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REDESCRIPTION OF THE BIGEYE SHINER, *NOTROPIS BOOPS* (PISCES: CYPRINIDAE)

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Abstract.—The wide-ranging yet poorly known bigeye shiner, *Notropis boops*, is redescribed from examination of 567 specimens from throughout the range of the species. Significant geographic variation was not found in any of the 20 morphological characters examined. Numbers of lateral-line scales and caudal vertebrae were slightly higher in the northern and eastern parts of the species' range. Populations of *N. boops* have been severely decimated in both Ohio and Illinois due to excessive siltation from poor agricultural practices; it is a common species throughout the central portion of its range.

The bigeye shiner, *Notropis boops* Gilbert, is a mostly common inhabitant of the central Mississippi basin, although it is disappearing or rare in some areas on the edges of its range, e.g., Ohio (Trautman 1981), Illinois (Smith 1979), and Alabama (Ramsey 1976). Since its original description (Gilbert 1884), little information has been published on the systematics of *N. boops*, except for its inclusion in atlases, checklists, and state fish books. Recently, Gilbert (1978) listed the type material of *Notropis boops*, Smith and Hocutt (1981) reported on variation in pharyngeal tooth formulae in Missouri, and Lehtinen and Echelle (1979) analyzed the reproductive cycle of the species in Oklahoma.

Because of its rather wide range on both sides of the Mississippi River and the paucity of systematic information available on the species, we undertook a study of geographical variation in *N. boops*. Examination of 20 morphological characters on 567 specimens from throughout the range of the species revealed that geographic variation is minimal. The objectives of this paper are to redescribe *N. boops* and to map and discuss its distribution.

Methods

Counts and measurements followed those described by Hubbs and Lagler (1964). In examination of the cephalic lateral line, the terminology, abbreviations, and counting procedures of Snelson (1971) were followed. Vertebral counts were made from radiographs. The first vertebra bearing a well-developed haemal spine was considered to be the first caudal element; all those anterior were considered trunk vertebrae.

All meristic characters were analyzed initially for sexual or geographic variation in minor drainages. When no significant sexual, intra- or interdrainage variation was apparent, the data were pooled into two major groups of populations—those occurring east of the Mississippi River and those occurring west of the river.

Material Examined

The following material was examined. Numbers of specimens counted or measured are in parentheses. Institutional abbreviations are identified in Acknowl-

edgments. Complete collection data are on deposit at the Department of Zoology, Southern Illinois University at Carbondale.

Notropis boops Gilbert

OHIO RIVER BASIN. *Scioto R. drainage.*—OH: Pike Co.: OSU 12334 (10). Scioto Co.: UMMZ 86011 (2). *Kentucky R. drainage.*—KY: Franklin Co.: UMMZ 144395 (3). Lincoln Co.: INHS 79062 (10). *Kinniconick Cr.*—KY: Lewis Co.: UL 5444 (5). *Harrods Cr.*—KY: Oldham Co.: UL 4779 (5). *Salt R.-Rolling Fork drainage.*—KY: Anderson Co.: UL 3175 (10). Jefferson Co.: UL 4774 (6). Madison Co.: UMMZ 125060 (4). Shelby Co.: UL 5372 (6). *Blue R.*—IN: Washington Co.: OSU 28646 (9). *Green R. drainage.*—KY: Casey Co.: UMMZ 169436 (1). Muhlenberg Co.: SIUC 1915 (10). *Wabash R. drainage.*—IN: Carrol Co.: OSU 27890 (2). Hamilton Co.: OSU 30104 (9). Lawrence Co.: UMMZ 167923 (3). Montgomery Co.: OSU 27169 (5). Parke Co.: UMMZ 144536 (1). Putnam Co.: OSU 27500 (8). Shelby Co.: OSU 29861 (10). IL: Edgar Co.: INHS 2937 (8). Shelby Co.: INHS 21720 (6). Vermilion Co.: INHS 12241 (8). *Cumberland R. drainage.*—TN: Smith-Wilson Co.: UT 44.249 (20). Williams Co.: INHS 83116 (1); UMMZ 175215 (10). KY: Cumberland Co.: INHS 78328 (10). *Tennessee R. drainage.*—AL: Jackson Co.: AU 12003 (10). Limestone Co.: UMMZ 200821 (2); UMMZ 200870 (1). TN: Bedford Co.: UMMZ 121290 (10); UT 44.709 (21). Benton Co.: UT 44.964 (4). KY: Calloway Co.: SIUC 291 (4); SIUC 308 (10); SIUC 383 (5); SIUC 388 (1). Marshall Co.: SIUC 1530 (6).

MISSISSIPPI RIVER BASIN. *Kaskaskia R. drainage.*—IL: Moultrie Co.: INHS 8915 (10). *Cuivre R. drainage.*—MO: Pike Co.: UMMZ 149205 (10). *Meramec R. drainage.*—MO: Franklin Co.: SIUC uncat. (5). Gasconade Co.: UMMZ 148339 (10). trib., Mississippi R.—MO: Perry Co.: UMMZ 149843 (8). *Miller Cr.*—IL: Alexander Co.: INHS 6047 (10). *St. Francis R. drainage.*—MO: Wayne Co.: SIUC uncat. (6). *White R. drainage.*—MO: Butler Co.: UT 44.942 (10). Carter Co.: UMMZ 193194 (5). Ripley Co.: UT 44.1826 (10). Shannon Co.: SIUC uncat. (8). Taney Co.: UMMZ 151181 (10). Clark Natl. Forest: UMMZ 117265 (8). AR: Madison Co.: UT 44.897 (9). Seary Co.: UMMZ 123532 (6). Van Buren Co.: INHS 123570 (10); INHS 81072 (10).

MISSOURI RIVER BASIN. *Gasconade R. drainage.*—MO: Gasconade Co.: INHS 80497 (3).

ARKANSAS RIVER BASIN. *Caney R. drainage.*—KS: Chautauqua Co.: KU 14424 (9). *Grouse Cr.*—Cowley Co.: KU 8616 (8). *Neosho R. drainage.*—KS: Cherokee Co.: KU 3192 (10); UMMZ 144939 (3); UMMZ 155100 (3); UMMZ 155175 (1); UMMZ 160379 (3). OK: Delaware Co.: UMMZ 103170 (10). *Illinois R. drainage.*—AR: Washington Co.: INHS 82466 (10). OK: Adair Co.: UT 48.1848 (3). Sequoyah Co.: UMMZ 137825 (6). *trib., Arkansas R.*—AR: Crawford Co.: UMMZ 123741 (10); UMMZ 123826 (10). *Fourche La Fave R. drainage.*—AR: Yell Co.: INHS 81092 (10).

RED RIVER BASIN. *Blue R. drainage.*—OK: Johnston Co.: OUMZ 30478 (10); OUMZ 40205 (4); UMMZ 156760 (4). *Kiamichi R. drainage.*—OK: LeFlore Co.: UMMZ 80947 (6). *Little R. drainage.*—OK: McCurtain Co.: INHS 80736 (10). AR: Polk Co.: UMMZ 170884 (10). *Saline R. drainage.*—AR: Sevier Co.: UMMZ 128088 (3). *Ouachita R. drainage.*—AR: Polk Co.: INHS 81032 (10). Montgomery Co.: SIUC 2494 (5). Saline Co.: SIUC 3645 (2); SIUC 3700 (5).

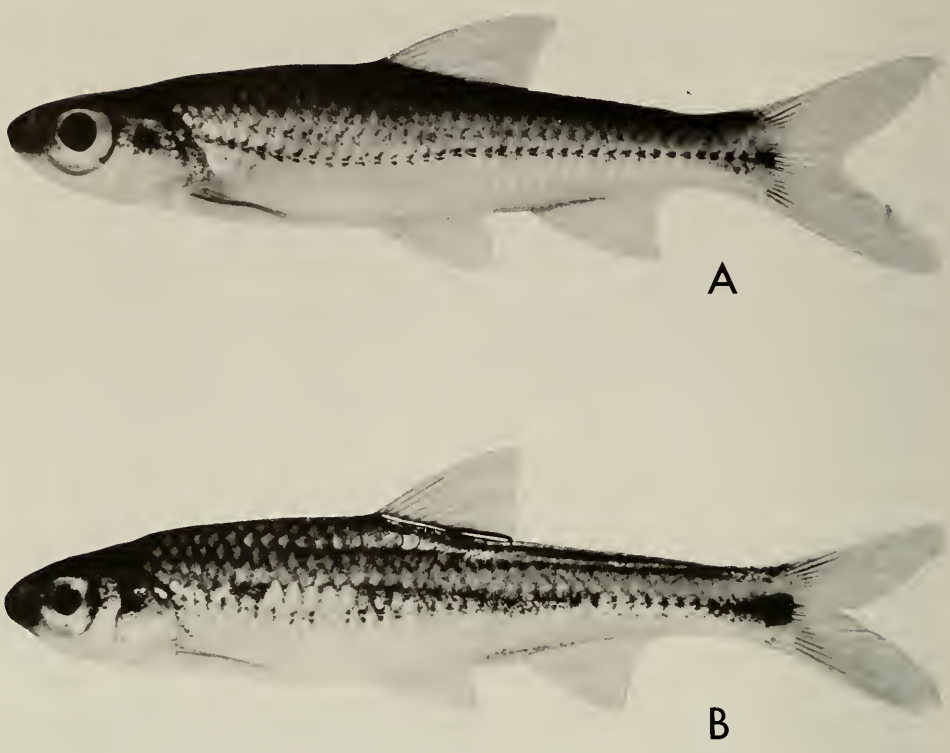

Fig. 1. A, *N. boops*, 54 mm SL female (SIUC 2494), Caddo River, Montgomery County, Arkansas, 9 October 1981; B, *N. xaenocephalus*, 55 mm SL male (INHS 75095), Stamp Creek, Bartow County, Georgia, 9 June 1976.

Notropis xaenocephalus (Jordan)

MOBILE BAY BASIN. *Etowah R. drainage.*—GA: Bartow Co.: INHS 75095 (10). *Oostanaula R. drainage.*—GA: Murray Co.: SIUC 2895 (10); SIUC 2884 (2). GA: Gordon Co.: SIUC 2904 (5).

Notropis boops Gilbert, 1884
Fig. 1

Types.—Syntypes of *N. boops* were collected by C. H. Gilbert from Salt Creek, Brown County, Indiana (10 specimens), and from Flat Rock Creek, Rush County, Indiana, by W. P. Shannon (about 30 specimens) (Gilbert 1884). C. R. Gilbert (1978) found and listed the following syntypes (numbers of specimens and their range in SL are in parentheses): Salt Creek—USNM 34982 (3, 44–46), MCZ 35961 (1, 54); 6 specimens not located. Flat Rock Creek—CAS-SU 3794 (20, 47–61); about 10 specimens not located. Some doubt exists regarding the status of the CAS-SU specimens because nothing in the jar indicated they were types and Gilbert was listed as the collector. Gilbert (1978) recommended that a lectotype be chosen from among the Salt Creek specimens. A lectotype of *N. boops* (45.6 mm SL) is herein selected and retains the original number USNM 34982. The lectotype conforms to the characters in the description that follows. The remain-

Table 1.—Proportional measurements (expressed in thousandths of SL) for *Notropis boops* in breeding condition summarizing sexual dimorphism. Specimens measured were 45–58 mm SL and were from the following drainages: Wabash (INHS 2937), Tennessee (UMMZ 200821), Mississippi (INHS 6047), White (INHS 81072), Arkansas (INHS 81092), and Ouachita (INHS 81032, 82466).

Character	Sex	n	Range	$\bar{x}$	*t*-Value	*P*
Head length	M	31	239–287	254	0.3536	N.S.
	F	19	245–266	253		
Head width	M	31	121–152	133	1.5504	N.S.
	F	19	124–140	130		
Head depth	M	30	138–176	150	1.1960	N.S.
	F	19	138–156	148		
Eye diameter	M	31	72–94	82	0.7226	N.S.
	F	19	76–96	83		
Snout length	M	31	58–71	65	1.8892	N.S.
	F	19	56–69	63		
Upper jaw length	M	30	48–76	62	0.3077	N.S.
	F	19	53–72	61		
Bony interorbital length	M	31	52–75	64	1.8051	N.S.
	F	19	53–72	62		
Anal fin length	M	31	139–191	167	2.7872	<.01
	F	19	139–182	159		
Dorsal fin length	M	31	138–267	228	0.7204	N.S.
	F	19	194–239	223		
Pelvic fin length	M	31	149–184	166	4.3382	<.005
	F	19	143–175	155		
Pectoral fin length	M	31	167–218	192	5.2201	<.005
	F	19	151–199	178		
Preanal length	M	30	631–688	671	3.2045	<.005
	F	19	672–702	681		
Prepelvic length	M	30	461–533	485	1.9223	N.S.
	F	19	462–510	492		
Predorsal length	M	31	469–553	491	1.8442	N.S.
	F	19	472–523	499		
Postdorsal length	M	31	500–609	532	1.5905	N.S.
	F	19	485–545	524		
Body width	M	31	112–150	128	0.8994	N.S.
	F	19	113–150	131		
Body depth	M	31	127–277	208	1.4403	N.S.
	F	19	130–256	223		
Caudal ped. depth	M	31	82–103	89	0.1100	N.S.
	F	19	79–94	87		
Caudal ped. length	M	31	113–256	220	0.3516	N.S.
	F	19	122–241	217		

ing syntypes now become paralectotypes bearing their original catalog numbers except those from USNM 34982 which now bear catalog number USNM 232410.

Diagnosis.—A moderate-sized species of *Notropis* (largest specimen measured is 66 mm SL); peritoneum black; intestine short (76.5–98.0% SL) with a single lengthwise loop; eye large (less than 3.5 times into head); anal-fin rays usually 8; pharyngeal teeth usually 1,4—4,1; no breeding colors.

Table 2.—Counts of lateral-line scales in *Notropis boops*.

Region	34	35	36	37	38	39	40	n	$\bar{x}$
East of Mississippi R.		23	91	86	17	3	1	221	36.5
West of Mississippi R.	3	25	125	81	18			225	35.9

Description.—Proportional measurements are shown in Table 1. General body shape and pigmentary features are illustrated in Fig. 1.

Dorsal-fin rays 7(1), 8(324). Anal-fin rays 7(5), 8(488), 9(24); $\bar{x}$ = 8.0. Left pectoral-fin rays 13(5), 14(61), 15(270), 16(160), 17(17), 18(1); $\bar{x}$ = 15.2. Pelvic-fin rays 7-6(1), 7-7(6), 7-8(13), 8-8(474), 8-9(8), 9-9(5). Principal caudal-fin rays 18(9), 19(449), 20(1), 21(4); $\bar{x}$ = 19.0.

Lateral-line scales 34–40 (Table 2). Body-circumference scales 21(7), 22(156), 23(144), 24(99), 25(37), 26(31), 27(2); $\bar{x}$ = 23.2. Body-circumference scales above lateral line 10(6), 11(360), 12(63), 13(47) ($\bar{x}$ = 11.3); below lateral line 8(4), 9(189), 10(160), 11(119), 12(4) ($\bar{x}$ = 9.8). Predorsal scale rows 10(1), 11(3), 12(100), 13(239), 14(119), 15(36); $\bar{x}$ = 13.2. Caudal-peduncle scale rows above lateral line 5(502), 6(6) ($\bar{x}$ = 5.0); below lateral line 5(506), 6(1), 7(1) ($\bar{x}$ = 5.0). Breast and nape completely scaled. Total gill rakers on first arch (all rudiments counted) 8(2), 9(6), 10(7), 11(4); $\bar{x}$ = 9.7.

Numbers of trunk, caudal, and total vertebrae are shown in Table 3. Pharyngeal teeth (sampled from throughout range) 1,4—4,0(6); 1,4—4,1(42). Teeth with prominent terminal hooks, but narrow grinding surfaces.

Lateral line on body complete to caudal base. Supratemporal canal broadly interrupted at dorsal midline; ST pore counts 2,2(20). Supraorbital canal without interruptions and not joining infraorbital canal behind eye; SO pore counts 7(5), 8(12), 9(2), 10(1); $\bar{x}$ = 8.0. Infraorbital canal complete; IO pore counts 10(2), 11(5), 12(12), 13(1); $\bar{x}$ = 11.6. Preoperculomandibular canal without interruptions; POM pore counts 9(7), 10(11), 11(2); $\bar{x}$ = 9.8.

Peritoneum black ventrally, silvery with scattered melanophores on dorsal surface of body cavity. Intestine short with a single lengthwise loop (Type I of Kafuku 1958). In 10 adults 48–59, $\bar{x}$ = 54 mm SL, ascending section 22.8–32.8, $\bar{x}$ = 28.6% SL; total intestinal length 76.5–98.0, $\bar{x}$ = 87.8% SL. Gas bladder two-chambered; total length 31.6–37.6, $\bar{x}$ = 33.8% SL, posterior chamber length 21.2–23.7, $\bar{x}$ = 22.7% SL. Peritoneal tunic covers anterior chamber. Pneumatic duct attached to dorsal surface of anterior chamber. Bladder lacks spiral markings or striations.

Distinct black lateral stripe about 1–1½ scale rows wide from tip of snout and lower jaw to caudal base. Caudal spot vague or lacking. Distinct, usually unpigmented stripe above black lateral stripe, about 1 scale row wide. Pre- and postdorsal stripe narrow, about 3–5 melanophores wide; stripe slightly expanded at origin of dorsal fin. Lateral-line pores on anterior half of body outlined with melanophores. Scales above unpigmented lateral stripe with melanophores on posterior edge of scale pocket; free scale edge forming a posterior band on exposed field leaving anterior central portion unpigmented. Thin black line on posterior edge of scale giving double-banded appearance to each scale. Top of head dark and uniformly pigmented. Body unpigmented ventral to lateral line, except

Table 3.—Counts of vertebrae (including the Weberian apparatus as four and the urostylar vertebra as one) in *Notropis boops*. East of Mississippi River = Wabash (INHS 2937), Cumberland (INHS 78328, UT 44.249), Tennessee (SIUC 308, UT 44.709), and Mississippi (INHS 6047) drainages; west of Mississippi River = Missouri (INHS 80497), White (INHS 81072), Arkansas (INHS 81092), Ouachita (INHS 81032), and Red (INHS 80736) drainages.

	Trunk					Caudal					Total					
Region	17	18	19	20	$\bar{x}$	16	17	18	19	$\bar{x}$	35	36	37	38	n	$\bar{x}$
East of Mississippi R.	1	2	55	18	19.2	2	43	29	2	17.4	1	34	37	4	76	36.6
West of Mississippi R.		1	30	18	19.3	15	29	5		16.8	3	31	15		49	36.2

some melanophores outline base of anal fin. Rays of dorsal and caudal fins outlined by melanophores. Rays of pectoral, pelvic, and anal fins occasionally outlined with a few scattered melanophores.

Numerous collections of breeding individuals from throughout the range of the species indicate that no breeding colors develop except for some creamy white in the membranes of the dorsal, caudal, and pectoral fins. Living individuals are generally greenish dorsally, silver in lateral aspect, and white ventrally.

Tubercles well-developed in breeding males from April through August, poorly developed in females and non-breeding males. Peak of tubercle development appears to be in May. Males with large dense tubercles dorsal and posterior to eyes, on front of snout (below and anterior to nares), and mandibles. Top of head with minute tubercles densely distributed. Ventral surface of head, gill membranes, preopercle, and opercle with sparsely scattered small tubercles. Small tubercles outline scales above lateral line, being prominent anteriorly and dorsally, and decreasing in size posteriorly and ventrally. Scales below lateral line and anterior to anal fin faintly outlined with tubercles. Small tubercles in single rows, mostly medially and distally, on branched and unbranched portions of all anal-fin rays, first 2 pelvic-fin rays, and first 5–7 dorsal-fin rays. Pectoral-fin tubercles on dorsal side of first 3–8 rays, occurring in double rows proximally and distally and densest (usually 4 rows) medially. Those on first unbranched ray rather evenly distributed in 2–4 rows on middle two-thirds of ray. Females rarely develop tubercles on chin; they are smaller and more sparsely distributed than those found on chin of males.

Variation.—No significant sexual differences in meristic characters were noted. Excluding dimensions directly affected by gonadal development, males in breeding condition display significantly greater values for lengths of the anal, pectoral, and pelvic fins, and the preanal distance (see Student's *t*-Tests, Table 1).

The urogenital papilla of adult females is enlarged and protruded during the spawning season; the papilla of males is only slightly swollen. There are no significant sexual differences in pigmentation pattern.

Notropis boops is remarkably uniform in external morphological features throughout its rather extensive range. Only two characters were found to exhibit some variation, the number of vertebrae and the number of lateral-line scales. Variation is slight in both characters, but the pattern of variation is similar. Specimens from east of the Mississippi River and in the northern part of the species' range average slightly higher numbers of lateral-line scales and caudal vertebrae (Tables 2–3). The variation in these two characters follows a general trend re-

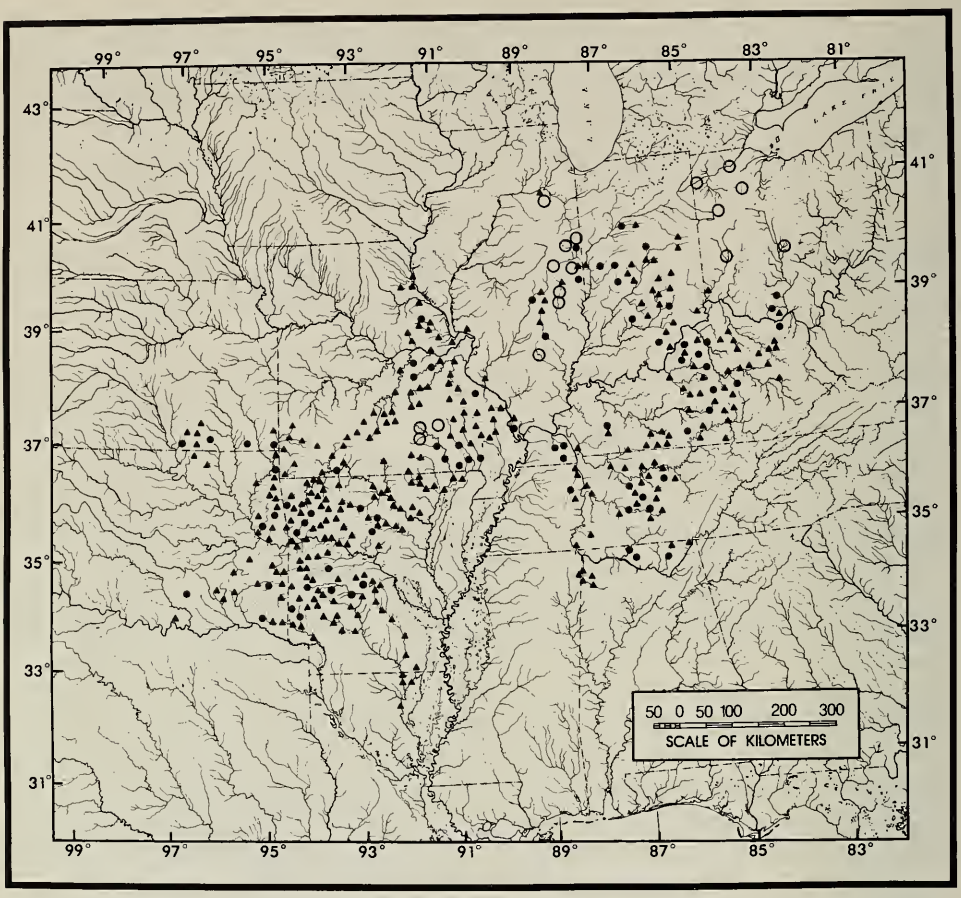

Fig. 2. Range of *N. boops*. Solid dots represent localities from which specimens were examined; triangles represent localities from the literature; open circles represent localities where the species presumably no longer occurs.

ported for many fishes in which the number of elements (e.g., vertebrae) progressively increases to the north (Barlow 1961).

Smith and Hocutt (1981) examined pharyngeal tooth counts in 100 individuals of *N. boops* from Big River, Missouri, and reported the following variation: 64% had a 1,4—4,1 count, 19% a 1,4—4,0 count, 8% a 0,4—4,0 count, 7% a 0,4—4,1 count, 1% a 1,4—3,1 count, and 1% a 1,5—4,1 count. Pharyngeal tooth counts from throughout the range of the species agree for the most part with those of Smith and Hocutt and indicate that a tooth is occasionally lost from the minor row.

Comparisons.—Among the species of *Notropis, N. boops* most closely resembles *N. xaenocephalus* (Jordan) as Swift (1970) originally suggested. These two species are extremely similar in overall body shape and pigmentation pattern (Fig. 1). *Notropis xaenocephalus* is, however, readily distinguished from *N. boops* by the following characters: pharyngeal teeth usually 2,4—4,2, anal-fin rays usually 7, peritoneum silvery with scattered melanophores, caudal spot well-developed, and tuberculation on the head, body, and fins less extensive.

Distribution

Notropis boops occurs in the central Mississippi basin where its range extends from the Scioto River drainage, Ohio, west to the lower Red River drainage, Oklahoma, south to the Ouachita River drainage, Louisiana, and north to the Illinois River drainage, Illinois (Fig. 2). Its reported occurrence in the Cache Creek drainage (Comanche County) of southwestern Oklahoma (Miller and Robison 1973) is not verified by specimens.

In recent years some populations of *N. boops* have been severely decimated, particularly in western Ohio (Trautman 1981) and east-central Illinois (Smith 1979) because of excessive siltation and turbidity. The continued use of poor agricultural practices in these states has modified many of the clear, gravel-bottomed streams that *N. boops* formerly inhabited (Fig. 2).

The species is on the endangered or rare fish list for Mississippi (Clemmer *et al.* 1975) and is of special concern in Alabama (Ramsey 1976). Although *N. boops* is rare or disappearing on the edges of its range it is common and abundant throughout most of Arkansas, eastern Oklahoma, southern Missouri, southeastern Kansas and central Kentucky and Tennessee.

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