scales are distinguishable because the pigmentation is less dense than that on the marginal areas.

The dark pigmentation on the dorsum of head is typical of many shiners. The pronounced heart-shaped patch of dark pigmentation over the posterior part of the brain is oriented with the apex of the "heart" at the mid-point of the occiput. There are two parallel elongate patches of dense pigment located on the interorbital area and an additional smaller pair on the internarial area. Scattered melanophores occur between these two pairs of blotches, and the upper surface of the snout is evenly covered with melanophores. Lateral to the heart-shaped patch very little pigmentation extends beyond the upper margins of the preopercle and opercle. Some specimens have a "string" of melanophores along the suborbital rim connecting with a moderately dense patch of pigmentation on the preorbital area. The lower suborbital, lower opercular, entire venter of head, lower part of the sides, breast, belly, and ventral part of the caudal peduncle are immaculate. Some specimens have pigmentation along the base of the anal fin. All fins are devoid of pigmentation.

GEOGRAPHICAL VARIATION.—No significant variation was found during comparison of the tributary population samples of the Yazoo shiner, *Notropis rafinesquei*.

ETYMOLOGY.—This new shiner is named to honor one of our early American naturalists, Constantine Samuel Rafinesque (1783-1840).

RANGE.—*Notropis rafinesquei* is endemic to the Yazoo River system of Mississippi. It occurs in the upper tributaries of the Yazoo system (Fig. 2) from the Loess or Bluff Hills physiographic region eastward and northeastward into the North Central Plateau physiographic region. It has not been found west of the Bluff Hills in the Yazoo Delta physiographic region. The distributions of the other three related species in the Yazoo River system are presented in Figure 3.

COMPARISONS.—The unique arrangement of the xanthic coloration of *Notropis rafinesquei* is described above. *Notropis sabiniae* is the only member of the *longirostris* species group that lacks a bright xanthic coloration. *Notropis longirostris* and *N. ammophilus* have



Figure 2. Distribution by record stations of *Notropis rafinesquei* (solid dots); type locality (solid star in open circle).

the xanthic coloration (usually lemon yellow in *longirostris* and orange in *ammophilus*) concentrated on the central part of the fins; in preservative the distal and basal xanthic coloration fades almost immediately. The latter species both lack the bright cleithral bar and the connecting postorbital xanthic bar. *Notropis rafinesquei* is more similar to *N. ammophilus* in melanophore pigmentation than either *N. sabiniae* or *N. longirostris*. The pronounced lateral stripe on the caudal peduncle and the pigment spots above and below lateral line pores are similar patterns in *N. rafinesquei* and *N. ammophilus*. The thin submarginal line of pigment on the lateral line scales and two rows above the lateral line is typical of *N. ammophilus* (Suttkus and Boschung, 1990) but is absent or poorly developed in *N. rafinesquei*. The basal-caudal spot or blotch of *N. ammophilus* is usually chevron-shaped and less distinct than the spot of *N. rafinesquei*; both *N. longirostris* and *N. sabiniae* lack a basal-caudal dark spot. Moreover, in *N. rafinesquei* the pale area between the posterior termination of the lateral stripe and the caudal spot emphasizes the latter.

Notropis rafinesquei, *N. ammophilus*, and *N. sabiniae* are short bodied forms whereas *N. longirostris* has an elongate

body. The comparison of *N. ammophilus*, *N. sabiniae*, and *N. longirostris* in Suttkus and Boschung (1990) and Tables 1 and 2 present data for a number of body proportions that reflect the two different body shapes. *Notropis rafinesquei* can be distinguished from the other two short bodied forms by comparison of specific body proportions (Tables 1 and 2). For example, head depth, head width, body depth, body width, and caudal peduncle depth. Proportions average less in *N. rafinesquei*, indicating that *N. ammophilus* and *N. sabiniae* are somewhat more robust than the former species.

Notropis rafinesquei, *N. ammophilus*, and *N. sabiniae* invariably have 4-4 pharyngeal teeth; *N. longirostris* is variable in this character. Fifty specimens of *Notropis longirostris* from the Yazoo River system have the following formulae: 4-4 (27); 1, 4-4 (5); 4-4, 1 (5); and 1, 4-4, 1 (13).

The number of vertebrae differ among the four species. *Notropis ammophilus* and *N. sabiniae* usually have 34 or 35 vertebrae, *N. rafinesquei* usually has 35 or 36, and *N. longirostris* usually has 36 or 37 (Table 4).

Notropis rafinesquei averages a lower number of pectoral fin rays, a higher number of lateral line scale rows, and a higher number predorsal diagonal scale rows than *N.*

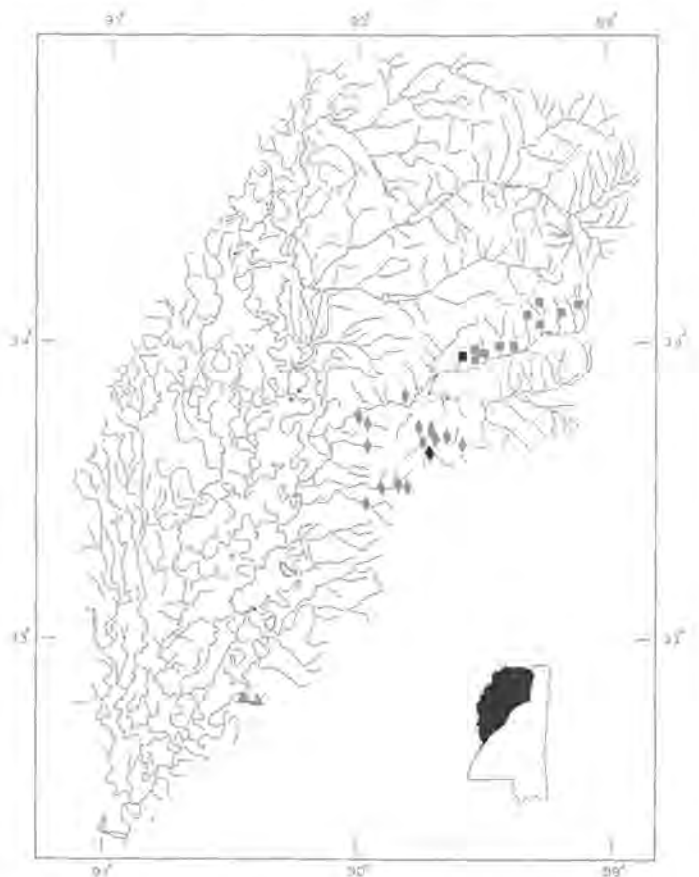


Figure 3. Distribution by record stations of *Notropis longirostris* (solid triangles), *Notropis sabiniae* (solid diamonds), and *Notropis ammophilus* (solid squares) in the Yazoo River system.

ammophilus, *N. longirostris*, and *N. sabiniae* (Table 3). Body circumferential scale rows of *Notropis rafinesquei* average higher than those in *N. ammophilus* and *N. longirostris*, but average lower than those present in *N. sabiniae*.

HABITAT AND BIOLOGY.—*Notropis rafinesquei* usually inhabits small to medium size streams with moderate current, and a sand or fine gravel substrate. Teoc Creek, the type locality, varies from three to nine meters or more in width and usually flows clear from depths of a few centimeters in the riffles to several meters in the pools. Upstream of Miss Hwy 35 the stream is shallow with primarily sand substrate. Teoc Creek is more than 10 meters wide at the downstream side of the concrete culvert under Hwy 35. There is a plunge pool that has a maximum depth slightly over one meter. During the summer and fall, flow from the plunge pool narrows to a shallow riffle 2 meters or less in width; this narrow stretch is frequented by *N. rafinesquei* and *N. camurus*. Frequently, while seining in the area, the fishes moved immediately into the plunge pool. *Notropis rafinesquei* like other members of the species group is a gregarious species. Spawning aggregations of *N. rafinesquei* were observed in Teoc Creek both above and below the Hwy 35 culvert on May 12, 1985.

All four species of the *longirostris* species group occur in the Yazoo River system. *Notropis rafinesquei* and *N. sabiniae* occur together at numerous sites; *N. rafinesquei* was taken at all 15 sites where *N. sabiniae* was taken in the Yazoo River system. *Notropis longirostris* occurs in the lower Yazoo system and *N. ammophilus* occurs in the upper Skuna River system, both in isolation from the other species of the complex (Fig. 3). This is the first published record of *N. longirostris* and *N. sabiniae* in the Yazoo River system and also constitutes the first record of *N. sabiniae* east of the Mississippi River (Lee, et al, 1980; Wiley and Mayden, 1985). *Notropis rafinesquei*, as mentioned above, is a small stream inhabitant, whereas sympatric *N. sabiniae* prefers larger stream habitat. Sand Creek at Miss Hwy 35 in Carrollton and Potacocowa Creek, north of Carrollton at Miss Hwy 35, are both large creeks in comparison to Teoc Creek. One collection from Sand Creek at Carrollton, during low water yielded 10 *N. rafinesquei* and 73 *N. sabiniae*. Two collections were obtained from the upper part of Sand Creek system. Thompson Creek, a trib to Sand Creek, at 4.5 airmi (7.2 km) upstream from the Carrollton site, and Sand Creek at 5.0 airmi (8.0 km) upstream from the Carrollton site, yielded 24 *N. rafinesquei* and 7 *N. sabiniae* and 123 *N. rafinesquei* and 17 *N. sabiniae*, respectively. Three collections from Potacocowa Creek at Miss Hwy 35 yielded 101 *N. rafinesquei* and 224 *N. sabiniae*.

Another example to illustrate the habitat preference of the two species are samples from two sites along Cane Creek. The upper site at Miss Hwy 35 was sampled twice and yielded 116 *N. rafinesquei* and 4 *N. sabiniae*. The lower site at Miss Hwy 7, 2.2 airmi (3.5 km) downstream of the Hwy 35 site,

was sampled once and yielded 63 *N. rafinesquei* and 109 *N. sabiniae*.

Species associates in the five collections from the type locality were as follows: *Erimyzon oblongus*, *Notropis camurus*, *N. lutrensis*, *Pimephales notatus*, *Semotilus atromaculatus*, *Ictalurus natalis*, *Fundulus olivaceus*, *Gambusia affinis*, *Lepomis cyanellus*, *L. macrochirus*, *Micropterus salmoides*, and *Etheostoma whipplei*. The 1788 specimens of *N. rafinesquei* composed 52.1% of the total (3430) specimens taken in the five collections.

Key to the *Notropis longirostris* Species Complex

1. Pronounced lateral stripe on posterior part of body; dark spot or blotch at basal-caudal area 2
 Lateral stripe not present; no dark spot or blotch at basal-caudal area 3
2. Bright xanthic coloration concentrated on central part of each fin; no xanthic cleithral bar; no xanthic post-orbital bar; basal-caudal pigment dusky and chevron-shaped; higher pectoral fin ray count (\bar{x} = 14.2); lower lateral line scale count (\bar{x} = 33.7); lower predorsal diagonal scale row count (\bar{x} = 13.5); lower body circumferential scale row count (\bar{x} = 21.4) *N. ammophilus*
 Bright xanthic coloration concentrated at base of fins; xanthic cleithral bar present; post-orbital xanthic bar present on nuptial males; basal-caudal pigment in form of oval spot, single slash-like mark, or double slash mark (like an = symbol); lower pectoral fin ray count (\bar{x} = 13.2); higher lateral line scale count (\bar{x} = 35.3); higher predorsal diagonal scale row count (\bar{x} = 15.7); higher body circumferential scale row count (\bar{x} = 23.5). *N. rafinesquei*
3. Pharyngeal tooth formula 4-4; no bright xanthic coloration; principal breeding tubercles of nuptial males in closely set clumps on end of snout and on lachrymal area; mental symphyseal bib present on nuptial males and gravid females; body, greatest depth usually greater than 20% standard length *N. sabiniae*
 Pharyngeal tooth formula frequently 1, 4-4, 1 or (1, 4-4, 0/0, 4-4, 1); bright xanthic coloration present; principal breeding tubercles of nuptial males scattered over top of head (not in clumps); no mental symphyseal bib; body, greatest depth usually less than 20% of standard length. *N. longirostris*

Acknowledgments

The author wishes to express his appreciation to a number of former students at Tulane University and University of New Orleans for help in collecting. They are in alphabetical order: John H. Caruso, Robert C. Cashner, Glenn H. Clemmer, Veronica Trau Colbert, Keith G. Goodfellow, Steven Herbert, John Pagels, and John S. Ramsey. Glenn H. Clemmer also assisted by making vertebral counts from radiographs. Maurice F. Mettee provided space in his laboratory (Geological Survey of Alabama) and assisted the author in preparing specimens for photographs by Patrick E. O'Neil. I am indebted to both of these individuals for their assistance and for generosity of their time. Also I would like to thank E.O. Wiley and two anonymous reviewers for their many helpful suggestions.

Material Examined:

Additional collections of *N. rafinesquei*, not designated as types, examined for counts, measurements, pigmentation, and/or used for distribution map (Fig. 2), totaling 7931 specimens, in 92 collections, are listed below. All specimens are from Mississippi. **Holmes County:** TU 141212 (1, 33), Harland Cr., (T15N, R1E, Sec 35), 20 June 1985; TU 146098 (142, 16-37), Tarrey Cr., at Owen Wells (T14N, R3E, Sec. 3), 15 August 1986; TU 146116 (53, 27-37), Tarrey Cr., 3.4mi E Lexington, Miss Hwy 12 (T15N, R3E, Sec 33), 15 August 1986; TU 146166 (530, 15-38), Shipp Cr., (T15N, R3E, Sec 28), 20 August 1986; TU 146185 (1, 36), trib to Tarrey Cr., (T15N, R3E, Sec 5), 20 August 1986; TU 146195 (39, 30-41), Gourdvine Cr., (T15N, R3E, Sec 36), 20 August 1986; TU 146207 (233, 12-36), trib to Black Cr., (T15N, R3E, Sec 15), 20 August 1986; TU 146259 (4, 17-34), Williams Cr., (T14N, R2E, Sec 7), 21 August 1986; TU 139627 (482, 20-37), Bophumpa Cr., 6.5 mi (10.4 km) N Lexington, Miss Hwy 17, (T16N, R2E, Sec 36), 17 February 1985, TU 145355 (385, 23-41), 16 May 1986; TU 145340 (9, 27-38), trib to Bophumpa Cr., Miss Hwy 17, (T15N, R2E, Sec 1), 16 May 1986; TU 145375 (89, 25-40), Bophumpa Cr., (T16N, R3E, Sec 31), 16 May 1986; TU 145427 (6, 25-34), Fannegusha Cr., (T15N, R2E, Sec 6), 16 May 1986. **Carroll County:** TU 139619 (3, 31-33), Coila Cr., at Coila, Miss Hwy 17, (T18N, R3E, Sec 27), 17 February 1985; TU 141312 (101, 30-40), Dry Cr., Miss Hwy 17, (T17N, R3E, Sec 8), 22 June 1985; TU 150059 (445, 17-40), Abiaca Cr., 0.3 mi (0.5 km) S Black Hawk, Miss Hwy 430, (T17N, R3E, Sec 20), 27 September 1987; TU 140799 (137, 25-38), Pelucia Cr., Miss Hwy 17, (T19N, R3E, Sec 35), 12 May 1985; TU 140026 (24, 26-40), Thompson Cr., at Winona Rd, (T19N, R4E, Sec 11), 16 March 1985; TU 140035 (123, 16-37), Sand Cr., 0.3mi S McCarley, (T19N, R4E, Sec 12), 16 March 1985; TU 140784 (10, 23-33), Sand Cr., at Carrollton, Miss Hwy 35, (T19N, R4E, Sec 18), 12 May 1985, TU 155837 (22, 29-36), 8 August 1989; TU 140015 (77, 18-33), Potacocowa Cr., 7.8 mi (12.5 km) S Holcomb, Miss Hwy 35, (T21N, R3E, Sec 27), 16 March 1985, TU 140758 (21, 25-34), 12 May 1985, TU 155854 (3, 31-33), 8 August 1989. **Montgomery County:** TU 3112 (102, 23-36), Wilkins Cr., 2.0 mi (3.2 km) N Duck Hill, US Hwy 51, (T21N, R5E, Sec 25), 23 May 1952; TU 153724 (13, 21-33), Little Bogue Cr. (East Fork Batupan), (T21N, R7E, Sec 29), 13 October 1988; TU 153742 (212, 15-32), Sykes Cr., 1.8 mi (2.9 km) S Elliott; US Hwy 51, (T21N, R5E, Sec 23), 14 October 1988, TU 155866 (95, 26-36), 8 August 1989; TU 153754 (126, 21- 34), Eskridge Cr., 0.2 mi (0.3 km) E of US Hwy 51, 1.4 mi (2.2 km) S Duck Hill, (T20N, R6E, Sec 8), 14 October 1988; TU 155524 (45, 28-37), Jacksons Cr., 0.6 mi (1.0 km) W US Hwy 51, Miss Hwy 404, (T21N, R5E, Sec 36), 12 July 1989; TU 155531 (16, 28-35), trib to Worsham Cr., 4.0 mi (6.4 km) SE Duck Hill, (T20N, R6E, Sec 21), 12 July 1989; TU 155547 (7, 31-35), trib to Mouse Cr., 1.3 mi (2.1 km) W Sweatman, (T21N, R7E, Sec 31), 12 July 1989. **Webster County:** TU 155340 (8, 28-36), Little Topashaw Cr., 0.5 mi (0.8 km) W Hohenlinden, (T15S, R1E, Sec 35), 29 June 1989; TU 155356 (1, 34), trib to Little Topashaw Cr., 2.1 mi (3.4 km) SW Hohenlinden, (T21N,

R11E, Sec 6), 29 June 1989. **Grenada County:** TU 139596 (97, 20-35), Cane Cr., 2.0 mi (3.2 km) S Holcomb, Miss Hwy 35, (T22N, R3E, Sec 34), 17 February 1985, TU 158035 (19, 24-33), 17 May 1990; TU 140003 (63, 16-33), Cane Cr., Miss Hwy 7, (T22N, R3E, Sec 20), 16 March 1985; TU 139584 (1, 28), trib to Yalobusha R., 2.0 mi (3.2 km) W Grenada, Miss Hwy 7, (T22N, R4E, Sec 9), 17 February 1985; TU 152688 (13, 15-35), Yalobusha R., at Illinois Central Gulf Railroad, (T22N, R5E, Sec 8), 23 June 1988, TU 153314 (68, 21-33), 24 August 1988; TU 153296 (1, 27), Yalobusha R., 1.6 mi (2.6 km) N Holcomb, Miss Hwy 8 & 35, (T22N, R3E, Sec 17), 24 August 1988; TU 156331 (414, 19- 37), trib to Yalobusha R., 1.5 airmmi (2.4 airkm) NE Riverdale, (T23N, R5E, Sec 30), 22 September 1989; TU 153644 (20, 19-33), Batupan Bogue, 1.3 mi (2.1 km) E Elliott, (T21N, R5E, Sec 11), 12 October 1988; TU 153660 (468, 19-36), Perry Cr., 1.9 mi (3.0 km) S Grenada, US Hwy 51, (T22N, R5E, Sec 29), 13 October 1988; TU 153671 (324, 20-35), Crowder Cr., 2.4 mi (3.9 km) E Elliott, (T21N, R6E, Sec 7), 13 October 1988; TU 153686 (27, 23-32), Little Bogue Cr., (East Fork Batupan), (T21N, R6E, Sec 18), 13 October 1988; TU 153704 (24, 22-33), Epison Branch, (T21N, R6E, Sec 17), 13 October 1988; TU 155503 (2, 33 and 35), trib to Perry Cr., 3.5 mi (5.6 km) SW Grenada, (T22N, R4E, Sec 36), 12 July 1989; TU 155514 (171, 22-36), Perry Cr., just W of US Hwy 51, (T22N, R5E, Sec 30), 12 July 1989; TU 155880 (510, 16-36), 9 August 1989. **Tallahatchie County:** TU 156567 (25, 35-41), Ascalmore Cr., 5.9 mi (9.5 km) S Charleston, Miss Hwy 35, (T24N, R2E, Sec 27), 5 October 1989; TU 86004 (37, 27-37), Hubbard Cr., SW Charleston, (T24N, R2E, Sec 3), 10 May 1962; TU 156895 (49, 16-35), Tillatoba Cr., 1.8 mi (2.9 km) S Miss Hwy 32, (T25N, R3E, Sec 35), 27 October 1989; TU 156906 (101, 19-40), Bellamy Cr., 1.3 mi (2.1 km) N Miss Hwy 32 (Charleston), (T25N, R2E, Sec 25), 27 October 1989; TU 156917 (6, 30-36), North Fork Tillatoba Cr., 2.3 mi (3.7 km) N Charleston, (T25N, R2E, Sec 13), 27 October 1989; TU 157095 (2, 22-34), Hunter Cr., 0.2 mi (0.3 km) N Miss Hwy 32 (Charleston), (T25N, R2E, Sec 25), 11 November 1989; TU 157113 (5, 22-41), North Fork Tillatoba Cr., (T25N, R3E, Sec 6), 11 November 1989; TU 157125 (4, 22-28), Mitchell Cr., 3.4 mi (5.5 km) N Charleston, (T25N, R2E, Sec 12), 11 November 1989; TU 156810 (3, 35-39), Sherman Cr., 7.0 mi (11.3 km) N Charleston, Miss Hwy 35, (T26N, R2E, Sec 22), 21 October 1989. **Yalobusha County:** TU 141224 (159, 14-37), Durden Cr., Miss Hwy 7, (T25N, R6E, Sec 33), 21 June 1985; TU 156389 (1, 17), Turkey Cr., about 6 mi (9.6 km) NE Coffeetown, 0.2 mi (0.3 km) E Hwy 32, (T25N, R7E, Sec 18), 23 September 1989; TU 156521 (9, 20-35), Simmons Cr., 1.0 mi (1.6 km) S Tillatoba, US Hwy 51, (T24N, R4E, Sec 8), 5 October 1989; TU 156538 (221, 18-41), trib to Tillatoba Cr., 1.4 mi (2.2 km) N Tillatoba, US Hwy 51, (T25N, R4E, Sec 30), 5 October 1989; TU 156551 (30, 16-37), Tillatoba Cr., 2.2 mi (3.5 km) S Oakland, US Hwy 51, (T25N, R4E, Sec 19), 5 October 1989; TU 157069 (6, 34-37), Jackson Cr., 1.2 mi (1.9 km) N junction Miss Hwy 32 and US Hwy 51 at US Hwy 51, (T26N, R4E, Sec 32), 11 November 1989. **Calhoun County:** TU 155227 (18, 30-35), Smith Cr., 1.7 mi (2.7 km) ESE Water Valley at dirt road, (T11S, R3W, Sec 3), 15 June 1989. **Panola County:** TU 54490 (149, 16-38), Peters Cr., 0.5 mi (0.8 km) N Pope, (T10S, R7W, Sec 9), 8 October 1968, TU 156831 (81, 17-37), 26 October 1989; TU 155241 (69, 28-36), trib to Peters Cr., 0.5 mi (0.8 km) NE Pope, US Hwy 51, (T27N, R3E, Sec 9), 28 June 1989; TU 155260 (81, 26-36), Long Cr., 0.9 mi (1.4 km) S Eureka Springs, (T10S, R6W, Sec 7), 28 June 1989; TU 155284 (17, 29-37), Rowsey Cr., 3.5 mi (5.6 km) SE Shuford, (T10S, R5W, Sec 19), 28 June 1989; TU 155295 (28, 27- 36), Flowers Cr., 2.2 mi (3.5 km) SW junction with Miss Hwy 315, (T10S, R5W, Sec 19), 28 June 1989; TU 155305 (42, 28-34), Bynum Cr., Miss Hwy 315, (T10S, R5W, Sec 8), 28 June 1989; TU 153449 (367, 17-41), Buck Horn Cr., 1.0 mi (1.6 km) NE Batesville, Miss Hwy 35, (T8S, R7W, Sec 35), 26 August 1988. **Lafayette County:** TU 152069 (1, 35), Sarter Cr., Miss Hwy 315, (T10S, R3W, Sec 35), 11 May 1988; TU 152086 (36, 24-34), Morris Cr., 1.2 mi (1.9 km) W Markette, Miss Hwy 328, (T9S, R3W, Sec 29), 11 May 1988; TU 14328 (1, 28), Fourmile Branch, 2.9 mi (4.7 km) SE Oxford, Miss Hwy 334, (T9S, R3W, Sec 2), 15 June 1955, TU 87671 (49, 25-38), 7 May 1974; TU 33047 (16, 16-40), Yellow Leaf Cr., 2.7 mi (4.3 km) E Oxford, Miss Hwy 6, (T8S, R2W, Sec 31), 14 July 1964; TU 57123 (11, 18-25), Pumpkin Cr., 3.0 mi (4.8 km) W

Denmark or 6.7 mi (10.8 km) E Oxford, Miss Hwy 6, (T9S, R2W, Sec 3), 17 April 1969, TU 57508 (19, 18-38), 21 April 1969, TU 152041 (72, 16-40), 10 May 1988, TU 155708 (29, 27-36), 27 July 1989, TU 158078 (32, 31-38), 18 May 1990; TU 87654 (43, 25-36), Pumpkin Cr., 6.7 mi (10.8 km) SE Oxford, Miss Hwy 334, (T9S, R2W, Sec 19), 6 May 1974; TU 88284 (88, 21-40), Cypress Cr., 13.9 mi (22.4 km) ENE Oxford, Miss Hwy 30, (T7S, R1W, Sec 27), 12 October 1973, TU 155804 (34, 26-37), 28 July 1989. **Union County:** TU 60688 (5, 24-27), Curtis Cr., 4.3 mi (6.9 km) E Abel's store, Miss Hwy 4, (T4S, R2E, Sec 5), 12 September 1968; TU 153331 (27, 23-40), Little Tallahatchie R., 2.2 mi (3.5 km) N Keownville, County Hwy 150, (T6S, R4E, Sec 8), 25 August 1988. **Tate County:** TU 54513 (37, 18-38), Hickahala Cr., 4.3 mi (6.9 km) S Coldwater, (T5S, R7W, Sec 18), 8 October 1968; TU 125882 (125, 16-38), Beartail Cr., 3.1 mi (5.0 km) N Miss Hwy 306 at Miss Hwy 305, (T4S, R6W, Sec 10), 20 June 1982. **Marshall County:** TU 158046 (1, 24), Oak Chewalla Cr., 1.7 mi (2.7 km) W Malone (Miss Hwy 7), (T6S, R3W, Sec 9), 18 May 1990.

Specimens of other species taken from the Yazoo River system, Mississippi, that were used for comparison and for the distributional map (Fig. 3) are listed below:

Notropis longirostris. **Yazoo County:** TU 150023 (394), Short Cr., 4.5 mi (7.2 km) S Yazoo City at Judkins Rd (T11N, R2W, Sec 18), 26 September 1987; TU 155824 (365), 8 August 1989. TU 150035 (122), Short Cr., 4.4 mi (7.1 km) S Yazoo City at Ridge Rd (T11N, R2W, Sec 21), 26 September 1987; TU 150072 (112), 27 September 1987.

Notropis sabiniae. **Carroll County:** TU 140801 (3), Pelucia Cr., at Miss Hwy 17 (T19N, R3E, Sec 35), 12 May 1985; TU 140028 (7), Thompson Cr. at Winona Rd (T19N, R4E, Sec 11), 16 March 1985; TU 140037 (17), Sand Cr., 0.3 mi (0.5 km) S McCarley (T19N, R4E, Sec 12), 16 March 1985; TU 140786 (73), Sand Cr., at Miss Hwy 35 in Carrollton (T19N, R4E, Sec 18), 12 May 1985, TU 155838 (4), 8 August 1989; TU 140017 (129), Potacocowa Cr., at Miss Hwy 35 (T21N, R3E, Sec 27), 16 March 1985, TU 140760 (74), 12 May 1985, TU 155855 (21), 8 August 1989. **Grenada County:** TU 139600 (2), Cane Cr., at Miss Hwy 35, 2.0 mi (3.2 km) S Holcomb (T22N, R3E, Sec 34), 17 February 1985. TU 158036 (2), 17 May 1990; TU 140006 (109), Cane Cr., at Miss Hwy 7 (T22N, R3E, Sec 20), 16 March 1985; TU 156332 (40), trib to Yalobusha R., 1.5 airmi (2.4 km) NE Riverdale (T23N, R5E, Sec 30), 22 September 1989; TU 153645 (6), Batupan Bogue 1.3 mi (2.1 km) E Elliott (T21N, R5E, Sec 11), 12 October 1988; TU 153672 (39), Crowder Cr., 2.4 mi (3.9 km) E Elliott (T21N, R6E, Sec 7), 13 October 1988; TU 153687 (38), Little Bogue Cr. (East Fork Batupan), (T21N, R6E, Sec 18), 13 October 1988; TU 153705 (3), Epison Branch (T21N, R6E, Sec 17), 13 October 1988. **Montgomery County:** TU 153725 (5), Little Bogue Cr. (East Fork Batupan), (T21N, R7E, Sec 29), 13 October 1988; TU 153743 (42), Sykes Cr., at US Hwy 51, 1.8 mi (2.9 km) S Elliott (T21N, R5E, Sec 23), 14 October 1988, TU 155867 (18), 8 August 1989; TU 153755 (23), Eskridge Cr., 0.2 mi (0.3 km) E of US Hwy 51, 1.4 mi (2.2 km) S Duck Hill (T20N, R6E, Sec 8), 14 October 1988.

Notropis ammophilus. **Calhoun County:** TU 155646 (10), Yoda Cr., at Miss Hwy 32, 1.1 mi (1.8 km) W Bruce (T12S, R2W, Sec 35), 26 July 1989; TU 155657 (99), trib to Persimmon Cr., at Miss Hwy 330, 3.9 mi (6.3 km) WSW Bruce (T12S, R2W, Sec 32), 26 July 1989, TU 155911 (42), 9 August 1989; TU 155674 (10), Savannah Cr., at Miss Hwy 32, 6.0 mi (9.6 km) NE Bruce (T12S, R1W, Sec 11), 26 July 1989; TU 155901 (14), Dog Cr., at Miss Hwy 330 (T24N, R8E, Sec 17), 9 August 1989; TU 156216 (11), Lucknuck Cr., at Miss Hwy 9 (T11S, R1W, Sec 11), 26 August 1989; TU 156256 (1) Cowpen Cr., at Miss Hwy 9, 8.6 mi (13.8 km) NNE Bruce (T11S, R1W, Sec 29), 26 August 1989. **Pontotoc County:** TU 155686 (25), trib to Kittahutty Cr., 2.0 mi (3.2 km) E Robbs (T11S, R1E, Sec 22), 26 July 1989; TU 155732 (20), Mud Cr., at Miss Hwy 341, 10.7 mi (17.2 km) SW Pontotoc (T11S, R2E, Sec 17), 27 July 1989. **Yalobusha County:** TU 155890 (22), trib to Skuna R., at Miss Hwy 330 (T24N, R7E, Sec 24), 9 August 1989; TU 156352 (5), York Cr., 1.2 mi (1.9 km) NE Spearman (T24N, R7E, Sec 17), 22 September 1989; TU 156367 (33), trib to Skuna R., 2.0 mi (3.2 km) N Tyson (T24N, R7E, Sec 11).

Literature Cited

- Hubbs, C. L., and K. F. Lagler. 1974. Fishes of the Great Lakes region. University of Michigan Press, Ann Arbor, Michigan. 213 p.
- Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina. x + 867 p.
- Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada: American Fisheries Society Special Publication 12. 174 p.
- Suttkus, R. D. and H. T. Boschung. 1990. *Notropis ammophilus*, a new cyprinid fish from southeastern United States. Tulane Studies in Zoology and Botany 27(2):49-63.
- Wiley, E. O. and R. L. Mayden. 1985. Species and speciation in phylogenetic systematics, with examples from the North American fish fauna. *Annals Missouri Botanical Gardens* 72:596-635.

Reproductive Behavior of *Exoglossum* Species

Eugene G. Maurakis, William S. Woolcott, and Mark H. Sabaj

Biology Department
University of Richmond, Virginia 23173

ABSTRACT: Maurakis, Eugene G., William S. Woolcott, and Mark H. Sabaj. Reproductive Behavior Of *Exoglossum* Species. Bulletin Alabama Museum of Natural History. Number 10:11-16, 5 tables. *Exoglossum* is one of three cyprinid genera in which adult males use their jaws for the deliberate movement of substrate material to construct pebble nests in the spring for spawning. Based on our observations, *Exoglossum laurae* and *Exoglossum maxillingua* select pebble size classes (2.5 and 6.0 mm) smaller than those (11.3 and 23.0 mm) in nests of *Nocomis* and *Semotilus*. Unlike nest-building males of *Nocomis* and *Semotilus*, those of *Exoglossum* do not dig spawning pits, but rather spawn directly over the pebbles on the upstream slope of nests where water currents are reduced. Parallel swims, a form of agonistic behavior common between adult males of *Nocomis* and *Semotilus*, is reported for the first time in *E. laurae* and *E. maxillingua*. A discussion is presented on the behavior of *Notropis semperasper* commandeering an *E. maxillingua* nest and defending it against the nest-building male and other breeding cyprinids.

Introduction

Exoglossum is one of three cyprinid genera in which adult males use their jaws for the deliberate movement of substrate material to construct pebble nests in the spring for spawning (Woolcott and Maurakis, 1988a). The genus, composed of two species, *Exoglossum laurae* and *Exoglossum maxillingua*, is characterized primarily by the morphological modifications of the lower jaw.

Information on the reproductive biology of *Exoglossum* species is limited. Working in the Allegheny River, Pennsylvania, Raney (1939) reported nests of *E. laurae* but did not observe spawning. Hankinson (1922) did not observe spawning behavior in *E. maxillingua*, but described its spawning habitats and nests in New York. The most comprehensive study of the breeding habits of *E. maxillingua* was made by Van Duzer (1939) who described spawning habitats, nest building, and spawning behavior of *E. maxillingua* in Catatank Creek, New York.

Objectives of our study were to compare the reproductive behaviors of *E. laurae* and *E. maxillingua*; compare the materials and construction of *Exoglossum* nests; and determine how the physical characteristics of nests and streams affected water currents at the nests.

Methods

Descriptions of nest construction and reproductive behaviors are based on recorded field observations and from photographs made in color with three types of cameras (Minolta Maxxum 500 35 mm; industrial grade Panasonic video camera; and a Sony television camera). Video tapes were replayed in the laboratory, analyzed, and compared with field notes and literature.

Pebble samples were collected from three *E. laurae* nests and five *E. maxillingua* nests. Pebble samples from nests were collected from the upstream, middle, and downstream parts of nests with a 1 liter plastic beaker. Substrate samples, collected with the same device, were taken at random as far as 25 m from nests. Nest and substrate samples were stored in tagged plastic bags and returned to the laboratory.

Pebble size analysis follows methods in Maurakis et al. (1990). Pebbles were air-dried and sifted through five custom-built wire sieves. Mesh sizes, restricted to commercially available prefabricated screen sizes, were 23.0 mm, 11.3 mm, 6.0 mm, 2.5 mm, and 0.8 mm. Material that sifted through the smallest size mesh was collected in a pan. The weight of material in each sieve or pan was used to calculate the percentage of material per mesh size. Hereafter,

all references to percentage of mesh size classes are based on weights.

Fishes were collected with a pulsed DC electroshocker, preserved, and stored at the University of Richmond. Stream depth (cm), width (m), and temperature (C) were recorded.

The velocity of water currents (taken 1 cm over nests and substrates), measured with a Marsh-McBirney current meter, were recorded 0.5 m upstream of nests, 0.5 m downstream of nests, and over crests of nests; and 1 cm above the upstream and downstream slopes of nests. Mean nest length, height, and width were generated from measurements of individual nests.

An electivity index (Ivlev, 1961) was calculated for each pebble size class per nest of each species. The equation $E = (n - p) / (n + p)$ (where E = pebble size selection, n = percentage of a particular pebble size in the nest, and p = the percentage of a particular pebble size in the substrate of the stream) was used to determine if selection of pebble size from the substrate was nonrandom. Electivity index values range from 1 to -1. Values closer to 1 indicate a greater selection of a particular pebble size. Percentages and electivity values were transformed to arcsin equivalents.

Average values of electivities, percent pebble composition of nests, and nest dimensions, derived from analysis of variance (ANOVA), were compared between species with a t-test (Steel and Torrie, 1980) and within species with Duncan's Multiple Range Test ($\alpha = 0.05$; Steel and Torrie, 1980). Backward stepwise regression (SAS, 1985) was used to examine relationships of water current over the spawning area to physical dimensions of nests and streams.

Results

Reproductive behaviors of *Exoglossum laurae* were observed and video recorded from 1330-1630 EDT (15 C) 26 May 1989 and 1520-1715 EDT (15 C) 29 May 1989; those of *Exoglossum maxillingua* from 1130-1540 EDT (18 C) 14 June 1987, 1330-1900 EDT (20 C) 28 May 1988, and 1715-1800 EDT (19.5 C) 6 June 1989.

Nest construction was similar in the two species. In each, a single dark-colored male built the nest. Nests were built in protected areas (e.g. between or aside large rocks and submerged logs) or in open gravel runs located in midstream or near the shore. Males collected pebbles from active nests of *Nocomis* species and abandoned *Exoglossum* nests, and from the substrate (up to 10 m from the nest site). On two occasions in Jackson River, a male *E. maxillingua* repeatedly swam the same routes upstream to abandoned nests (one 20 m away and the other 10 m) to collect pebbles for his nest.

In both species males alternately collected pebbles and reworked the shape of the nest. When shaping the nest, the male swam with a pebble to the downstream slope of the nest and then moved forward to the crest where he dropped the pebble from his mouth. After depositing the pebble, the male glided forward, down the upstream slope of the nest with his anal fin in contact with the surface of the nest. He

then collected a pebble from the upstream edge of the nest, returned to the downstream slope, and repeated the behavior of depositing the pebble on the crest. Unlike species of *Nocomis* and *Semotilus*, male *Exoglossum* did not excavate a spawning pit on the nest.

Two forms of agonistic behavior were exhibited by nesting males. Attendant males lunged at or chased other mature *Exoglossum* males, other fishes, and tadpoles from the nest area when they were within approximately 1 m of the nest. At times, the approach of either a darker or lighter male, about equal in length to the attendant male, resulted in parallel swim behavior similar to that described by Reighard (1910) for *Semotilus atromaculatus*. Swims with dark males covered about 3 to 4 m; those with lighter males were never longer than 2 m. The nesting male, which always won the contest, returned to his nest as the challenging male swam away.

During one parallel swim involving two male *E. maxillingua* over an *Exoglossum* nest in Jackson River, an adult, tuberculate *Notropis semperasper* (about 65 mm, SL and about 85% SL of *E. maxillingua* males) moved over the nest, defended the nest, and eventually drove away both *E. maxillingua*. Continuing to defend the nest, it repelled challenges by *Campostoma anomalum*, *Luxilus cornutus*, and *Lythrurus ardens*. *Notropis semperasper* was not observed to spawn over the *Exoglossum* nest.

Spawning in *E. laurae* and *E. maxillingua* occurred on the upstream slope of the nest. When a female approached the nest, the guarding male moved to the crest of the nest and began to move his head from side to side in a wigwag motion. The female moved forward and aligned herself beneath and parallel to the caudal region of the male. The male curved his caudal peduncle over that of the female, and both fishes quivered in a half-open spawning clasp down the upstream slope to the base of the nest, where the male released the female. At times the action was so vigorous that a cloud of fine sand was released into the water behind the spawning pair. The entire spawning act lasted 2 to 4 seconds.

Newly-spawned eggs were nonadhesive and demersal. Older eggs were in clumps. Yolk-sac larvae, protolarvae, and mesolarvae were found in active nests of both species.

Stream depth and width at nests of *E. laurae* ranged from 49-52 cm, and from 6-9 m, respectively; those for *E. maxillingua* nests ranged from 16-34 cm, and from 4-30 m, respectively. There were no significant differences in nest dimensions between the two species (Table 1).

Average percentages of the 6 mm and 2.5 mm pebble size classes in nests of both species were significantly greater than those of other sizes (Table 2). Average percentages (85.7% and 74.8%) of the 23.0 mm pebble size class in substrate materials for *E. laurae* and *E. maxillingua*, respectively, were significantly greater than those of other sizes. There were no significant differences in average percentages within size classes between the two species with two exceptions in the smaller size classes (Table 3).

Table 1. Results of t-tests for nest dimensions (cm) between *Exoglossum laurae* and *Exoglossum maxillingua*. Differences were not significant ($p = 0.05$).

Nest	Species		ANOVA	
	<i>E. laurae</i>	<i>E. maxillingua</i>	df	t
Length				
Mean	27.0	36.0	6	-1.8513
Range	25.0 - 33.0	26.0 - 48.0		
Width				
Mean	48.6	32.8	6	1.1597
Range	35.0 - 72.0	15.7 - 57.3		
Height				
Mean	8.1	6.0	6	2.5847
Range	7.0 - 9.0	4.9 - 7.7		

Table 2. Results of Duncan's Multiple Range Test for average percentage of nest material according to size class (mm) for *Exoglossum laurae* and *Exoglossum maxillingua*. Underscored means do not differ significantly ($p = 0.05$).

Species	Nest Stone Size						ANOVA	
	23.0	<0.8	0.8	11.3	2.5	6.0	df	F
<i>E. laurae</i>								
Mean	<u>0.0</u>	0.2	0.2	5.6	14.2	79.4	5	546.96
<i>E. maxillingua</i>								
Mean	<u>0.0</u>	0.1	<u>0.5</u>	9.7	16.2	70.9	5	519.19

Electivity indices for the 6.0 and 2.5 mm size classes, with similar percentages in nests of both species, were significantly greater than those for other size classes (Table 4).

Average water current on the upstream slope of nests (0.043 m/sec) where spawning took place was significantly lower ($F = 4.29$, $df = 25$) than values measured upstream of the nest (0.112 m/sec), downstream of the nest (0.128 m/sec), and on the crest of the nest (0.138 m/sec), but not significantly lower than that on the downstream slope (0.058 m/sec). Nest height was the only factor associated with reduced water current on the upstream slope of nests (Table 5). The angle (range = 8-10°) of the upstream slope was less than that (range = 15-27°) of the downstream slope of the nest.

Discussion

Water temperatures (15-20 C) in May and June when we observed nest construction and spawning behaviors of the two *Exoglossum* species in Virginia are consistent with those

in the literature. Raney (1939) recorded *E. laurae* nest building at water temperatures of 20.5-21.0 C in Pennsylvania in June. Miller (1964) gave no temperatures but stated that *Exoglossum* nests did not appear in New York until late May. Van Duzer (1939) reported that nest building of *E. maxillingua* in New York did not begin earlier than May 15 in a tributary of Catatonk Creek, and that spawning occurred at water temperatures between 17.0-20.5 C. Jenkins and Burkhead (in press) observed *E. laurae* spawning in Sinking Creek, Virginia, at a water temperature of 20 C in June, 5 C higher than the temperature at which we observed spawning for this species. Lee et al. (1980) cited Taub (unpubl.) who reported *E. laurae* spawning from 14-18 C in Ohio during May.

Nest shapes (i.e. oblong and circular) and dimensions of *Exoglossum* nests in this study were comparable to those given by other investigators. Jenkins and Burkhead (in press) reported nest diameters from 30-100 cm for *E. laurae*. Raney (1939) stated that nests of *E. laurae* were oblong and about 10 cm high, and ranged from 15.2-45.7 cm in diameter. Van Duzer (1939) found that rectangular nests of *E. maxillingua* measured 7-17 cm high, 30-120 cm long, and 25-46 cm wide. Both Hankinson (1922) and Van Duzer (1939) reported that diameters of circular nests of *E. maxillingua* were about 46 cm.

Table 3. Results of Duncan's Multiple Range Test for average percentage of substrate material according to size class (mm) for *Exoglossum laurae* and *Exoglossum maxillingua*. Underscored means do not differ significantly ($p = 0.05$).

Size Class (mm)	Species		ANOVA	
	<i>E. laurae</i>	<i>E. maxillingua</i>	df	F
23.0				
Mean	<u>74.8</u>	<u>85.7</u>	6	1.24
11.3				
Mean	<u>8.9</u>	<u>19.2</u>	6	1.22
6.0				
Mean	<u>3.3</u>	<u>3.4</u>	6	0.06
2.5				
Mean	1.0	1.5	6	99.99
0.8				
Mean	0.3	0.5	6	7.50
<0.8				
Mean	<u>0.7</u>	<u>0.8</u>	6	0.47

Table 4. Results of Duncan's Multiple Range Test for average electivity according to size class (mm) within *Exoglossum laurae* and *Exoglossum maxillingua*. Under-scored means do not differ significantly ($p = 0.05$).

Species	Stone Size Class.						ANOVA	
	23.0	<0.8	0.8	11.0	2.5	6.0	df	F
<i>E. laurae</i>								
Mean electivity	23.0	<0.8	0.8	11.0	2.5	6.0	5	26.71
	-0.99	-0.69	-0.58	-0.27	<u>0.80</u>	<u>0.92</u>		
<i>E. maxillingua</i>								
Mean electivity	23.0	<0.8	11.0	0.8	2.5	6.0	5	395.44
	-0.99	-0.82	0.01	0.15	<u>0.89</u>	<u>0.91</u>		

Table 5. Results of Backward Stepwise Regression (SAS, 1985) for effects of stream depth; nest length, height, and width; and stream flow on water currents on the upstream slope of nests of *Exoglossum* species ($p = 0.05$).

Parameter	B value	F value	Probability > F
Intercept	-0.05395608		
Nest height	0.01534407	10.14	0.0190
Nest width	0.00075237	5.47	0.0794
Stream flow	0.26015556	2.17	0.2005
Nest length	-0.00191179	1.78	0.3139
Stream depth	-0.00058437	0.71	0.4619

This study is the first to compare quantitatively the composition of spawning nests of *Exoglossum* species. Both species preferentially selected the 6.0 and 2.5 mm size class pebbles. Raney (1939) stated that pebbles in *E. laurae* nests averaged about 0.5 inch (12.7 mm) in diameter. Hankinson (1922) gave the largest stone size diameter as about 0.5 inch for *E. maxillingua*, similar to values of 0.5 to 0.75 inches (19 mm) reported by Van Duzer (1939). The modified mouth morphology of *Exoglossum* species limits the use of larger (>11.3 mm) stone sizes that were common in nests of *Semotilus* species reported by Maurakis et al. (1990) and those in *Nocomis* nests (pers. obs.).

Stream depths at nest sites of both *Exoglossum* species in our study were similar to those in literature accounts. Raney (1939) reported that *E. laurae* nests were in areas where depth ranged from 30.5-45.7 cm; Jenkins and Burkhead (in press) gave water depths of 20-50 cm. Nests of *E. maxillingua* studied by Hankinson (1922) and Van Duzer (1939) were located in deeper areas where depths ranged from 46-76 cm.

Our observations and video recordings are the first on parallel swim behavior in *Exoglossum*. This form of

agonistic behavior is like that in *Semotilus* species (Woolcott and Maurakis, 1988b) except that the distance and duration of swims between *Exoglossum* males were shorter. Parallel swims between the dark nest-building male and other dark males covered more distance than those between the nest builder and lighter males.

Our observations and video recordings of *N. semperasper* successfully driving away a resident male *E. maxillingua* from his nest are the first record of this activity for *N. semperasper*, but is not the first record of a *Notropis* species commandeering an *Exoglossum* nest. Miller (1964) reported that *Notropis rubellus* and *L. cornutus* took over *E. maxillingua* nests in Catonk Creek, New York and that, subsequent to the takeover, the male *E. maxillingua* never reworked the nests. We often observed *N. rubellus* and *L. cornutus* spawning over nearby pebble nests of *Nocomis*, but unlike Miller (1964), we have never observed them spawning over *Exoglossum* nests.

This is the second report of a member (*N. semperasper*) of the genus *Notropis* defending territory over pebble nests. Loos et al. (1972) presumed that *N. semperasper* used pebble nests for spawning but gave no supporting evidence for the statement. Based on reproductive condition of male and female *N. semperasper*, Jenkins and Burkhead (1975) indicated that spawning probably occurred in May and June. We observed *E. maxillingua* nest defense by *N. semperasper* in June but did not see spawning. Eggs of a related species, *N. (Notropis) amoenus* were collected from six *Nocomis* nests in Pennsylvania (several hundred from one nest) and reared to juveniles by Loos (pers. comm.). Another member of the subgenus *Notropis*, *Notropis atherinoides*, spawns at night (Flittner, 1964). Except for *N. rubellus*, more closely allied to *Notropis* than to *Hydrophlox* (Mayden and Matson, 1988), members of the subgenus *Notropis* do not exhibit breeding colors (i.e. yellow to red) as do the daylight spawning nest associates in genera *Luxilus* and *Lythrurus* and subgenus *Notropis (Hydrophlox)*. Hybrids among many species of *Notropis* and species of nest-building genera (*Nocomis* and *Semotilus*) are common (Schwartz, 1981); however, there are no reports of hybridization between *N. atherinoides*, *N. semperasper*, or *N. amoenus* with other cyprinids (Menzel, 1978; Schwartz, 1981). Information on *N. amoenus* from Loos (pers. comm.) and our observations of *N. semperasper* suggest that at least two members of the subgenus *Notropis* use pebble nests. That hybrids of *N. amoenus* and *N. semperasper* with other cyprinids that either build or use nests have not been identified, and that a related species (*N. atherinoides*) spawns at night suggest that *N. amoenus* and *N. semperasper* may spawn over nests when other nest associates and nest-building species are not active over nests.

Van Duzer (1939), Miller (1964), and Jenkins and Burkhead (in press) reported that *L. cornutus* and rarely *N. rubellus* were nest associates of *E. maxillingua*. Jenkins and Burkhead (in press) reported *E. laurae* driving away

Luxilus albeolus from its nest. We never observed associates feeding or spawning over nests of either species of *Exoglossum* even though several (i.e. *Campostoma anomalum anomalum*, *L. cornutus*, *Clinostomus funduloides*, and *L. ardens* for *E. maxillingua*; *Campostoma anomalum pullum*, *Phoxinus oreas*, *Luxilus cerasinus*, and *Luxilus chrysocephalus* for *E. laurae*) were spawning over nests of *Nocomis leptoccephalus* that were within 4 m of *Exoglossum* nests. Frenzied breeding activity of *Nocomis* species and nest associates over nearby *Nocomis* nests may have resulted in the absence of nest associates over nests of *Exoglossum* species. The associates that approached nests of *Exoglossum* always were chased away from the area by the nest-building or guarding *Exoglossum*.

Our study is the first to describe the spawning behavior of *E. laurae*, which is like that in the *E. maxillingua* studied by ourselves and reported in the study by Van Duzer (1939). The half-open spawning clasp in *Exoglossum* spawning pairs as they move down the upstream slope of nests is unique to the genus and supports the monophyly of the genus. During one spawning event, we observed a male that continued the spawning activity even though the female slipped from between the male and the crest. The male continued the spawning pose, quivering, and forward motion until he reached the base of the nest. *Exoglossum* does not make a spawning clasp like that displayed in species of *Nocomis* and *Semotilus* where the male clasps the female as she is thrown vertically toward the water surface (Maurakis et al., 1990; pers. obs.).

Analysis of stream and physical characteristics of nests indicated that nest height was the primary factor associated with decreased water current velocities on the upstream slope of the nest, where spawning took place in both species of *Exoglossum*. This decreased velocity facilitates the descent of eggs and milt during the spawning act, a condition similar to that created in spawning pits of *Semotilus* species by the ridge characteristics of their pit/ridge nests (Maurakis et al., 1990). Increased nest height is accomplished when an *Exoglossum* male reworks the shape of the nest by adding pebbles to the crest of the nest prior to and during spawning. The nest, functionally a dam, reduced the water current on the upstream slope where spawning occurred and where newly-spawned, nonadhesive, demersal eggs were found. Unlike mature eggs in spawning pits of nests of *Semotilus* species (Woolcott and Maurakis, 1988b; Maurakis et al., 1990) and *Nocomis* species (pers. obs.), older cohesive eggs on the upstream slope of *Exoglossum* nests were in clumps up to 2 cm in diameter. Clumping may be an adaptive feature that prevents individual eggs from washing from the interstices of the surface pebbles of *Exoglossum* nests.

Materials

All collections were made in Virginia (VA) by Eugene G. Maurakis (EGM) and William S. Woolcott (WSW). The drainage, collection number, number of nests observed and

collected in parentheses, locality (all in Virginia), and date for *E. laurae* and *E. maxillingua* are:

Exoglossum laurae. New, EGM-VA-225 (3), Craig Co., Sinking Creek, St. Rt. 42, 0.8 km S of jct. with Co. Rt. 226, 26 and 29 May 1989.

Exoglossum maxillingua. James, WSW-VA-373 (10), Bath Co., Jackson River about 1.6 km N of St. Rt. 39 bridge, and about 8 km W of jct. with U.S. Rt. 220 at Warm Springs, 14 June 1987. James, WSW-VA-383 (5), Bath Co., same locality as previous, 28 May 1988. James, EGM-VA-227 (1), Craig Co., Johns Creek, Co. Rt. 658 bridge at jct. with Co. Rt. 632, 30 May 1989. Roanoke, EGM-VA-228 (2), Montgomery Co., North Fork Roanoke River on Co. Rt. 723, 4.8 km N of New Ellett, 6 June 1989.

Acknowledgements

Thanks are expressed to John T. Goodin for assistance in the field, Sharon M. Doyle for laboratory analysis of pebble samples, and Jules J. Loos for making us privy to his observations on eggs and behavior of spawning associates of nest-builders. The study was funded in part by University of Richmond Faculty Research Grants and the Robert F. Smart Undergraduate Research Award.

Literature Cited

- Flittner, G. A. 1964. Morphometry and life history of the emerald shiner, *Notropis atherinoides*, Rafinesque. Unpublished Ph.D. Dissertation, University of Michigan.
- Hankinson, T. L. 1922. Nests of the cut-lips minnow *Exoglossum maxillingua* (Le Sueur). Copeia 1922(102):1-3.
- Ivlev, V. S. 1961. *Experimental Ecology of the Feeding of Fishes*. Yale University Press, New Haven, Connecticut.
- Jenkins, R. E. and N. M. Burkhead. 1975. Distribution and life history of the cyprinid fish *Notropis semperasper* endemic to the upper James River drainage, Virginia. Chesapeake Science 16(3):178-191.
- Jenkins, R. E. and N. M. Burkhead, N. D. *The Freshwater Fishes of Virginia*. American Fisheries Society, Bethesda, Maryland. In press.
- Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980 et seq. *Atlas of North American Freshwater Fishes*. North Carolina State Museum of Natural History, Raleigh, North Carolina.
- Loos, J. J., W. S. Woolcott, and N. R. Foster. 1972. An ecologist's guide to the minnows of the freshwater drainage systems of the Chesapeake Bay area. Association of Southeastern Biologists Bulletin 19(3):126-138.
- Maurakis, E. G., W. S. Woolcott, and J. T. Magee. 1990. Pebble-nests of *Semotilus* species. Proceedings of Southeastern Fishes Council 22:7-13.
- Mayden, R. L. and R. H. Maitson. 1988. Evolutionary relationships of eastern North American cyprinids: An allozyme perspective (Abstract). Program and Abstracts 68th Annual Meeting of Ichthyologists and Herpetologists: 138.
- Menzel, B. W. 1978. Three hybrid combinations of minnows (Cyprinidae) involving members of the common shiner species complex (genus *Notropis*, subgenus *Luxilus*). American Midland Naturalist 99(1):249-256.
- Miller, R. J. 1964. Behavior and ecology of some North American cyprinid fishes. American Midland Naturalist 72(2):313-357.
- Raney, E. C. 1939. Observations on the nesting habits of *Parexoglossum laurae* Hubbs and Trautman. Copeia 1939(2): 112-113.
- Reighard, J. E. 1910. Methods of studying the habits of fishes, with an account of the breeding habits of the horned dace. Bulletin United States Fisheries 28(1908): 1113-1136.
- SAS Institute, Inc. 1985. *SAS User's Guide: Statistics*. Version 5. SAS

- Institute, Inc. Cary, North Carolina.
- Schwartz, F. J. 1981. World literature to fish hybrids with an analysis by family, species, and hybrid: Supplement 1. National Oceanic and Atmospheric Administration Technical Report. National Marine Fisheries Service Special Scientific Report-Fisheries-750.
- Steel, R. G. D. and J. H. Torrie. 1980. *Principles and Procedures of Statistics*. McGraw-Hill Book Company, Inc. New York, New York.
- Van Duzer, E. M. 1939. Observations on the breeding habits of the cutlips minnow, *Exoglossum maxillina*. *Copeia* 1939 (2):65-75.
- Woolcott, W. S. and E. G. Maurakis. 1988a. A need for clarification of the concept of nest building among cyprinid minnows. *Proceedings Southeastern Fishes Council* 18:3.
- Woolcott, W. S. and E. G. Maurakis. 1988b. Pit-ridge nest construction and spawning behaviors of *Semotilus lumbee* and *Semotilus thoreauianus*. *Proceedings Southeastern Fishes Council* 18:1-3.

Scaphirhynchus suttkusi, a new sturgeon (Pisces: Acipenseridae) from the Mobile Basin of Alabama and Mississippi

James D. Williams

U.S. Fish and Wildlife Service
National Fisheries Research Center
Gainesville, Florida 32606

and

Glenn H. Clemmer

Nevada Natural Heritage Program
123 West Nye
Carson City, Nevada 89710

ABSTRACT: Williams, J. D., and G. H. Clemmer, 1991. *Scaphirhynchus suttkusi*, a new sturgeon (Pisces: Acipenseridae) from the Mobile Basin of Alabama and Mississippi. *Bulletin Alabama State Museum of Natural History*, Number 10:17-31, 7 tables, 7 figures.

A new species, *Scaphirhynchus suttkusi*, the Alabama sturgeon, is described. This sturgeon is restricted to the Mobile Basin in Alabama and Mississippi. Historically, the species occurred in all of the large Coastal Plain rivers of the Mobile Basin, but its populations have been reduced because of destruction of its riverine habitat by impoundments and dredging. *Scaphirhynchus suttkusi* is morphologically similar to the shovelnose sturgeon, *S. platyrhynchus*, which occurs in the Mississippi and Rio Grande basins. The new species differs significantly from *S. platyrhynchus* in several plate and fin ray counts and mensural characters associated with the head region and the placement of the dorsal and anal fins. The disjunct distributions of the Alabama sturgeon and *S. platyrhynchus* in the Mississippi Basin, and the absence of both species in the intervening drainages, is a pattern shared with four other species-pairs.

Introduction

William F. Smith-Vaniz donated three fresh specimens of *Scaphirhynchus platyrhynchus*, which he had obtained from a fish market on the Mississippi River at Rosedale, Mississippi, to the University of Alabama Ichthyological Collection (UAIC). While preparing the three sturgeons for the collection, a superficial comparison was made of the Mississippi River specimens to a single specimen in the UAIC from the Tombigbee River, Alabama (Chermock, 1955). It was immediately apparent that the specimen from the Tombigbee River had a larger eye. This prompted a search for additional material from the Mobile Bay drainage, which has now yielded a total of 32 specimens from a variety of sources, including one mounted specimen from a bait shop in Tuscaloosa, Alabama.

The first specimen of *Scaphirhynchus* from the Mobile Basin was collected from the Alabama River, Montgomery, Alabama in 1880 and was deposited in the Smithsonian Institution (USNM 43675), where it was catalogued as *Acipenser*. Presumably because this specimen was incorrectly identified, it was overlooked by Bailey and Cross (1954) in their review of the genus *Scaphirhynchus*. In the January 1930 issue of *Alabama Game and Fish News* (Anonymous 1930) an article on "The Sturgeon" had two photographs of shovelnose sturgeon that had been captured in the Alabama River. It was noted that the species was "not uncommon in Alabama, though it is found more abundantly farther north." Chermock (1955) published the first record of *Scaphirhynchus* from the Mobile Bay drainage, identified as *S. platyrhynchus* from the Tombigbee River.

The habitat of this undescribed species has been drastically reduced during the past half century. Construction of main-stream impoundments for navigation and the associated dredging required to maintain the channel for barge traffic has converted riverine habitat into reservoirs. Burke and Ramsey (1985) examined present and historic distribution of the Alabama Sturgeon. They found approximately 40% of its historic habitat remained relatively undisturbed but only 15% of the suitable habitat supported a strong population of the species. Concern for the long term survival of the Alabama sturgeon has resulted in its listing as endangered by the American Fisheries Society (Williams et al., 1989), and it is currently being considered for endangered status by the U. S. Fish and Wildlife Service.

Bailey and Cross (1954) provided a thorough review of the genus *Scaphirhynchus*, including a diagnosis and description of the genus and the two described species. Although the meristic and mensural data presented by Bailey and Cross (1954) indicate distinctive morphological differences between *S. platyrhynchus* and *S. albus*, Phelps and Allendorf (1983) found them to be electrophoretically indistinguishable. Additional meristic and mensural data on *S. platyrhynchus* and *S. albus* and their hybrids were presented by Carlson et al. (1985). These studies provide additional data for morphological comparisons of the new species with shovelnose and pallid sturgeons.

Materials and Methods

Type material of *Scaphirhynchus suttkusi* is deposited in the collections of the following institutions: Auburn University (AU); Tulane University (TU); University of Alabama Ichthyological Collection (UAIC); Florida Museum of Natural History (UF); University of Michigan (UMMZ); and National Museum of Natural History, Smithsonian Institution (USNM). Comparative material of *S. platyrhynchus* from these collections, as well as Northeast Louisiana University (NLU) was used in the preparation of this description. The abbreviation RM for river mile is used in the locality data for some collections. Detailed collection data for these specimens are provided in the material examined section.

Standard methods for counting plates and fin rays of sturgeons were established by Bailey and Cross (1954). While there have been very few researchers reporting meristic and mensural data for sturgeons most, including ourselves, have used the methods of Bailey and Cross (1954). Since this publication is not widely available we have repeated the techniques for plate and fin ray counts and measurements as a direct quote from Bailey and Cross (1954:169-170):

"In the plate counts all clearly carinate scutes are included. In the series of dorsal plates the postoccipital is reckoned as the anteriormost (this is normally the first to bear a well-formed spine), but the predorsal plate is excluded. In the lateral series the first plate counted is just behind the shoulder girdle (the tabular and posttemporal,

which bear spines, are excluded); at the posterior end small plates are counted if they are carinate. A small plate at the anterior end of the ventrolateral row is tallied, even if it is not keeled, as long as it is clearly an element in this series. In the dorsal and anal fin-ray counts all anterior rudiments behind the predorsal and preanal plates are included. The last ray in those fins, as counted, is double at its base. The pectoral count includes the strong spine anteriorly and all posterior rudiments (these may be tiny, and an appreciable personal error is involved in counting unstained material). The pelvic count includes all rudiments anteriorly. In all fins the rays are closely spaced, and accurate counts require patience, good illumination, and considerable magnification; they usually entail preparatory removal of superficial tissue by scraping. Use of insect pins to mark out sectional counts helps to eliminate errors. The standard length terminates at the posterior end of the last carinate plate of the lateral series (this point is treated as the base of the caudal fin). The origin of the dorsal and anal fins is taken as the posterior edge of the predorsal and preanal plates (the large, noncarinate plates lying just in front of these fins). Body width is measured at the shoulder girdle. Caudal-peduncle depth and width are taken at the plane of the least depth. Head length is measured to the posterior (bony) margin of the primary bone of the operculum, which in sturgeons is the subopercle (the opercular membrane is commonly curled under, and to include it introduces an avoidable error). Head depth is the vertical measurement from the top of the left parietal crest. Head width is the maximum breadth of the rostrum. Rostral length is taken from snout tip to the prominent angle of the suborbital. The orbital length is established visually. Nostril width is the greatest dimension of each nostril. Mouth width is the greatest overall extent of the lips. Measurements involving barbels are taken from the anterior edge of their bases; the lengths are taken on both barbels of a pair and the longer is recorded. The front of the mouth is that point on the mid-line that lies on the anterior, cartilaginous edge of the labial depression. Caudal-fin measurements are taken from the fin base (see definition of standard length above); the filament is included, but since this structure is commonly broken the measurement is minimal. The height of the tenth lateral plate is taken, and the distance from the lower edge of this scute to the closest plate in the ventrolateral series is used as the interspace between these rows of plates."

In addition to the standard plate counts taken by Bailey and Cross (1954) we took three additional counts. Two of these involved the two longitudinal rows of adjacent or slightly overlapping plates along the ventral midline of the body between the anus and the caudal fin base. The number of plates between the anus and the anal fin origin and plates between the posterior end of the anal fin and the base of the caudal fin were counted. Plates between the anus and

anal fin origin were counted on the left side beginning with the first plate lateral to the anus and counting posteriorly along that row to and including the single large plate at the anterior base of the anal fin. Plates between the posterior end of the anal fin base and caudal fin base were counted on the left side, beginning with the first plate lateral to the last ray of the anal fin, counting posteriorly to and including the single plate at the base of the caudal fin.

The third plate count was the number of lateral plates anterior to the dorsal fin origin. Lateral plates were counted from a vertical line through the dorsal fin origin anteriorly to the first plate in the lateral series. Any part of the base of a lateral plate intersecting the vertical line through the dorsal fin origin was included and used as the starting point in making this count.

In a wide ranging species like *Scaphirhynchus platyrhynchus* it is likely that clinal variation exists in the meristic variables. We considered this possibility and utilized, to the extent that specimens were available, material from the southernmost portion of the range of *S. platyrhynchus*. Of the 42 specimens utilized for plate counts only five were from the upper portions of the Mississippi, Missouri and Ohio rivers. Fin ray counts were taken from 30 individuals from the southern portion of the range (Mississippi River near St. Louis, Missouri and south). Fin ray counts were not taken on twelve specimens utilized for plate counts because the fins were damaged or too brittle to obtain accurate counts.

In order to maintain consistency in data acquisition, plate and fin ray counts were made by J. D. Williams and measurements were made by G. H. Clemmer. Taking meristic and mensural data from sturgeons can be difficult but, in most cases, it can be done accurately. Plate counts were made with relative ease compared to fin ray-counts. Although rays of the dorsal, anal, and pelvic fins could be enumerated with certainty the pectoral fin was much more difficult. The base of the pectoral fin is thick and fleshy so the small rays of the inner portion of the fin required dissection to be counted. In some specimens the rays were brittle and would frequently split, making accurate counting difficult. The use of insect pens to mark off sections of a fin, as recommended by Bailey and Cross (1954), was essential in making fin ray counts.

The difficulty associated with taking measurements often depended on the condition of the specimen and quality of preservation. Specimens that were preserved in jars were often bent, requiring considerable effort to straighten in order to obtain an accurate measurement of standard length. Measurements of soft body parts, such as body depth and width, mouth width, and interspace between rows of plates, were so affected by preservation and condition of the specimen that they were virtually useless for comparative purposes. Other measurements, especially those associated with hard structures such as the head and plates, could be made easily and accurately. In most cases measurements of the median and paired fins could be made with ease and

certainty.

Meristic and mensural data were taken from 27 *Scaphirhynchus suttkusi* and 45 *S. platyrhynchus*. Principal components analysis of mensural and meristic characters was used to make multivariate comparisons between the two species. The principal components analysis was performed separately on meristic and standardized mensural data. Analysis of variance was used to discriminate between significant and nonsignificant variables in a comparison of the two species. Of the 10 meristic and 36 mensural characteristics examined, 6 and 14 variables, respectively, were found to be significant and were utilized in the analysis. Principal components for the meristic variables were calculated from a correlation matrix, while the components for the mensural variables were calculated from a covariance matrix. Statistical analyses were performed using the SAS program (SAS Institute Inc., 1985, 1988).

Scaphirhynchus suttkusi, new species

Alabama Sturgeon

Figure 1

Scaphirhynchus platyrhynchus—Chermock, 1955:154 (Tombigbee River, Alabama); Smith-Vaniz, 1968:19 (Mobile Bay drainage); Ramsey et al., 1972:67 (status in Alabama); Mettee, 1978:32 (Cahaba River); Lee, 1980:44 (distribution map, Mobile Bay drainage); Boschung, 1989:41 (distribution in upper Tombigbee drainage, Alabama and Mississippi); Pierson et al., 1989a:57 (distribution in Cahaba drainage, Alabama).

Scaphirhynchus sp.—Clemmer et al., 1975:8 (endangered in Mississippi); Jenkins, 1976:643 (compilation of undescribed species); Ramsey, 1976:55 (endangered in Alabama); Deacon et al., 1979:40 (endangered); Ramsey, 1984:2 (reported from large rivers below the Fall Line in Alabama); Ramsey, 1986:18 (reported from Mobile Bay drainage, Alabama and Mississippi); Mettee et al., 1989:14 and 24 (distribution in western Mobile Basin); Pierson et al., 1989b:4 (distribution in Cahaba River); Williams et al., 1989:3 (conservation status); Burke and Ramsey, 1985 (distribution, habitat and movements).

Scaphirhynchus platyrhynchus ssp.—U.S. Fish and Wildlife Service, 1982:58455 (conservation status); U. S. Fish and Wildlife Service, 1985:37960 (conservation status); Johnson, 1987:4 and 13 (conservation status in Mississippi); U. S. Fish and Wildlife Service, 1989:556 (conservation status).

HOLOTYPE.—TU 135000, adult male, 552 mm standard length (SL), Alabama, Monroe County, overflow pool of Alabama River just above mouth of Little River at Dixie Landing, 18 March 1977, collected by W. E. Smith.

PARATYPES.—Alabama River drainage, Alabama: *Clark County*: AU 25919 (1) Alabama River about 4 mi SSE of

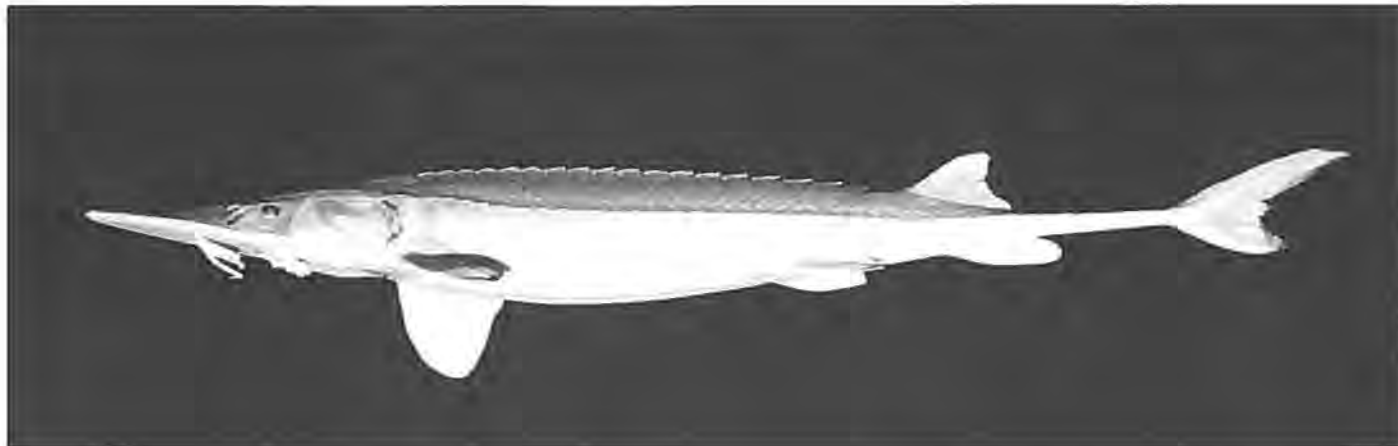


Figure 1. Lateral view of the holotype of *Scaphirhynchus suttkusi*, a male, 552mm SL, TU 135000.

Carlton, (RM 22.4), east bank on sand flat, 20 April 1984, J. S. Burke. *Dallas County*: UAIC 3634.01 (12), Junction of Alabama and Cahaba rivers, 21 March 1969, P. Hackney. *Elmore County*: USNM 200617 (1), Coosa River ca. 1 mi below Wetumpka, 27 November 1961, G. Best. *Monroe County*: TU 350001 (1) Overflow pool of Alabama River just above mouth of Little River at Dixie Landing, 5 April 1977, W. E. Smith; UF 84888 (1) Alabama River about 6 mi WSW of Caliborne, (RM 58.5), 17 April 1985, J. S. Burke and T. Holman; UMMZ 218753 (1) Alabama River about 8 mi W of Fountain, 2 May 1985, J. S. Burke. *Perry County*: AU uncatalogued (1) Probably from Cahaba River, found preserved at Marion National Fish Hatchery, before 1967; TU 64937 (1), Cahaba River near Marion National Fish Hatchery, ca. 1 mi W Sprott, 30 April 1966; UAIC uncatalogued specimen (1), Cahaba River, ca. 13 mi below bridge at Suttle, March 1967, W. Tatum; UMMZ 218752 (1), Cahaba River near Cahaba, "about 1969", L. Walls. *Wilcox County*: AU 25917 (1) Lake Claiborne, impounded Alabama River, about 3 mi ENE of Coy, (RM 109.8), west bank on Taft Bar, 2 May 1985, J. S. Burke and T. Holman; TU 50553 (1), Alabama River at Bear Creek, river mile 112.8, 2 March 1968, J. Grady; TU 52868 (1), Alabama River at Clifton Ferry Landing, river mile 137.3, 29 June 1968, R. D. Suttkus; UAIC 2180.01 (1), Alabama River, ca. 10 mi S Millers Ferry, February 1966, unknown commercial fisherman; UAIC 2616 (1), Alabama River at Millers Ferry, 4 June 1967, unnamed commercial fisherman; UAIC 2845.01 (1), Alabama River ca. 10 mi S Millers Ferry, 28 May 1966, unknown commercial fisherman; Tombigbee River drainage, Alabama: *Green/Sumter County Line*: UAIC 401 (1), Tombigbee River SW of Eutaw near Epes, 13 November 1953, unknown fisherman.

Other material not designated as types.—Alabama River drainage, Alabama: *Dallas County*: AU uncatalogued (1), skeletal remains found on the Alabama River, west bank, at confluence with Cahaba River, 19 September 1967, J. Dobie and R. Mount; UAIC uncatalogued (1) mounted specimen, from the Alabama River near Selma, 1965?,

caught by fisherman. *Montgomery County*: USNM 43675 (1) [Alabama River] Montgomery, 1880, T. S. Doron. This specimen was originally catalogued as *Acipenser* but was reidentified by R. D. Suttkus as *Scaphirhynchus*. The partially disintegrated condition of this specimen prevented its designation as a type.

DIAGNOSIS.—*Scaphirhynchus suttkusi* is a species of the genus *Scaphirhynchus* as defined by Bailey and Cross (1954) and is morphologically most similar to *S. platyrhynchus*. It can be distinguished from *S. platyrhynchus* by the following combination of characters (values for *S. platyrhynchus* in parentheses): eye large, its length into head width 6.5 to 8.2 times, usually 7.0-8.0, (7.7-14.4, usually 9.0-11.0); lateral plates anterior to the dorsal fin origin 27-32, usually 29-30 (23-31, usually 27); dorsal fin rays 29-34, usually 30-31 (30-36, usually 33-34); anal fin rays 18-22, usually 20 (19-24, usually 21); plates between the anus and anal fin origin 4-6, usually 5 (4-6, usually 4); plates between posterior end of anal fin and caudal fin base 7-8, usually 8 (7-10, usually 9).

Scaphirhynchus suttkusi can be distinguished from *S. albus* by the presence of small dermal plates on the belly between the rows of ventrolateral plates and its smaller maximum size. The dorsal and anal fin ray counts in *S. albus* are higher (dorsal fin rays 37-43; anal fin rays 24-28) than in *S. suttkusi*. Most of the gill rakers on the lower half of the first arch of *S. albus* have one or two blunt tips while those of *S. suttkusi* have three or four blunt tips.

DESCRIPTION.—A moderately large species, *Scaphirhynchus suttkusi* attains a length of 720 mm SL. The general body shape is illustrated in Figure 1. The attenuated caudal filament, an extension of the upper lobe of the caudal fin, is broken off the specimen in Figure 1. The head, lateral and dorsal view, is illustrated in Figure 2. Proportional measurements expressed as thousandths of standard length are given in Table 1. Frequency distribution of plate and fin ray counts are given in Table 2.

Total gill rakers on the first arch in *S. suttkusi* range from

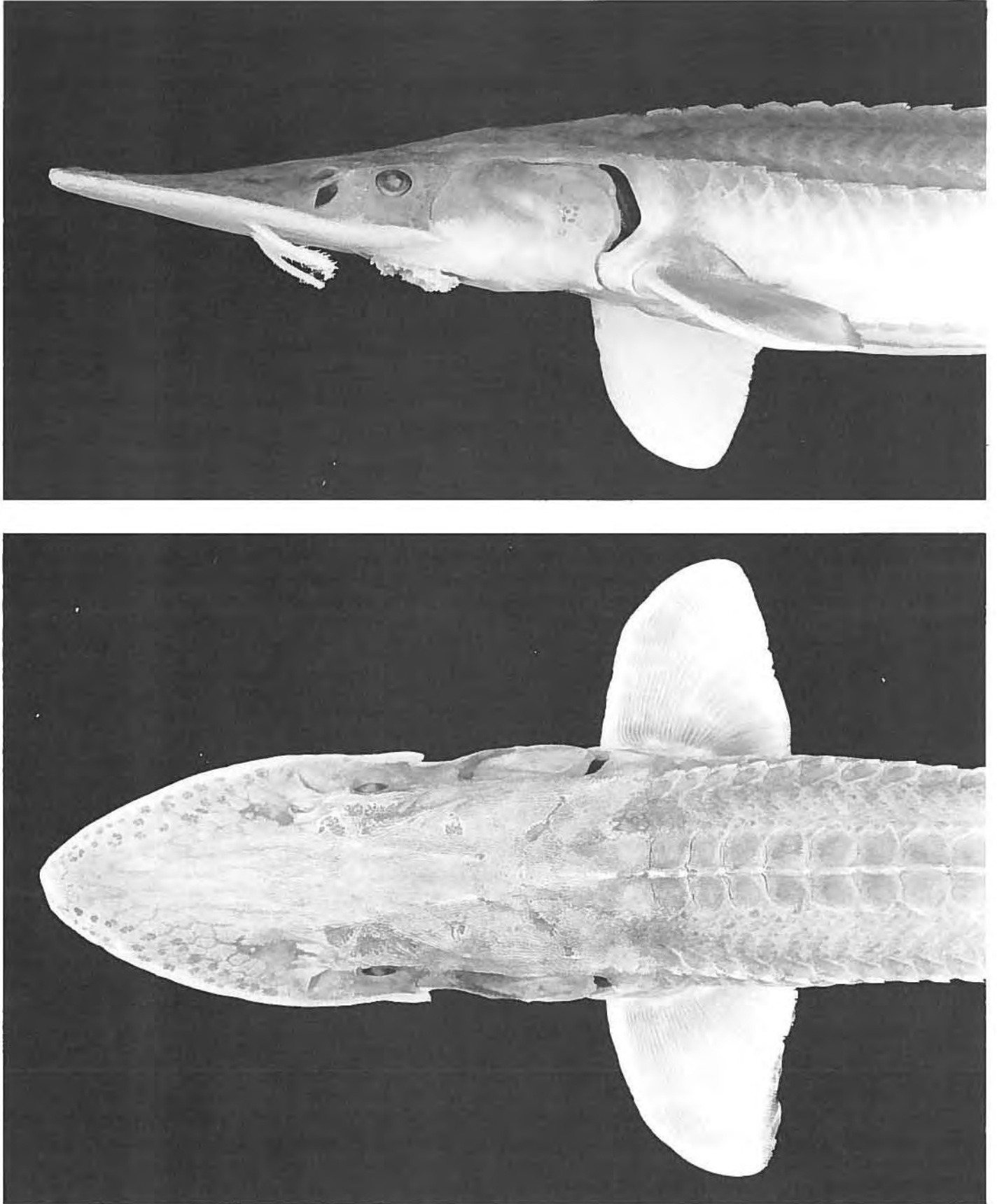


Figure 2. Lateral and dorsal view of head of the holotype of *Scaphirhynchus suttkusi*, a male, 552mm SL, TU 135000.

Table 1. Proportional measurements of *Scaphirhynchus suttkusi* and *S. platyrhynchus* expressed as thousandths of standard length.

	<i>S. suttkusi</i>						<i>S. platyrhynchus</i>					
	N	Minimum	Maximum	Mean	Std. Dev.	Std. Err.	N	Minimum	Maximum	Mean	Std. Dev.	Std. Err.
Standard length (mm)	27	356.800	720.000	534.026	89.434		45	168.000	675.700	457.673	127.001	
Snout to caudal fork	26	1.008	1.080	1.066	0.013	0.003	41	1.040	1.112	1.074	0.013	0.002
Snout to dorsal origin	26	480	772	723	0.053	0.004	45	640	757	701	0.022	0.003
Snout pelvic origin	21	561	626	592	0.017	0.004	45	534	634	584	0.022	0.003
Pelvic to anal fin origin	25	159	184	173	0.007	0.001	45	136	193	164	0.010	0.002
Anal fin origin to caudal fin base	27	203	272	234	0.019	0.004	45	28	310	255	0.041	0.006
Body depth	26	83	144	111	0.017	0.003	41	73	147	109	0.014	0.002
Body width	27	90	129	109	0.010	0.002	45	96	124	109	0.006	0.001
Caudal peduncle length	27	163	234	195	0.018	0.004	45	182	259	222	0.021	0.003
Caudal peduncle depth	27	15	19	16	0.001	0.000	45	12	17	14	0.001	0.000
Caudal peduncle width	27	13	27	21	0.004	0.001	45	10	24	18	0.003	0.000
Head length	27	247	284	270	0.008	0.002	45	236	292	265	0.014	0.002
Head depth	27	67	85	76	0.004	0.001	45	61	91	73	0.007	0.001
Head width	27	110	133	120	0.005	0.001	45	113	164	132	0.012	0.002
Interorbital width	27	71	89	81	0.004	0.001	45	67	89	79	0.005	0.001
Rostral length	27	177	209	193	0.008	0.002	45	163	226	195	0.015	0.002
Snout length	27	142	164	154	0.005	0.001	45	126	171	152	0.011	0.002
Orbit length	27	14	18	16	0.001	0.000	44	10	21	13	0.002	0.000
Anterior nostril width	27	7	12	10	0.001	0.000	45	7	14	9	0.002	0.000
Posterior nostril width	27	16	23	21	0.002	0.000	45	18	34	22	0.004	0.001
Snout tip to outer barbel	27	93	114	104	0.005	0.001	45	84	124	103	0.009	0.001
Snout tip to inner barbel	27	89	107	99	0.005	0.001	45	78	118	95	0.009	0.001
Outer barbel length	27	62	79	71	0.005	0.001	45	48	90	71	0.010	0.001
Inner barbel length	27	49	66	58	0.005	0.001	45	42	70	54	0.007	0.001
Dorsal fin base	27	62	82	69	0.005	0.001	45	59	88	70	0.007	0.001
Dorsal fin height	22	60	85	75	0.006	0.001	42	37	100	83	0.010	0.001
Anal fin base	27	35	47	41	0.003	0.001	45	28	51	41	0.005	0.001
Anal fin height	26	80	101	93	0.005	0.001	44	76	109	93	0.007	0.001
Caudal fin length	16	84	453	315	0.107	0.027	21	224	764	364	0.129	0.028
Lower lobe caudal fin	25	84	116	95	0.007	0.001	37	84	129	106	0.010	0.002
Pectoral fin length	27	112	149	129	0.009	0.002	45	117	166	138	0.011	0.002
Pelvic fin length	27	85	104	95	0.005	0.001	45	83	114	96	0.006	0.001
Tenth Lateral plate height	27	31	42	38	0.003	0.001	45	28	50	40	0.004	0.001
Ventral to lateral plate interspace	26	11	39	21	0.007	0.001	43	9	31	19	0.006	0.001
Mouth width	27	69	103	77	0.007	0.001	40	28	95	76	0.010	0.002
Mouth to inner barbel	22	50	69	57	0.004	0.001	41	50	78	58	0.005	0.001

18-23, with 5-9, usually 6, on the upper limb and 12-14, usually 13, on the lower limb. Most of the gill rakers on the lower limb of the first arch are fan-shaped with 3-4 blunt tips. The 2 to 3 gill rakers near the ends of the gill arch vary from fan-shaped without blunt tips to almost rod-like. The numbers and shape of gill rakers in *S. suttkusi* are similar to those of *S. platyrhynchus*.

There is considerable ambiguity about the nature of pseudobranchiae in sturgeons. Jordan and Evermann (1896) reported pseudobranchiae in *Scaphirhynchus* as obsolete. Forbes and Richardson (1908) and Vladykov and Greeley (1963) considered the pseudobranchiae as rudimentary. Bailey and Cross (1954:175) stated that members of the subfamily Scaphirhynchinae do not have pseudobranchiae but, indicated that there was "an accessory opercular gill that is poorly developed, consisting of only 20 to 25 short filaments." How these differ morphologically, histologically, or physiologically from pseudobranchiae is not clear.

Specimens of *S. suttkusi* have "accessory opercular gills" although there is considerable variation in their size and distribution. They are generally arranged in broken patches parallel to the outer edge of the opercular membrane. They may extend along one fourth to one third of the opercular margin. Individual elements are up to 7-8 mm in length and occasionally are attached to each other at or near their base.

Weisel (1979) reported on the anatomy and histology of the feeding and digestive organs of *Scaphirhynchus platyrhynchus*. Gross examination of the viscera of four *S. suttkusi* did not reveal any differences in the arrangement or proportions of internal organs from those reported by Weisel (1979) for *S. platyrhynchus*.

The head, body, and fins of preserved specimens are uniformly pigmented. Dorsal and lateral surfaces of the head and body are light brown to tan. The ventral surface of head and body is typically cream colored. The dorsal and caudal fins and the dorsal surface of paired fins are grayish. The

Table 2. Frequency distribution of plate and fin ray counts in *Scaphirhynchus suttkusi* and *S. platorynchus*.

Dorsal Plates											
	13	14	15	16	17	18	19	20	21	N	\bar{x}
<i>S. suttkusi</i>		1	5	16	5	2	0	1		30	17.2
<i>S. platorynchus</i>	1	5	8	9	11	6	2			42	16.2

Lateral Plates															
	38	39	40	41	42	43	44	45	46	47	48	49	50	N	\bar{x}
<i>S. suttkusi</i>			2	2	1	3	3	4	6	5	2	1		29	44.9
<i>S. platorynchus</i>	1	1	3	1	6	4	6	6	6	3	3	1	1	42	44.2

Ventrolateral Plates							N	\bar{x}
	9	10	11	12	13	14		
<i>S. suttkusi</i>			8	10	10	2	30	12.2
<i>S. platorynchus</i>	1	3	8	11	11	8	42	12.2

Plates Between Anus and Anal Fin Origin					N	\bar{x}
	4	5	6			
<i>S. suttkusi</i>	3		23	3	29	5.0
<i>S. platorynchus</i>	25		16	1	42	4.4

Plates Posterior of the Anal Fin Base					N	\bar{x}
	7	8	9	10		
<i>S. suttkusi</i>	7	21			28	7.8
<i>S. platorynchus</i>	2	12	23	5	42	8.7

Lateral Plates Anterior of Dorsal Fin Origin												
	23	24	25	26	27	28	29	30	31	32	N	\bar{x}
<i>S. suttkusi</i>					2	2	6	8	2	3	23	29.7
<i>S. platorynchus</i>	1	0	3	4	10	5	3	3	1		30	27.3

Dorsal Fin Rays										N	\bar{x}
	29	30	31	32	33	34	35	36			
<i>S. suttkusi</i>	5	7	9	1	2	2				26	30.8
<i>S. platorynchus</i>		2	4	5	6	6	5	2		30	33.1

Anal Fin Rays							N	\bar{x}	
	18	19	20	21	22	23	24		
<i>S. suttkusi</i>	3	5	12	5	1			26	19.9
<i>S. platorynchus</i>		2	6	12	5	3	2	30	21.2

Pectoral Fin Rays										N	\bar{x}	
	39	40	41	42	43	44	45	46	47	48		
<i>S. suttkusi</i>		1	2	4	1	6	7	2	2	1	26	44.1
<i>S. platorynchus</i>	1	2	2	7	5	3	3	2	2	1	28	43.3

Pelvic Fin Rays									N	\bar{x}	
	23	24	25	26	27	28	29	30	31		
<i>S. suttkusi</i>	2	4	5	4	4	4	2	1		26	26.1
<i>S. platorynchus</i>			7	7	6	5	2	2	1	30	26.9

anal fin and ventral surface of paired fins are light gray to off white. Life colors and colors of freshly thawed specimens are basically as described above with the exception of a light olivaceous wash over the dorsal and lateral surfaces of the body.

ETYMOLOGY.—We are pleased to name this sturgeon for Royal D. Suttkus, Tulane University, in recognition of his longstanding dedication to ichthyology. The name *suttkusi* is a masculine noun in the genitive singular. We suggest the common name Alabama sturgeon for this species that is distributed almost entirely within the boundaries of the state of Alabama.

COMPARISONS.—*Scaphirhynchus suttkusi* is morphologically more similar to *S. platorynchus* than to *S. albus*. There are several characters that support this observation. Maximum body size in *S. suttkusi* and *S. platorynchus* rarely exceeds 80 centimeters (cm) fork length (FL) and 2.3 kilograms (kg) while *S. albus* is known to reach lengths of 168 cm and weights of 28 kg. Scutes are present on the belly of both *S. suttkusi* and *S. platorynchus* but are absent from *S. albus*. Gill rakers on the lower limb of the first arch of *S. suttkusi* and *S. platorynchus* usually have 3 or 4 blunt tips while those of *S. albus* usually have 2 tips. The plate and fin ray counts of *S. suttkusi* and *S. platorynchus* are more similar to each other than either is to *S. albus*.

Variation in meristic characters of *Scaphirhynchus platorynchus* throughout its range was not examined. A cursory comparison of northern and southern populations was made utilizing plate and fin ray counts taken by us and those reported by Bailey and Cross (1954). Specimens utilized for meristic characters reported by Bailey and Cross (1954) were taken almost exclusively (20 of 25 lots, number of specimens not reported) from the Missouri River system. The Missouri River population is most likely to be representative of a northern population. Our material was primarily (37 of 42 specimens) from the lower Mississippi River drainage (south of the junction of the Missouri and Mississippi rivers) which is likely to be representative of a southern population. Of the *S. platorynchus* material examined by us and by Bailey and Cross (1954) some came from the same geographic area. The amount of overlap is not known since they did not report the number of specimens in each lot examined. We did not perform a statistical comparison of the two groups (t-test) because there was geographic overlap of the two samples and the possible error associated with different individuals taking the data. However, a cursory comparison of available data, even without a statistical analysis, provides some insight into the nature of the variation in *S. platorynchus*.

Bailey and Cross (1954) reported three plate counts, dorsal, lateral, and ventrolateral, for *Scaphirhynchus platorynchus*. In comparing our plate counts with those reported by Bailey and Cross (1954) a weak north-south

cline was evident. The mode for all three plate counts was one plate lower in the northern population. Means were also lower in the northern population. Only one of these three plate counts, dorsal plates, differed significantly between southern populations of *S. platyrhynchus* and *S. suttkusi*.

The four fin ray counts, dorsal, anal, pelvic, and pectoral, present a different pattern. Our dorsal and anal fin ray counts for *Scaphirhynchus platyrhynchus* (southern) and those reported by Bailey and Cross, (1954) (northern) are almost identical. For dorsal rays the range and mode are the same and the means differ by 0.1 ($\bar{x} = 33.1$ southern; $\bar{x} = 33.2$ northern). The modal number of anal rays are the same in southern and northern populations and the difference in the mean is 0.15 ($\bar{x} = 21.2$ southern; $\bar{x} = 21.35$ northern). The dorsal and anal fin ray counts for the southern populations of *S. platyrhynchus* and *S. suttkusi* were significantly different.

The pectoral and pelvic fin ray counts in northern and southern populations of *Scaphirhynchus platyrhynchus* exhibited a strong cline. The mode and means of the northern population (Bailey and Cross, 1954) were considerably higher. It is difficult to obtain accurate pectoral fin ray counts (see Methods section) however, the difference in the northern (mode 48, $\bar{x} = 47.45$) (Bailey and Cross, 1954) and southern (mode 42, $\bar{x} = 43.3$) populations, allowing for some error in counting, is still indicative of a cline. The difference in pelvic fin rays in northern and southern populations was less than the pectoral fin rays but followed the same pattern. There was no significant difference in pectoral and pelvic fin rays between the southern population of *S. platyrhynchus* and *S. suttkusi*.

There is a noteworthy pattern that emerged from the cursory review of meristic variables in *Scaphirhynchus platyrhynchus*. The median meristic variables, dorsal plates, dorsal and anal fin rays, exhibited very little (dorsal plates) or no (dorsal and anal fin rays) clinal variation in *S. platyrhynchus*. All three of these meristic variables were significantly different when comparing southern populations of *S. platyrhynchus* and *S. suttkusi*. In contrast, paired meristic variables, lateral and ventrolateral plates, pectoral and pelvic fin rays, all exhibited clinal variation. The direction of the cline in plates and fin rays differed with the plate counts lower in the northern population and fin rays higher in the northern population. None of these variables differed between southern populations of *S. platyrhynchus* and *S. suttkusi*.

In the following paragraphs, references to *S. platyrhynchus* are based on our data taken primarily from specimens from the southern portion of its range. The comparison of meristic variables of *S. suttkusi* and *S. platyrhynchus* involved six plate counts and four fin ray counts. The Wilcoxon 2-sample test was used to analyze the meristic variables. This analysis revealed significant differences in six of the ten variables (Table 3). The three standard plate counts taken in sturgeons, dorsal, lateral, and ventrolateral, showed very

Table 3. Mean, standard deviation, and P-value for ten meristic characters for *Scaphirhynchus suttkusi* and *S. platyrhynchus*.

	<i>S. suttkusi</i>			<i>S. platyrhynchus</i>			Significance
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	
Dorsal plates	30	17.20	1.13	42	16.19	1.47	.0066
Lateral plates	29	44.86	2.43	42	44.19	2.75	.2547
Ventrolateral plates	30	12.20	0.93	42	12.24	1.30	.7288
Plates between anus and anal fin origin	29	5.00	0.46	42	4.43	0.54	.0001
Plates between posterior end of anal fin and caudal fin base	28	7.75	0.44	42	8.74	0.73	.0001
Lateral plates anterior to dorsal fin origin	23	29.65	1.40	30	27.33	1.75	.0001
Dorsal fin rays	26	30.77	1.45	30	33.10	1.69	.0001
Anal fin rays	26	19.85	1.00	30	21.23	1.28	.0002
Pectoral fin rays	26	44.08	2.00	28	43.25	2.25	.1521
Pelvic fin rays	26	26.11	1.93	30	26.93	1.68	.1310

little difference except for the dorsal plates, which differed significantly (Table 3) and exhibited a higher mean in *S. suttkusi*, $\bar{x} = 17.2$ versus $\bar{x} = 16.2$ in *S. platyrhynchus*.

We recorded three additional plate counts not typically reported for sturgeons. All three of these revealed differences between the two species (Table 3). Plates between the anus and anal fin origin were usually 5 in *Scaphirhynchus suttkusi* ($\bar{x} = 5.0$) and 4 in *S. platyrhynchus* ($\bar{x} = 4.4$). Plates between the posterior end of anal fin and the caudal fin base were lower in *S. suttkusi*, typically 8 ($\bar{x} = 7.8$), than *S. platyrhynchus*, typically 9 ($\bar{x} = 8.7$). Differences in these counts between the two species reflects the more posterior placement of the anal fin in *S. suttkusi*.

Of the six plate counts, lateral plates anterior of the dorsal fin origin exhibited the greatest difference between the two species. In *S. suttkusi* there were usually 30 lateral plates anterior to the dorsal fin origin ($\bar{x} = 29.7$), compared to a modal count of 27 ($\bar{x} = 27.3$) in *S. platyrhynchus*. This difference reflects the more posterior placement of the dorsal fin in *S. suttkusi* (Table 1), as the total number of lateral plates is almost identical, $\bar{x} = 44.9$ in *S. suttkusi* and $\bar{x} = 44.2$ in *S. platyrhynchus*, with a similar range in both species.

Two of the four fin ray counts were different (dorsal and anal) and two were almost identical (pectoral and pelvic). Pectoral rays, which were difficult to count accurately, showed similar distributions and means, $\bar{x} = 44.1$ in *S. suttkusi* and $\bar{x} = 43.3$ in *S. platyrhynchus*. Mean and modal number of pelvic rays were similar between the two species (Table 2). There was a modal difference of one anal fin ray, *S. suttkusi* 20 ($\bar{x} = 19.9$) and *S. platyrhynchus* 21 ($\bar{x} = 21.2$). The dorsal fin rays exhibited the greatest degree of divergence of any of the meristic characters. In *S. suttkusi* the modal number of dorsal rays was 31 ($\bar{x} = 30.8$), compared to a mode of 33-34 ($\bar{x} = 33.1$), in *S. platyrhynchus* (Table 2).

Variance of the meristic characters was analyzed using principal components analysis (PCA). The best axis for separation of *Scaphirhynchus suttkusi* and *S. platyrhynchus* was PC I (Fig. 3). Character loading on PC I was fairly uniform (Table 4) with the exception of lower variance attributed to dorsal plates. Characters loaded in the following order of decreasing variance: 1. lateral plates anterior to dorsal fin origin; 2. anal fin rays; 3. dorsal fin rays; 4. plates between anus and anal fin origin, and; 5. plates between posterior end of anal fin and caudal fin base. The PC II axis illustrates the range of variation exhibited by the two species. Loading most significantly on PC II was the dorsal plates, followed by lateral plates anterior to dorsal fin origin, plates between anus and anal fin origin and plates between posterior end of anal fin and caudal fin base (Table 4). Principal components I and II explain 64% of the total variance of the six meristic characters used in the analysis (Table 5).

Table 4. Variance loadings for the principal components in the analysis of meristic variables of *Scaphirhynchus suttkusi* and *S. platyrhynchus*.

	PCI	PCII	PCIII	PCIV	PCV
Dorsal plates	-.200	-.749	0.459	-.055	-.103
Lateral plates anterior to dorsal fin origin	-.476	0.408	-.167	0.234	0.229
Dorsal fin rays	0.445	-.026	0.626	0.356	-.284
Anal fin rays	0.462	0.162	0.129	-.140	0.851
Plates between anus and anal fin origin	-.409	-.379	0.311	0.610	0.355
Plates between posterior end of anal fin and caudal fin base	0.393	0.320	-.506	0.652	-.084

Table 5. Eigenvalues of the correlation matrix for meristic variables for the first five principal components of *Scaphirhynchus suttkusi* and *S. platyrhynchus*.

	Eigenvalue	Difference	Proportion	Cumulative
PCI	2.63014	1.42434	0.438357	0.43836
PCII	1.20581	0.41903	0.200968	0.63933
PCIII	0.78677	0.19591	0.131129	0.77045
PCIV	0.59087	0.06276	0.098478	0.86893
PCV	0.52811	0.26981	0.088018	0.95695

A total of 35 mensural variables was examined on 27 *Scaphirhynchus suttkusi* and 45 *S. platyrhynchus*. Review of the mensural data for the two species reveals divergence in some head, caudal peduncle, fin, and fin placement characters. In the head region the most obvious is the larger orbit of *S. suttkusi*. The interorbital width in *S. suttkusi* is somewhat wider, but the head width is narrower. These are illustrated in the plot of orbit length to head width (Fig. 4). The caudal peduncle length, width and depth are all less in *S. suttkusi* than in *S. platyrhynchus* (Table 1). Reduced caudal peduncle length and greater distance between the pelvic fin

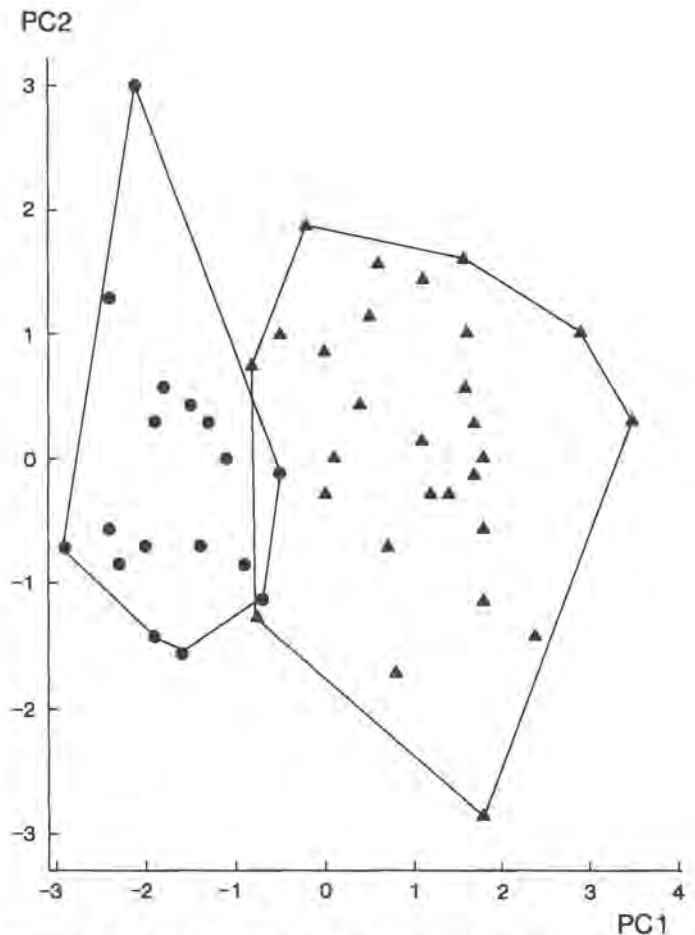


Figure 3. Plot of scores on the first and second principal components for six meristic characters for *Scaphirhynchus suttkusi* (dots) and *S. platyrhynchus* (triangles).

and anal fin origin in *S. suttkusi* is due to the more posterior placement of the anal fin. An increase in the distance between the snout tip and origin of the dorsal fin reflects the more posterior placement of the dorsal fin in *S. suttkusi*. Three fin measurements, dorsal, lower lobe of caudal, and, pectorals, are proportionally longer in *S. platyrhynchus* than in *S. suttkusi* (Table 1).

Principal components analysis was used to analyze the variance of 14 mensural characters (Table 6). The plot of scores for the first two principal components provide some discrimination for *S. suttkusi* and *S. platyrhynchus* (Fig. 5) and accounts for 58% and 15%, respectively, of the variance in the 14 mensural characters utilized in the analysis (Table 7). Two characters, distance from tip of snout to dorsal fin origin and anal fin origin to caudal fin base, loaded heavily on PC I. These characters involve the location of the dorsal and anal fin and reflect the divergent nature of the placement of these two fins. The four characters loading most heavily on PC II are head length, head width, snout length and distance from the snout tip to the base of the inner barbel. A plot of scores for PC I and PC III (Fig. 6) gave the best overall components for separation of the two species. Three

Table 6. Variance loadings for the principal components in the analysis of mensural variables of *Scaphirhynchus suttkusi* and *S. platyrhynchus*.

Variable	PCI	PCII	PCIII	PCIV
Pelvic fin to				
anal fin origin	-.175	-.114	0.005	-.009
Head length	0.035	0.660	-.043	-.023
Head width	0.192	0.306	0.141	-.182
Snout length	0.002	0.493	-.054	0.072
Snout tip to				
inner barbel	-.022	0.381	-.061	0.026
Tenth lateral				
plate height	-.020	-.087	0.151	0.063
Dorsal fin height	0.060	-.097	0.587	0.008
Length lower				
lobe caudal fin	0.057	0.022	0.543	-.087
Snout to dorsal				
fin origin	-.694	0.080	0.071	0.637
Anal fin origin to				
caudal fin base	0.661	-.068	-.117	0.711
Caudal peduncle				
width	-.023	-.008	-.020	0.019
Interorbital				
width	-.002	0.112	0.004	-.012
Pectoral fin				
length	0.065	0.156	0.535	0.193
Orbit length	-.028	0.057	-.069	0.011

Table 7. Eigenvalues of the covariance matrix for mensural variables for the first four principal components of *Scaphirhynchus suttkusi* and *S. platyrhynchus*.

	Eigenvalue	Difference	Proportion	Cumulative
PCI	0.001142	0.000850	0.578603	0.57860
PCII	0.000292	0.000105	0.147744	0.72635
PCIII	0.000187	0.000084	0.094751	0.82110
PCIV	0.000103	0.000036	0.052189	0.87329

fin measurements, dorsal fin height, length of the lower lobe of the caudal fin, and pectoral fin length, loaded heavily and uniformly on PC III (Table 6). Principal components I and III explain 67% of the total variance (Table 7).

Distribution

Scaphirhynchus suttkusi is endemic to the Mobile Bay drainage of Alabama and Mississippi (Fig. 7). All distribution records are from the main channels of major rivers in areas below the Fall Line. Specimens of Alabama sturgeon that have been deposited in museums are from the Coosa, Cahaba, Alabama, and upper Tombigbee rivers. Capture records from commercial fishermen and fishery biologists are known from the above mentioned rivers and the Black Warrior, lower Tombigbee, Mobile, and Tallapoosa rivers in Alabama (Burke and Ramsey 1985). Lee (1980:44) reported one locality from the eastern part of the State of Mississippi. This record was based on a single specimen from the Tombigbee River near West Point, Clay County, Mississippi, in the collection of the Mississippi Museum of Natural

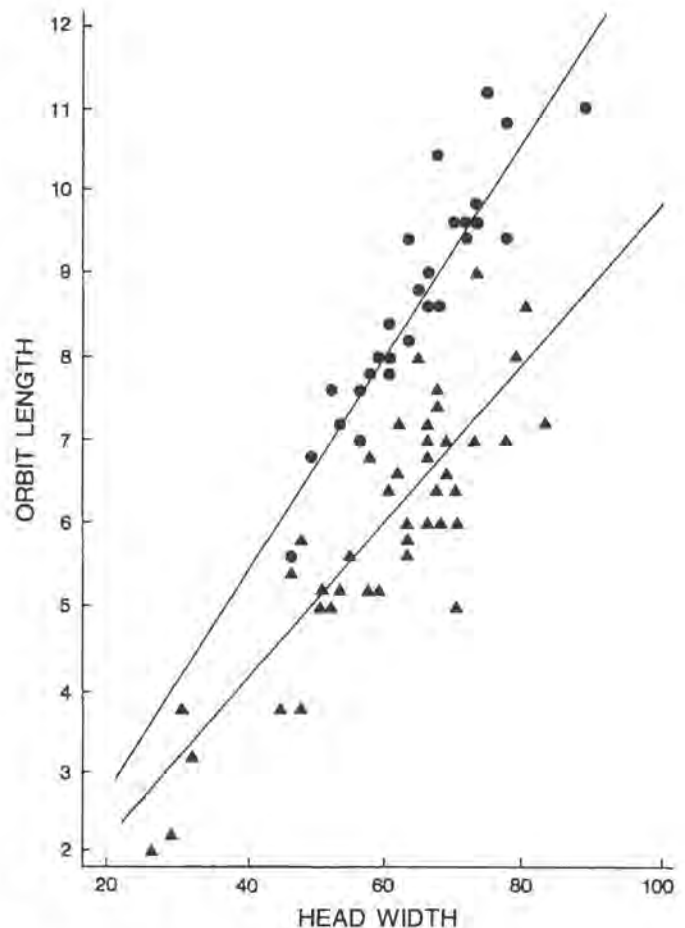


Figure 4. Relationship of orbit length to head width in *Scaphirhynchus suttkusi* (dots) and *S. platyrhynchus* (triangles).

Sciences, Jackson, Mississippi. This specimen was separated from identifying data when the Museum was flooded and was subsequently discarded. Denzel Ferguson (pers. comm.) examined a specimen collected by a commercial fisherman at Columbus, Mississippi in the mid-1960's. Longtime fishermen on the Tombigbee River questioned during the 1970's frequently recognized the sturgeon as an infrequently encountered species that had not been seen for several years.

Habitat and Life History

Based on capture data, *Scaphirhynchus suttkusi* inhabits the main channel of large coastal plain rivers. Most specimens have been taken in moderate to swift current at depths of 6 to 14 m, over sand and gravel or mud bottom. This is similar to the habitat of *S. platyrhynchus* reported by Carlson and Pflieger (1981) and Hurley et al. (1987).

Examination of stomach contents of four individuals revealed the presence of larval aquatic insects, oligochaetes, and fragments of mollusc shells. The most abundant food items, by volume and numbers, were larval aquatic insects. Fishermen report catching sturgeons on trot lines using a

variety of bait, such as poultry parts, fish, and commercially prepared bait, which suggests these fish are also scavengers.

Several gravid females provide limited information on the reproductive biology of *Scaphirhynchus suttkusi*. The smallest female (UAIC 3634), 397 mm SL, collected 21 March 1969, had the body cavity filled with black (mature) eggs. A large female (TU 64937), 659 mm SL, collected 30 April 1966, was full of eggs and the abdomen was noticeably distended. The eggs were black and measured 2.4-2.8 mm in diameter. Other gravid females taken during April had ripe eggs measuring 2.4-3.0 mm in diameter. One female (UAIC 401), 720 mm SL, collected 13 November 1953, had brownish eggs completely filling the body cavity. These eggs were smaller, ranging in size from 1.8 to 2.1 mm in diameter. The collection of gravid females with ripe eggs during late March, April, and early May could represent a prolonged spring spawning or simply reflect yearly variations in the occurrence of preferred spawning temperatures. Actual timing of spawning during this period may vary depending on temperature and river discharge. The capture of 12 individuals, including several gravid females, in one set of a gill net at the mouth of the Cahaba River on 21 March 1969, suggests directional movements during the spawning season.

Biogeography

The distribution pattern of fishes endemic to the Mobile Basin that are closely related to species in the Mississippi Basin but absent from intervening Gulf coast drainages is not common. Four fishes that exhibit this pattern are, *Scaphirhynchus platyrhynchus*, *Notropis blennioides*, *N. shumardi*, and *N. wickliffi*. With one exception, *S. platyrhynchus*, none of these species occur in Gulf coast drainages west of the Mississippi River. These four taxa have related species (= sister taxa?), *S. suttkusi*, *N. edwarddraneyi*, *N. candidus*, and *N. cahabae*, that inhabit the main channel of one or more Mobile Basin rivers (Suttkus and Clemmer 1968; Suttkus 1980; Mayden and Kuhajda 1989). None of the eight species occur in the intervening drainages of Lake Pontchartrain or the Pearl and Pascagoula rivers.

An additional species, *Notropis uranoscopus*, endemic to the main channel of large streams in the Mobile Basin, appears to fit the distribution pattern discussed above. According to Suttkus (1959) *Notropis uranoscopus* is closely related to *N. stramineus* which inhabits the Mississippi and Rio Grande drainages; however, its precise relationships have not been determined (Mayden, 1989). Phylogenetic analysis of other Mobile Basin endemics will likely reveal additional species that share this distribution pattern.

There are other species found in both the Mississippi and Mobile basins that are absent from the intervening drainages: *Acipenser fulvescens*, *Moxostoma erythrurum*, *M. duquesnei*, *Etheostoma nigrum*, and *Stizostedion vitreum*. Of these five species, only two, *A. fulvescens* and *S. vitreum*, are typically confined to riverine or large stream habitats.

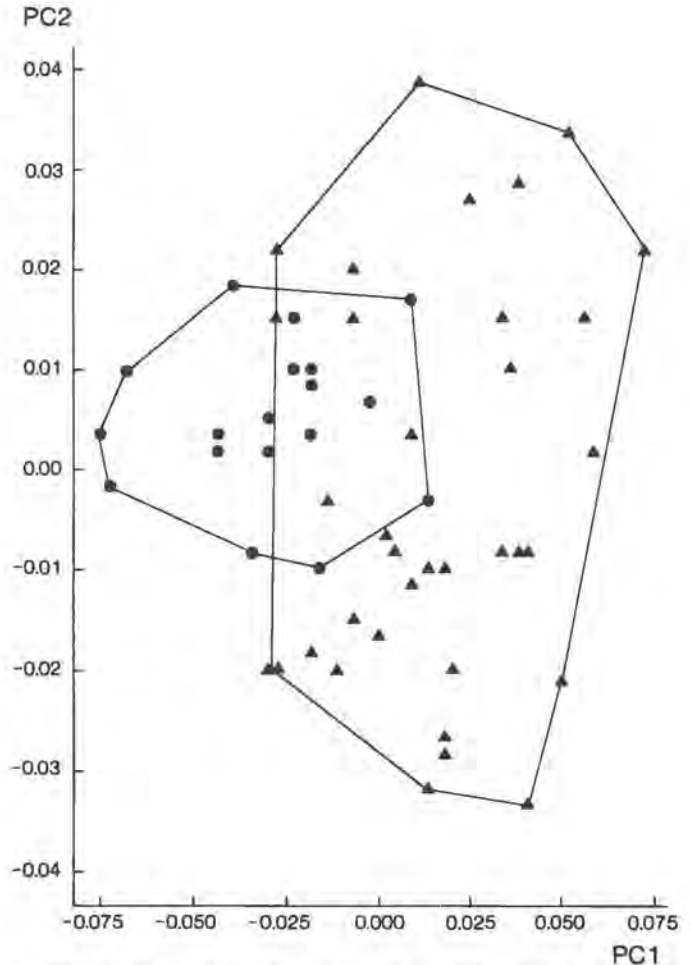


Figure 5. Plot of scores of the first and second principal components for 14 mensural characters for *Scaphirhynchus suttkusi* (dots) and *S. platyrhynchus* (triangles).

The two species of *Moxostoma* and *E. nigrum* may occur in the main channel of large rivers, but also inhabit smaller tributaries, including creeks. While these five species occur in the Mississippi and Mobile basins, only the two species of *Moxostoma* have been the subject of detailed systematic study and one, *M. duquesnei*, was found to have a distinct race in the Mobile Basin (Jenkins, 1980). Biochemical data from a second species, *S. vitreum*, have revealed some differences between Mississippi Basin and Mobile Basin populations (Murphy, 1990), but this needs further investigation.

The presence of five species of fishes in the Mobile Basin with sister taxa in the Mississippi basin, that are absent in the intervening drainages represents an unusual distribution pattern with three plausible explanations. One is that the Mississippi and Mobile rivers were once joined, which would allow species inhabiting the main channel of these large rivers to move between the two systems. This scenario requires explanation of the absence of these species in the intervening drainages. This could have occurred during a Pleistocene marine flooding event that completely inundated

these systems or reduced them to small, direct tributaries to the Gulf of Mexico, thereby eliminating large riverine habitat required by these species.

Another possible scenario is the continuous distribution of the ancestral form across the Gulf drainages with subsequent extinction in the smaller intervening river systems. A marine flooding event, such as the one described above, is a plausible explanation for the extinction of populations in the intervening drainages.

A third explanation for this pattern is the existence of the Appalachian River (Hayes and Campbell, 1894), a large river arising in the southern Appalachians (occupying an area that is currently part of the Tennessee basin) flowing southward through the Mobile Basin with an outlet to the Gulf of Mexico via Mobile Bay. The existence of this river has been debated by geologists and biologists during the past century with an array of evidence provided pro and con (see Mayden, 1988; Starnes and Etnier, 1986, and Swift et al., 1986 and references therein).

Mayden and Kuhajda (1989) presented data on the relationships of *Notropis wickliffi* - *N. cahabae* and populations of *N. volucellus* that support the existence of the Appalachian River. The distribution pattern of other related species pairs (*Scaphirhynchus platyrhynchus* - *S. suttkusi*; *Notropis blennioides* - *N. edwarddraneyi*; and *N. shumardi* - *N. candidus*) occurring in the Mississippi drainage and Mobile Basin is consistent with the existence of the ancient Appalachian River and the alternative explanations mentioned above. However, it should be noted that *N. shumardi* is absent in the Tennessee drainage and *N. blennioides* is not known to occur in the upper Tennessee drainage in recent times. Phylogenetic studies of fishes and other aquatic organisms are needed to permit a more complete evaluation of the role of the Appalachian River as a dispersal route.

Status

The three species of *Scaphirhynchus*, *S. albus*, *S. platyrhynchus*, and *S. suttkusi*, have declined in distribution and numbers of individuals during the past 50-75 years (Williams, unpub. data). One species, *S. albus*, is federally listed as an endangered species and *S. suttkusi* is under review for endangered or threatened species status by the U. S. Fish and Wildlife Service. Both species were considered endangered species by the American Fisheries Society (Williams et al., 1989) and *S. albus* is listed as endangered by the IUCN Conservation Monitoring Centre (1988). While *S. platyrhynchus* is not endangered or threatened on a national basis, it is assigned a conservation status or has been extirpated in 8 of the 24 states where it is known to occur.

The decline of sturgeons of the genus *Scaphirhynchus* in the United States is due primarily to the loss of habitat. Destruction of habitat, by impoundments, regulated flows, dredging, and channelization in many of the main channels of large rivers has rendered them uninhabitable by

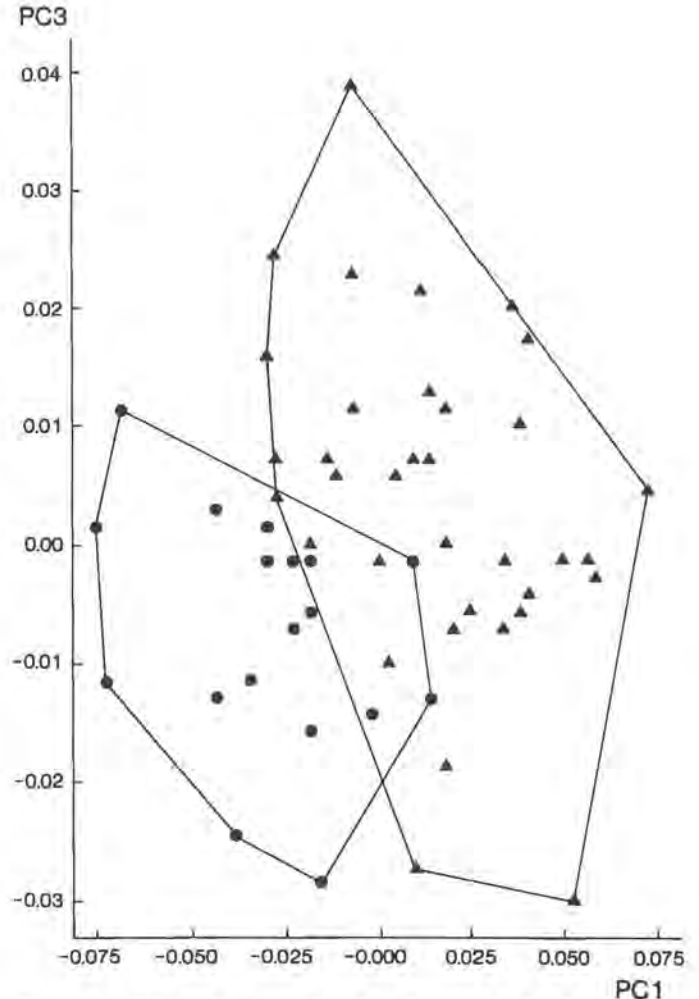


Figure 6. Plot of scores of the first and third principal components for 14 mensural characters for *Scaphirhynchus suttkusi* (dots) and *S. platyrhynchus* (triangles).

Scaphirhynchus. These alterations of the riverine habitat in the Missouri and Mississippi rivers in Missouri likely brought about the conditions which resulted in the hybridization of *S. albus* and *S. platyrhynchus* (Carlson et al., 1985). Loss of habitat of *S. suttkusi* in the Mobile Basin was researched and documented by Burke and Ramsey (1985).

The genus *Scaphirhynchus* in North America dates back to the Cretaceous (Bailey and Cross, 1954). Without a major conservation effort in the next decade we run the risk of losing both *Scaphirhynchus albus* and *S. suttkusi*.

Acknowledgments

We would like to express our appreciation to: Henry L. Bart, Jr., Auburn University; Herbert T. Boschung and Richard L. Mayden, University of Alabama; Neil H. Douglas, Northeast Louisiana University; Royal D. Suttkus, Tulane University; Reeve M. Bailey and Douglas W. Nelson, University of Michigan; Susan Jewett and Richard P. Vari, National Museum of Natural History, for the loan of specimens and use of facilities; Doug Carlson, formerly with

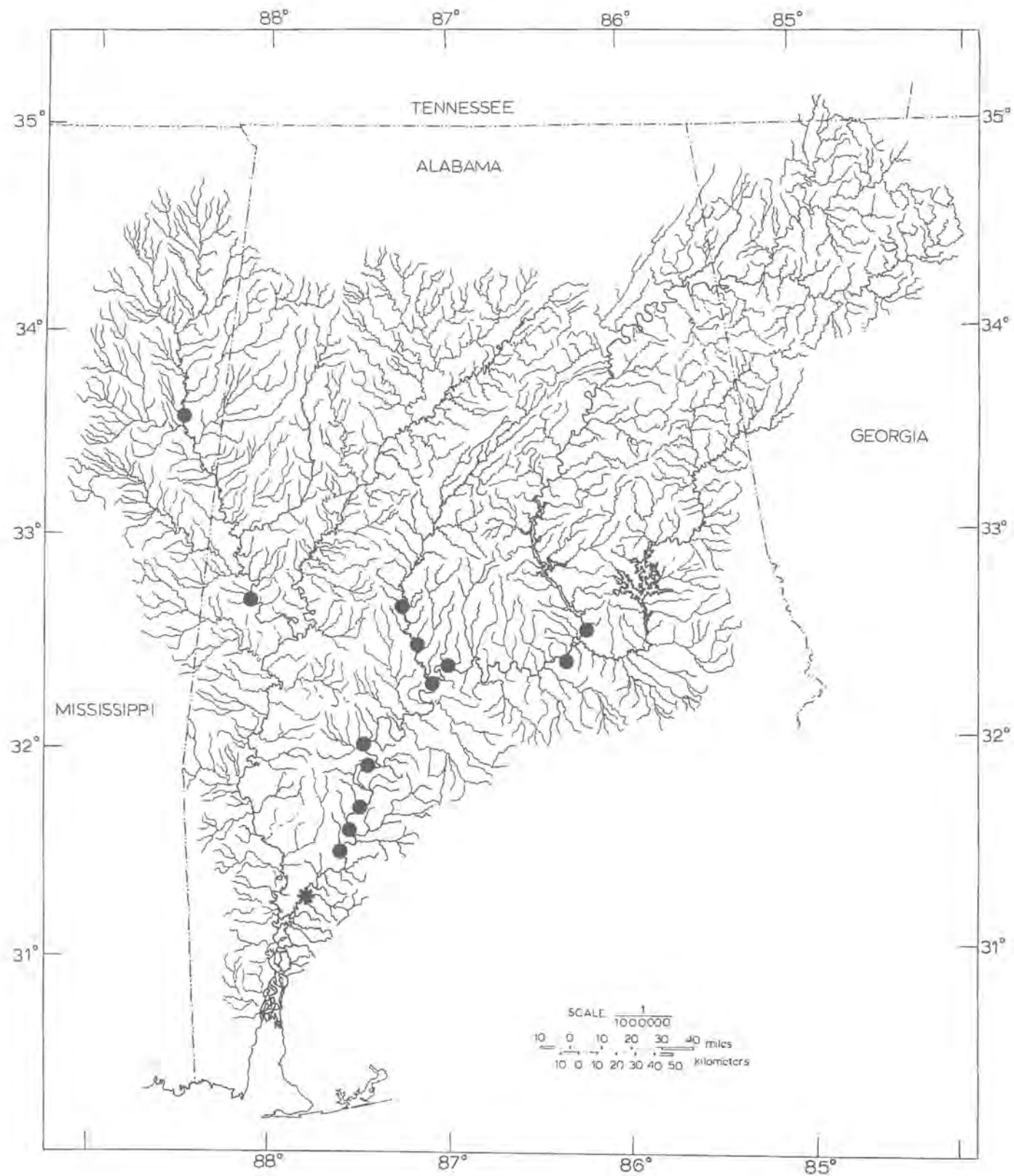


Figure 7. Distribution of the Alabama sturgeon, *Scaphirhynchus suttkusi* in the Mobile basin of Alabama and Mississippi. The asterisk represents the type locality.

the Missouri Department of Conservation, for the collection of specimens of the shovelnose sturgeon; John S. Burke and John S. Ramsey, for information on the biology of the Alabama sturgeon; Ann M. Foster and Howard Kochman, for assistance with principal components and SAS analysis; John H. Caruso, for photography of specimens in the Tulane University collection; and George Burgess, Noel Burkhead, Carter R. Gilbert, and Steven Walsh for review and comments on an early draft of this manuscript. Special thanks to Sherry Bostick for her assistance in producing several drafts of this document.

Material Examined

Specimens of *Scaphirhynchus platyrhynchus* examined for comparative purposes are listed below.

MISSISSIPPI RIVER DRAINAGE: *Alabama:* **Lauderdale Co.:** UMMZ 132704 (1) Tennessee River at Wilson Dam, 18-19 July 1937. **Morgan Co.:** UMMZ 200908 (3) Tennessee River at Decatur, April 1940; USNM 143799 (1) Wheeler Reservoir on the Tennessee River, no date given. *Illinois:* **County not recorded:** USNM 125820 (1) Mississippi River, Lynxville, 18 June 1932; USNM 125824 (1) Mississippi River, Lynxville, 18 June 1932. *Indiana:* **Vigo Co.:** USNM 66972 (1) Wabash River, Terre Haute, no date given. *Iowa:* **County not recorded:** USNM 174670 (1) Iowa River. *Louisiana:* **Catahoula Parish:** NLU 5872 (9) Red River 0.5 mi. from mouth of Black River, 18-25 January 1967; NELU 5891 (9) Red River 0.5 mi. from mouth of Black River, 3-5 February 1967. **East Carroll Parish:** NLU 9819 (1) Mississippi River 7 mi. downstream from Lake Providence, 27 April 1968. **St. Charles Parish:** NLU 27033 (1) Mississippi River, about 1.5 mi. south of Hahnville, 12 June 1973; NLU 30767 (1) Mississippi River, about 2 mi. north of Bonnet Carre Spillway, 27 March 1974. *Mississippi:* **Bolivar Co.:** UAIC uncatalogued (3) Mississippi River near Rosedale, 15 December 1962. *Missouri:* **St. Louis Co.:** TU 150949 (1) and UF 84887 (9) Mississippi River below Chain of Rocks Dam, river mile 190.5, August 1978. *North Dakota:* **McKenzie Co.:** USNM 76584 (1) Mouth of Yellowstone River, June 1913. *Ohio:* **Hamilton Co.:** USNM 3255 (2) Ohio River, Cincinnati, entered into USNM catalog February 1861.

RIO GRANDE DRAINAGE: *New Mexico:* USNM 15994 (2) Rio Grande, October 1874, Dr. O. Loew (field label in jar reads - Explorations west of the 100 th. meridian, U. S. Engineer Dept. 1872).

Literature Cited

- Anonymous. 1930. The sturgeon. *Alabama Game and Fish News* 1930(1):13.
- Bailey, R. M., and F. B. Cross. 1954. River sturgeons of the American genus *Scaphirhynchus*: characters, distribution, and synonymy. *Papers Michigan Academy Science, Arts and Letters* 39:169-208.
- Boschung, H. T. 1989. Atlas of fishes of the upper Tombigbee River drainage, Alabama - Mississippi. *Proceedings Southeastern Fishes Council* No. 19. 104 pp.
- Burke, J. S., and J. S. Ramsey. 1985. Status survey on the Alabama shovelnose sturgeon (*Scaphirhynchus* sp. cf. *platyrhynchus*) in the Mobile Bay drainage. Unpublished report. Submitted to U. S. Fish and Wildlife Service, Jackson, Mississippi. 61 pp.
- Carlson, D. M., and W. L. Pflieger. 1981. Abundance and life history of the lake, pallid and shovelnose sturgeons in Missouri. Final report, Endangered Species Project SE-1-6. Missouri Department of Conservation, Columbia, Missouri. 63 pp.
- Carlson, D. M., W. L. Pflieger, L. Trial, and P. S. Haverland. 1985. Distribution, biology and hybridization of *Scaphirhynchus albus* and *S. platyrhynchus* in the Missouri and Mississippi rivers. *Environmental Biology Fishes* 14 (1):51-59.
- Chermock, R. L. 1955. First record of the shovelnose sturgeon, *Scaphirhynchus platyrhynchus*, from the Tombigbee River, Alabama. *Copeia* 1955(2):154.
- Clemmer, G. H., R. D. Suttkus, and J. S. Ramsey. 1975. A preliminary list of endangered and rare fishes of Mississippi, P. 6-11. *In: A preliminary list of rare and threatened vertebrates in Mississippi.* Mississippi Game and Fish Commission, Jackson, Mississippi.
- Deacon, J. E., G. Kobetich, J. D. Williams, and S. Contreras. 1979. Fishes of North America, endangered, threatened, or of special concern. 1979. *Fisheries* 4(2):29-44.
- Forbes, S. A., and R. E. Richardson. 1908. The fishes of Illinois. Illinois State laboratory Natural History, Urbana, Illinois. 357 pp.
- Hayes, C. W. and M. R. Campbell. 1894. Geomorphology of the southern Appalachians. *National Geographic Magazine* 6:63-126.
- Hurley, S. T., W. A. Hubert, and J. G. Nickum. 1987. Habitats and movements of shovelnose sturgeons in the upper Mississippi River. *Transactions American Fisheries Society* 116:655-662.
- International Union for Conservation of Nature. 1988. 1988 IUCN red list of threatened animals. The IUCN Conservation Monitoring Centre, Cambridge, U. K. 154 pp.
- Jenkins, R. E. 1976. A list of undescribed freshwater fish species of continental United States and Canada, with additions to the 1970 checklist. *Copeia* 1976(3):642-644.
- Jenkins, R. E. 1980. *Maxostoma duquesnei* (Lesueur), black redhorse. Page 419. *In: Lee, D. S., et al. (eds.), Atlas of North American freshwater fishes.* North Carolina State Museum National History, Raleigh. 845 pp.
- Johnson, J. E. 1987. Protected fishes of the United States and Canada. American Fisheries Society, Bethesda, Maryland. 42 pp.
- Jordan, D. S., and B. W. Everman. 1896-1900. The fishes of North and Middle America. *Bulletin U.S. National Museum* 47(1-4):3313 pp. + 392 pls.
- Lee, D. S. 1980. *Scaphirhynchus platyrhynchus* (Rafinesque), shovelnose sturgeon. Page 44. *In: Lee, D. S., et al. (eds.), Atlas of North American freshwater fishes.* North Carolina State Museum National History, Raleigh. 854 pp.
- Mayden, R. L. 1988. Vicariance biogeography, parsimony, and evolution in North American freshwater fishes. *Systematic Zoology* 37(4):329-355.
- Mayden, R. L. and B. R. Kuhajda. 1989. Systematics of *Notropis cahabae*, a new cyprinid fish endemic to the Mobile Basin. *Bulletin Alabama Museum National History* No. 9. 16 pp.
- Mettee, M. F. 1978. The fishes of the Birmingham-Jefferson County region of Alabama with ecologic and taxonomic notes. *Geological Survey Alabama Bulletin* 115. 182 pp.
- Mettee, M. F., P. E. O'Neil, J. M. Pierson, and R. D. Suttkus 1989. Fishes of the western Mobile River basin in Alabama and Mississippi. *Geological Survey Alabama Atlas* No. 24. 170 pp.
- Murphy, B. R. 1990. Evidence for a genetically unique walleye population in the upper Tombigbee River system of northeastern Mississippi. *Proceedings Southeastern Fishes Council* No. 22:14-16.
- Phelps, S. R., and F. Allendorf. 1983. Genetic identity of pallid and shovelnose sturgeon (*Scaphirhynchus albus* and *S. platyrhynchus*). *Copeia* 1983:696-700.
- Pierson, J. M., W. M. Howell, R. A. Stiles, M. F. Mettee, P. E. O'Neil, R. D. Suttkus, and J. S. Ramsey. 1989a. Fishes of the Cahaba River system in Alabama. *Geological Survey Alabama Bulletin* No. 134. 22 pp. + appendices.
- Pierson, J. M., R. S. Krotzer, and S. G. Puleo. 1989b. Distribution and status of rare or environmentally sensitive fishes in the lower Cahaba River, Alabama. *Journal Alabama Academy Sciences* 60:1-10.
- Ramsey, J. S. 1976. Freshwater fishes. Pages 53-65. *In: Boschung, H. T. (ed.), Endangered and threatened plants and animals of Alabama.* *Bulletin Alabama Museum Natural History* No. 2. University of Alabama, University, AL.
- Ramsey, J. S. 1984. Freshwater fishes. Pages 1-14. *In: Mount, R. H. (ed.) Vertebrate wildlife of Alabama.* Auburn University Agricultural Experimental Station, Auburn, Alabama.
- Ramsey, J. S. 1986. Freshwater fishes. Pages 1-21. *In: Mount, R. H. (ed.) Vertebrate animals of Alabama in need of special attention.* Auburn University Agricultural Experimental Station, Auburn, Alabama.

- Ramsey, J. S., W. M. Howell, and H. T. Boschung, Jr. 1972. Rare and endangered fishes of Alabama. Pages 57-86. *In*: Keeler, J. E. (ed.). Rare and endangered vertebrates of Alabama. Alabama Department Conservation National Resources, Division Game and Fish, Montgomery, Alabama.
- SAS Institute Inc. 1985. SAS users guide: basics. Version 5 Edition. Cary, North Carolina. 1290 pp.
- SAS Institute Inc. 1988. SAS/STAT users guide. Release 6.03 Edition. Cary, North Carolina. 1028 pp.
- Smith-Vaniz, W. F. 1968. Freshwater fishes of Alabama. Auburn University Agricultural Experimental Station, Auburn, Alabama. 211 pp.
- Starnes, W. C. and D. A. Etnier. 1986. Drainage evolution and fish biogeography of the Tennessee and Cumberland rivers drainage realm. Pages 325-361. *In*: The zoogeography of North American freshwater fishes (Hocutt, C. H. and E. O. Wiley, eds.), John Wiley and Sons, New York, New York.
- Suttkus, R. D. 1959. *Notropis uranoscopus*, a new cyprinid fish from the Alabama River system. *Copeia* 1959(1):7-11.
- Suttkus, R. D. 1980. *Notropis candidus*, a new cyprinid fish from the Mobile Bay basin, and a review of the nomenclatural history of *Notropis shumardi* (Girard). *Bulletin Alabama Museum Natural History* 5:1-15.
- Suttkus, R. D., and G. H. Clemmer. 1968. *Notropis edwardraneyi*, a new cyprinid fish from the Alabama and Tombigbee River systems and a discussion of related species. *Tulane Studies Zoology Botany* 15(1):18-39.
- Swift, C. C., C. R. Gilbert, S. A. Bortone, G. H. Burgess, and R. W. Yerger. 1986. Zoogeography of the freshwater fishes of the southeastern United States: Savannah River to Lake Pontchartrain. Pages 213-265. *In*: Hocutt, C. H., and E. O. Wiley (eds.). The zoogeography of North American freshwater fishes. John Wiley and Sons, New York, NY.
- U.S. Fish and Wildlife Service. 1982. Endangered and threatened wildlife and plants; review of vertebrate wildlife for listing as endangered or threatened species. *Federal Register* 47(251):58454-58460.
- U.S. Fish and Wildlife Service. 1985. Endangered and threatened wildlife and plants; review of vertebrate wildlife. *Federal Register* 50(181):37958-37967.
- U.S. Fish and Wildlife Service. 1989. Endangered and threatened wildlife and plants; animals notice of review. *Federal Register* 54(4):554-579.
- Vladykov, V. D., and J. R. Greeley. 1963. Order Acipenseroidi. Pages 24-60. *In*: Fishes of the western North Atlantic. *Memories Sears Foundation Marine Research* 1(3):630.
- Weisel, G. F. 1979. Histology of the feeding and digestive organs of the shovelnose sturgeon, *Scaphirhynchus platorhynchus*. *Copeia* 1979(3):518-525.
- Williams, J. E., J. E. Johnson, D. A. Hendrickson, S. Contreras-Balderas, J. D. Williams, M. Navarro-Mendoza, D. E. McAllister, and J. E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern:1989. *Fisheries* 14(6):2-20.

MUSEUM PAPERS (1910-1960, Terminated)

1. Smith Hall, The New Museum and Home of the Geological Survey. E.A. Smith. 7 pp., 1 plate.	Out of Print
2. The Museum as an Educator. Herbert H. Smith. 25 pp., 8 plates, 1912.	Out of Print
3. Directions for Collecting Land Shells. Herbert H. Smith. 12 pp., 1912.	Out of Print
4. Annotated List of the Avery Bird Collection. Ernest G. Holt. 142 pp., 1 plate, 1921.	\$3.00
5. Preliminary Catalogue of Alabama Amphibians and Reptiles. H.P. Loding. 59 pp., 1922.	Out of Print
6. The Anculosae of the Alabama River Drainage. Calvin Goodrich. 57 pp., 3 plates, 1922.	Out of Print
7. The Genus <i>Gyrotoma</i> . Calvin Goodrich. 32 pp., 2 plates, 1924.	Out of Print
8. The Terrestrial Shell-Bearing Mollusca of Alabama. Bryant Walker. 32 pp., illus., 1928.	Out of Print
9. Footprints from the Coal Measures of Alabama. T.H. Aldrich, Sr. and Walter B. Jones. 64 pp., illus., 1930.	\$3.00
10. Goniobases of the Vicinity of Muscle Shoals. Calvin Goodrich. 25 pp., 1930.	Out of Print
11. Alabama Reptiles. William L. Haltom. 145 pp., 39 plates, 57 figs., 1931.	Out of Print
12. Description of a Few Alabama Eocene Species and Remarks on Varieties. T.H. Aldrich, Sr. 21 pp., 6 plates, 1931.	\$3.00
13. Moundville Culture and Burial Museum. Walter B. Jones and D.L. DeJarnette. 8 pp., 22 illus., 1936.	Out of Print
14. The Argiopidae or Orb-Weaving Spiders of Alabama. Allan F. Archer. 77 pp., 5 plates, 1940.	\$3.00
15. Anthropological Studies at Moundville. Part I. Indian Skeletons from the Museum Burials at Moundville. Part II. Possible Evidence of Scalping at Moundville. C.E. Snow. 57 pp., illus., 1940.	\$3.00
16. Condylodiaphysial Angles of Indian Humeri from North Alabama. C.E. Snow. 38 pp., illus., 1940.	\$3.00
17. The Bessemer Site (Excavation of Three Mounds and Surrounding Village Areas near Bessemer, Alabama). D.L. DeJarnette and S.B. Wimberly. 122 pp., illus., 1941.	\$3.00
18. Supplement of the Argiopidae of Alabama. Allan F. Archer. 47 pp., 4 plates, 1941.	\$3.00
19. McQuorquodale Mound. A Manifestation of the Hopewellian Phase in South Alabama. S.B. Wimberly and H.A. Tourtelot. 42 pp., illus., (1941) 1943.	\$3.00
20. Mound State Monument. 19 pp., illus., 1941.	Out of Print
21. Two Prehistoric Indian Dwarf Skeletons from Moundville. C.E. Snow. 90 pp., 2 plates, 1946.	\$3.00
22. The Theridiidae or Comb-Footed Spiders from Moundville. Allan F. Archer. 67 pp., 2 plates, 1946.	\$3.00
23. The Flint River Site, Ma 48. William S. Webb and D.L. DeJarnette. 44 pp., illus., 1948.	Out of Print
24. The Whitesburg Bridge Site, Ma 10. William S. Webb and D.L. DeJarnette. 44 pp., illus., 1948.	Out of Print
25. The Perry Site, LU 25. William S. Webb and D.L. DeJarnette. 69 pp., illus., 1948.	\$3.00
26. Little Bear Creek Site, CT 8. William S. Webb and D.L. DeJarnette. 64 pp., illus., 1948.	Out of Print
27. New Anophthalmid Beetles (Fam. Carabidae) from the Appalachian Region. J. Manson Valentine. 19 pp., 2 plates, 1948.	\$3.00
28. Land Snails of the Genus <i>Stenotrema</i> in the Alabama Region. Allan F. Archer. 85 pp., 10 plates, 1948.	\$3.00
29. Moundville: An Historic Document. Carl E. Guthe. 14 pp., 1950.	Out of Print
30. A Study of the Theridiid and Mimetid Spiders with Descriptions of New Genera and Species. Allan F. Archer. 44 pp., 4 plates, 1950.	\$3.00
31. Carvernicolous Pselaphid Beetles of Alabama and Tennessee, with Observations on the Taxonomy of the Family. Orlando Park. 107 pp., illus., 1951.	\$3.00
32. Guntersville Basin Pottery. Marion D. Hemilich. 69 pp., illus. 1952.	\$3.00
33. A Key to the Amphibians and Reptiles of Alabama. Ralph L. Chermock. 88 pp., illus., 1952.	Out of Print
34. New Genera of Anophthalmid Beetles from Cumberland Caves (Carabidae, Trechini). J. Manson Valentine. 41 pp., 5 plates, 1952.	\$3.00
35. New Genera and Species of Cavernicolous Diplopods from Alabama. Richard L. Hoffman. 13 pp., illus., 1956.	\$3.00
36. Archaeological Investigations in Mobile County and Clarke County, Southern Alabama. Steve B. Wimberly. 262 pp., 7 plates, 1960.	\$5.00

MUSEUM BULLETIN SERIES (1975 -)

- | | |
|--|--------|
| 1. Systematics of the Percid Fishes of the Subgenus <i>Ammocrypta</i> , Genus <i>Ammocrypta</i> , with Descriptions of Two New Species. James D. Williams. 56 pp, illus., June, 1975. | \$5.00 |
| 2. Endangered and Threatened Plants and Animals of Alabama. Herbert Boschung, Editor. 93 pp, illus., October, 1976. | \$7.50 |
| 3. Containing: A New Species of <i>Semotilus</i> (Pisces: Cyprinidae) from the Carolinas. Franklin F. Snelson, Jr. and Royal D. Suttkus. <i>Etheostoma neopteron</i> , a New Percid Fish from the Tennessee River System in Alabama and Tennessee. W. Mike Howell and Guido Dingerkus. Taxonomy, Ecology and Phylogeny of the Subgenus <i>Depressicambarus</i> , with the Description of a New Species from Florida and Redescriptions of <i>Cambarus graysoni</i> , <i>Cambarus latimanus</i> , and <i>Cambarus striatus</i> (Decapoda: Cambaridae). Raymond William Bouchard. 60 pp, illus., February, 1978. | \$5.00 |
| 4. Systematics of the Percid Fishes of the Subgenus <i>Microperca</i> , Genus <i>Etheostoma</i> . Brooks M. Burr. 53 pp, illus., July 1978. | \$5.00 |
| 5. Containing: <i>Notropis candidus</i> , a New Cyprinid Fish from the Mobile Bay Basin, and a Review of the Nomenclatural History of <i>Notropis shumardi</i> (Girard). Royal D. Suttkus. <i>Notropis stanauli</i> , a New Madtom Catfish (Ictaluridae) from the Clinch and Duck Rivers, Tennessee. David A. Etnier and Robert E. Jenkins. 23 pp, illus., May, 1980. | \$5.00 |
| 6. Containing: A New Species of Cyprinodontid Fish, Genus <i>Fundulus</i> (<i>Zygonectes</i>), from Lake Pontchartrain Tributaries in Louisiana and Mississippi. Royal D. Suttkus and Robert C. Cashner. Karyotypes in Populations of the Cyprinodontid Fishes of the <i>Fundulus notatus</i> species-complex: A Geographic Analysis. W. Mike Howell and Ann Black. An Isozymic Analysis of Several Southeastern Populations of the Cyprinodontid Fishes of the <i>Fundulus notatus</i> Species-Complex. Fred Tatum, Ronald Lindahl and Herbert Boschung. 35 pp, illus., April, 1981. | \$5.00 |
| 7. Plant Resources, Archaeological Plant Remains, and Prehistoric Plant-Use Patterns in the Central Tombigbee River Valley. Gloria May Caddell. 39 pp, February, 1982. | \$5.00 |
| 8. Containing: Description, Biology and Distribution of the Spotfin Chub, <i>Hybopsis monacha</i> , a Threatened Cyprinid Fish of the Tennessee River Drainage. Robert E. Jenkins and Noel M. Burkhead. Life History of the Banded Pygmy Sunfish, <i>Elassoma zonatum</i> Jordan (Pisces: Centrarchidae) in Western Kentucky. Stephen J. Walsh and Brooks M. Burr. 52 pp, illus., August, 1984. | \$6.00 |
| 9. Systematics of <i>Notropis cahabae</i> , a New Cyprinid Fish Endemic to the Cahaba River of the Mobile Basin. Richard L. Mayden and Bernard R. Kuhajda. 16 pp, illus., November, 1989. | \$3.50 |

SPECIAL PUBLICATIONS

- | | |
|---|------------------|
| 1. Moundville, An Introduction to the Archaeology of a Mississippi Chiefdom, 2nd Edition. John Walthall. 60 pp., illus., 1976. | To be reprinted. |
| 2. Ten Thousand Years of Alabama History, A Pictorial Resume. W. Phillip Krebs. 130 pp., illus., January, 1986. | \$10.00 |
| 3. The Mounds Awaken: Mound State Monument and the Civilian Conservation Corps. Joy Baklanoff and Arthur Howington. 36 pp., illus. October, 1989. | \$3.00 |

NOTICE TO AUTHORS

Send manuscripts to: Editor, BULLETIN ALABAMA MUSEUM OF NATURAL HISTORY, The University of Alabama, Box 870340, Tuscaloosa, Alabama 35487-0340. Papers concerning all natural history disciplines, including Anthropology, Astronomy, Biology, the Earth Sciences, and Scientific History will be considered. Please do not submit papers that have been published or that are being considered elsewhere.

Before submitting, it is recommended that you carefully examine this Notice to Authors, or you may contact the Editor for a copy of the style sheet. Careful review of a recent BULLETIN for style and sequence may be helpful.

Authors should submit a clean, double-spaced, typed manuscript on white 8.5 x 11 inch paper, including copies of all tables, figures and photographs (originals will be requested upon acceptance of paper). Manuscripts should NOT have a right-justified margin. Diacritical marks are the responsibility of the author.

Papers are arranged accordingly:

- Title
- Author(s) and Address(es)
- Abstract [all bold face, with author/title leader]
- Text - [headings should be bold face and mixed case]
- Materials Examined
- Appendix(s)
- References
- Figure Captions [BULLETIN does not use designation "Plates"]
- Figures
- Tables

Abstracts should be a summary of the paper. Use metric or English (metric) equivalents. Words to be italicized should be underlined in manuscript. Words to be bold face should be double-underlined or bold type. Location of tables and figures should be noted on manuscript. Illustrations should be black and white drawings or good quality photographs. No foldouts, please.

Upon acceptance, author should supply: corrected typed manuscript, a standard 5.25 or 3.5 inch disk containing manuscript and tables, and original artwork and photos. BULLETIN word processing standard is Microsoft Word, although most major word-processing programs, MacIntosh or ASCII files can be dealt with. Authors are encouraged to discuss electronic compatibility with the Editor. Original art, graphs and photos will be returned.

Page charge contributions are welcomed. Because of continually increasing costs, financial contributions to the BULLETIN from its authors are of great assistance. However, inability to pay will not prejudice the editorial processing of an article. If organizational funding is available, it is urged that authors arrange for contributions to the BULLETIN to offset printing costs. The cost of printing is presently calculated at \$91.83 a page.

