STATUS AHD HABITAT UTILIZATION OF THE PEPPERED SHINER, *NOTROPIS PERPALLIDUS* (PISCES: CYPRINIDAE)

By

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Santa Barbara, California

1978

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1984

STATUS AND HABITAT UTILIZATION OF THE
PEPPERED SHINER, NOTROPIS PERPALLIDUS
(PISCES: CYPRINIDAE)

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ACKNOWLEDGEMENTS

I would like to extend my sincerest appreciation to Dr. Anthony A. Echelle for the opportunity to continue my education and for his guidance in the design, implementation and reporting of this study. Also, I would like to thank David Edds, Derek Smithee, Norma Classen, Chris Henry and Alice Echelle for their assistance in the field.

The help of Dr. Michael Douglas and Allen Rutherford in the use of computers and invaluable discussion is greatly appreciated. My thanks also go to Dr. O. E. Maughan for his advice and encouragement during the course of this study. I am also grateful for constructive discussions with Dr. Stanley Fox and David Edds.

Special thanks are due to the U. S. Fish and Wildlife Service, and the Oklahoma State Cooperative Fisheries Research Unit for the financial support I received and for the use of field equipment during the course of this work.

My deepest appreciation belongs to my wife, Nancy, for her understanding and constant support, as well as her effort in typing and reviewing this manuscript. I am also indebted to my parents, Wilbur and Ethel Wagner, for their nurturing the qualities and values in myself that allowed me to undertake this study.

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CHAPTER I

INTRODUCTION

The peppered shiner (*Notropis perpallidus*) is a small, relatively unknown minnow (family Cyprinidae) originally described by Hubbs and Black (1940). The holotype and a single paratype were taken in the Saline River, 8 km north of Warren, Bradley County, Arkansas, by John and Ruby Black on 20 June 1939. The species has been placed in the subgenus *Notropis*, within which its closest relative apparently is *N. shumardi* (Gilbert and Bailey, 1962; Snelson, 1968a).

The biology of the peppered shiner is poorly known, and data concerning habitat preference are conflicting. Much of the relevant information is reported in faunal surveys (Jordan and Gilbert, 1886; Finnel et al., 1956; Reynolds, 1971; Pigg, 1974; Pigg and Hill, 1977), although some authors have given specific information on meristics, abundance and habitat use (Moore, 1948; Reeves, 1953; Harris, 1977).

The most complete study of *N. perpallidus* was conducted by Snelson and Jenkins (1973). Their study included meristic and morphometric data intended to amplify the original description, a summary of known collection and habitat data, as well as some life history information. Robison (1981) also examined the distribution, abundance and ecology of *N. perpallidus*.

N. perpallidus has been listed as rare (Robison et al., 1974) and threatened (Williams, 1981) on unofficial endangered species lists, but the lack of sufficient data on which to reliably assess the status of the species has caused some investigators to assign it an indeterminate status (Hubbs and Pigg, 1976). In truth, the status of N. perpallidus can be determined only after a careful survey of its present and historical geographic range, and assessments of abundance, habitat requirements, and future threats to survival. My objectives were to (1) describe microhabitat use by N. perpallidus , (2) assess the present frequency of occurrence and abundance of this species within its known range, (3) evaluate potential threats, (4) collect information on the biology of N. perpallidus, and (5) make recommendations for management planning and status assessment.

CHAPTER II

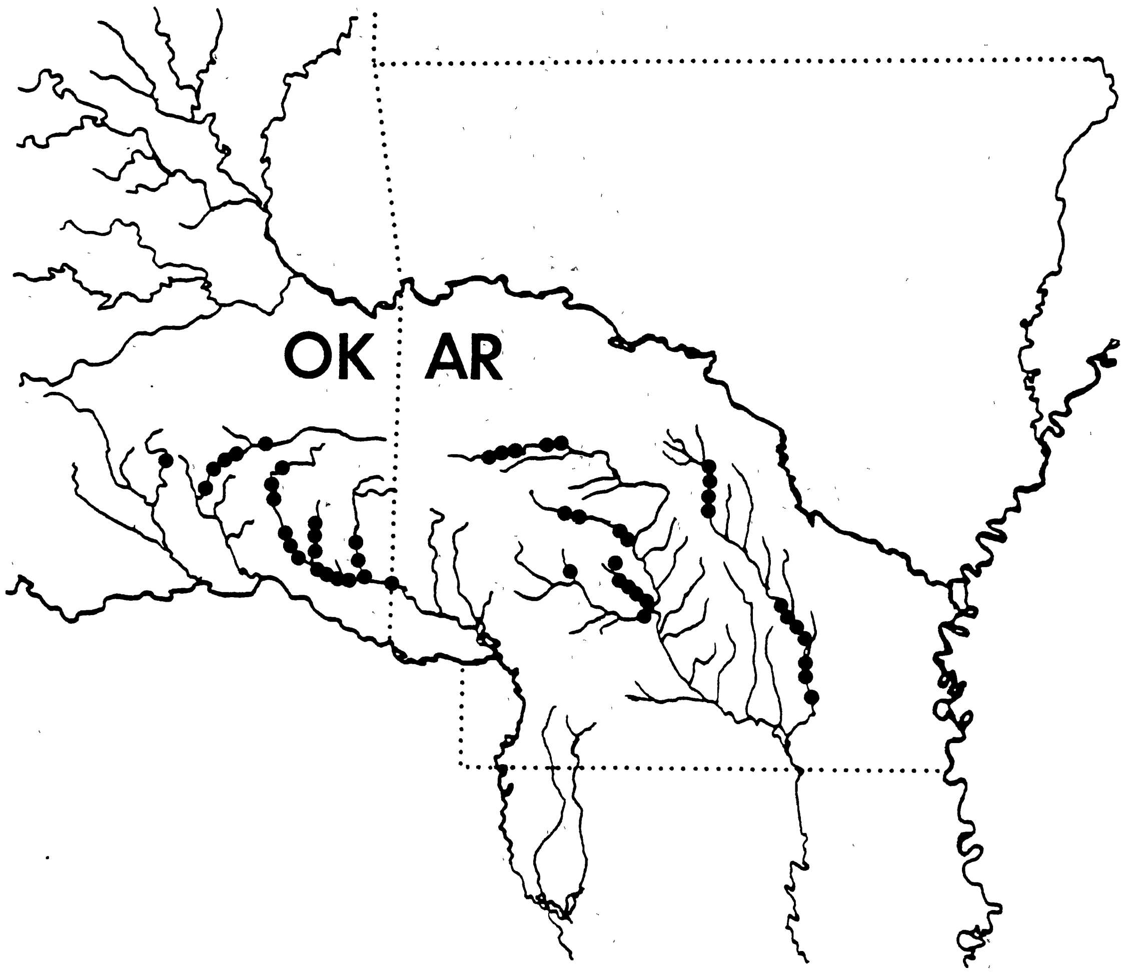
METHODS AND MATERIALS

This report is based on personal field collections, augmented by museum records (Appendix A) and the available literature. All collection sites of N. perpallidus known to the author (Fig. 1) were located on USGS topographic maps. Site elevation, stream order and gradient were obtained from these maps with the use of a Numonics Model 1224 digitizer (Figs. 2-4). Stream order was calculated according to Horton (1945), as modified by Hynes (1972).

Samples of N. perpallidus were collected from September 1982 to October 1983. Most of the collecting effort was devoted to sites where N. perpallidus has been previously collected, to determine the current condition of those populations. Sample stations within each site were chosen to represent a variety of microhabitat types, including riffle, chute, head of riffle, tail of riffle, pool, backwater, and waters in the lee of islands.

At each station within a site, a single downstream seine haul was made over a distance of approximately 5 m, using a 1.83 x 4.57 m seine of 6 mm mesh. To minimize disturbance from one station to the next, adjacent seine hauls were at least 5 m apart. This method of seining was adapted from Gorman and Karr (1978) and Matthews and Hill (1979). All fish collected from each sample station were preserved in 10%

Figure 1. Range and Known Locations of <u>Notropis perpallidus</u>


OK
AR

formalin in the field and transferred to 40% isopropyl alcohol for permanent storage.

To identify sample stations for subsequent habitat measurements, weighted numbered floats were dropped at the beginning and end of each seine haul. Habitat measurements were recorded for each sample station. Depth was measured with a metric wading rod; water current was measured using a Pygmy-Gurley meter; substrates were classified according to predesigned categories. Four depths, five currents, six substrates and four biotic structure categories were employed, giving a total of 19 habitat variables (Appendix B). At each sample station, point measurements of habitat structure were taken along in transects separated by approximately 1.5 m throughout the length of the station; habitat measurements were recorded at 1 m intervals along the transects.

To quantify habitat at each sample station, each of the 19 variables was weighted according to their frequency at a given station. Percentages were then assigned values between 0 and 10 in the following manner: 0 = absent, 1 = 1-10%, 2 = 11-20%, and so on up to 10 = 91-100%. This coding of habitat abundance reduced noise resulting from eigenvector ordinations later in the analysis (Gauch, 1982).

Principal components analysis was used to examine physical microhabitat used by <u>N. perpallidus</u>. Data for all localities were used in creating a coded habitat-variable x sample-station matrix. All drainages were included in a single analysis. Principal components were extracted from the matrix of correlations between habitat variables. The computations were performed by BMDP4M, a subprogram of the UCLA Biomedical Computer Programs (Dixon, 1983).

Principal components are extracted to create a space of reduced dimensionality in which each dimension is a weighted, linear function of all the original variables. The first principal component is computed so as to explain the maximum amount of the variance in the original variables (19 habitat variables here) that can be explained by a linear function; the second component explains the maximum amount of the remaining variance, and so on. By definition principal components are uncorrelated and orthogonal (Neff and Marcus, 1980). Based on Horn's test (Green, 1978) the first five components (56.2% of total variance) were chosen for further analysis. The computer program also produced correlation coefficients (loadings) between coded habitat scores and principal components scores for the newly created habitat factors (Table I), as well as giving scores for each of the 245 sample stations on each principal component. To help visualize microhabitat utilization and to compute indices of niche structure, each of the five principal components was divided into increments of 0.5 standard deviation units. The total number of <u>N. perpallidus</u> occurring within each principal component unit was divided by the number of sample stations taken from within the respective units. The weighted numbers of specimens were summed across units for each principal component, and this sum was used to calculate percentage utilization for each interval (Figures 5-9). Niche breadth along each principal component was calculated with Simpson's index of diversity $B = 1/\sum_{i}^{n} p_i^2$ where p_i is the proportionate utilization of the ith interval (Pianka, 1973). Overall niche breadth was estimated as the product of the niche breadths along all five principal component axes (Table II) (Pianka, 1973). For comparative purposes, similar computations were done for seven additional species of Notropis.

Habitat utilization by the eight Notropis species along univariate axes represented by current, depth and substrate variables were examined to assist interpretation of the principal components analysis. For a finer-grained analysis, seven current speed (increments of 0.1 m/sec) and nine depth (increments of 0.1 m) categories were designated. Individual sample stations were assigned a current, depth and substrate value based on the most frequent category recorded at the station. The number of fish found and the amount of effort (one seine haul = one sample station = one unit of effort) in each interval was totaled. To correct for uneven effort, the total number of fish associated with each category was divided by the number of seine hauls in that category, and the result was expressed as the percentage of the fish that utilized a specific category (Table III).

Associates of N. perpallidus at the microhabitat level were examined by means of product-moment correlation analyses. Fish species selected for this analysis occurred in at least seven sample stations from sites where N. perpallidus was taken. Only sample stations from sites where both N. perpallidus and the species under consideration occurred on the same sample date were used in determining association. The method removes bias due to differences in geographical distribution of the species.

CHAPTER III

THE BIOLOGY AND ECOLOGY OF *NOTROPIS PERPALLIDUS*

Description

Diagnostic Characteristics

Gilbert and Bailey (1962) and Snelson (1968a) considered *Notropis perpallidus* to be a divergent member of the subgenus *Notropis*. The general characteristics of the subgenus were described by Snelson (1968a) as follows: pharyngeal tooth count 2,4-4,2; moderate-sized scales, numbering 35-40 in the lateral line; an anal ray count usually between 9-11; the dorsal fin inserted posterior to the pelvic insertion; a decurved complete lateral line; a moderate to large terminal, oblique mouth; normal shaped scales; dorsal fin membranes usually lacking pigment concentrations; primarily silver coloration; and small, numerous breeding tubercles.

The diminutive size and the overall reduction of pigmentation in *N. perpallidus* separate it from other members of the subgenus. The largest reported male and female were 40.5 mm and 38.7 mm SL, respectively. The maximum length of *N. perpallidus* ranks it among the smallest in the genus, probably second to *N. saladonis* which reaches a reported maximum length of 38 mm SL (Hubbs and Hubbs, 1958).

Snelson and Jenkins (1973) described the distinctive pigmentation characteristics of *N. perpallidus* as follows: (1) reduction of overall pigmentation, but with the few melanophores present being unusually large; (2) middorsal stripe absent except in a few cases where a thin predorsal line is formed by a series of isolated macromelanophores; (3) two parallel black dashes (occasionally fused) on either side of dorsal midline immediately before dorsal fin origin, with a black area of varying intensity under posterior half of dorsal fin base; and (4) black pigment well developed along anal fin base. In life, *N. perpallidus* is easily distinguished by macromelanophores, almost translucent flesh and lack of silver pigmentation.

Other characters that differentiate *N. perpallidus* include the dorsal fin insertion not inserted posterior to the pelvic insertion and the lateral line scale count of 32-35. Sexual dimorphism and geographic variation in morphology or coloration are not evident (Snelson and Jenkins, 1973).

Holotype and Type Locality

The holotype and single paratype of the peppered shiner, *N. perpallidus* (UMMZ 125991 and UMMZ 125922), were taken from the Saline River, 8 km north of Warren, Bradley County, Arkansas (probably Sec. 3, T12S, R9W). A detailed description of the specimens is found in Hubbs and Black (1940) with some subsequent details being provided by Snelson and Jenkins (1973). No other type specimens have been described in the literature.

Distribution

Historical Collections

The first known collection (Appendix C) of the species was from the Saline River (UMMZ 197684) near Benton, Arkansas, in 1884, by Jordan and Gilbert (1886), although it was misidentified as N. dilectus. Subsequently, Black and Black took two specimens downstream from this site in the Saline River near Warren, Bradley County, Arkansas (Hubbs and Black, 1940). Moore's report (1948) of a single specimen of N. perpallidus from the Mountain Fork tributary of the Little River system in Oklahoma significantly expanded the known range of this species. Reeves (1953) subsequently collected the shiner from four localities in the Little River drainage, two in the Mountain Fork River and two from the Lower Little River. Specimens from three localities in the Little River drainage were later reported by Finnel, Jenkins and Hall (1956). More recently, the species has been taken from the Glover River near Glover, McCurtain County, Oklahoma (e.g., Robison, 1981).

In Oklahoma, collections of the shiner also have been made in the Kiamichi and Muddy Boggy drainages (Pigg and Hill, 1974; Pigg, 1977). Snelson, Gilbert and Platania (1980) and Robison (1981) did not consider the Muddy Boggy drainage as part of the range of N. perpallidus. Pigg's (1977) collection of three specimens from a single locality in the Muddy Boggy drainage (McGee Creek) extends the known range of this species westward into a major tributary of the Red River drainage.

In Arkansas, the distribution of N. perpallidus has been well documented by Neil H. Douglas and his graduate students at Northeast

Louisiana University, Dewey and Moen (1978), and by Robison (1981). Reynolds (1971), in collections at 32 localities along the length of the Saline River in central Arkansas, found *N. perpallidus* at five locations. The most upstream collection (Sec. 21, T2S, R15W) was close to the locality where Jordan and Gilbert took the first known specimen of this species.

Harris (1977) surveyed the upper Ouachita River from the headwaters to Remmel Dam (Lake Catherine). A total of 74 specimens of *N. perpallidus* was taken from four localities above Lake Catherine. However, Raymond (1975), in a survey of the fish fauna from Remmel Dam to the Arkansas-Louisiana state line, reported only one specimen of *N. perpallidus* taken on the Ouachita River near the mouth of the Little Missouri River.

In a pre-impoundment study of the Caddo River, Fruge (1971) collected 62 specimens of *N. perpallidus* from four localities. Dewey and Moen (1978), in a post-impoundment study, collected 14 specimens from three locations.

Myers (1977) surveyed the Little Missouri River drainage from 1970-1973. A total of 58 collections at 20 locations yielded 21 specimens of *N. perpallidus* from three localities. Two of the collections were from the lower mainstream of the Little Missouri River and the third collection was from the Antoine River, a tributary of the Little Missouri River.

Present Distribution

The distribution of *Notropis perpallidus* is restricted to tributaries of the Red and Ouachita Rivers in southwestern Oklahoma and southcentral Arkansas (Miller and Robison, 1973; Buchanan, 1973; Snelson and Jenkins, 1973; Snelson, Gilbert and Platania, 1980). It had been previously reported that within the Red River drainage the species was restricted to the Little and Kiamichi systems (Snelson, Gilbert and Platania, 1980), but, Pigg's (1977) collection from McGee Creek shows that the Muddy Boggy system should also be included within the natural range of the species. Within the Ouachita River drainage, *N. perpallidus* is found in the Saline, Ouachita, Caddo and Little Missouri River systems.

I obtained information on 136 collections of *N. perpallidus* from 55 localities (Appendix C). These include records from my recent field work, and that of others and a survey of museum records. These collections represent 823 specimens (Table IV). Compared to data provided by Robison (1981), this is an increase of 21 localities, 79 collections and 472 specimens.

During this study, specimens were taken from seven sites in the Little River drainage. Four collections were made at three sites above Pine Creek Reservoir on the Little River. Despite extensive efforts, the shiner was taken at only one site on the Little River downstream from Pine Creek Reservoir. In 1983, J. Pigg (pers. comm.) was unable to capture specimens at the Highway 70 bridge north of Idabel where he had taken it several times in past years.

I collected N. perpallidus at three locations on the Glover River. The most upstream collection (low water bridge at Weyerhauser road 7100, Sec. 9, T5S, R23E) was the first record of the shiner from that locality. No specimens were taken in the Mountain Fork drainage. The last known collection of the shiner from the Mountain Fork River was in 1967, before impoundment of Broken Bow Reservoir in 1968. Historically, N. perpallidus had never been taken above the site of the existing reservoir. Taylor and Wade (1972) were unable to take any N. perpallidus during a post-impoundment survey of the Mountain Fork River.

Recent collections in the Kiamichi River have established the presence of a viable population. J. Pigg (pers. comm.) took one specimen of N. perpallidus from the river, 1.6 km southeast of Clayton, Pushmataha County, Oklahoma in 1982. In 1983, during the course of this study, specimens were collected from four localities along the midreaches of the Kiamichi. The collection made below a bridge about 27 km north of Antlers represents a previously unreported locality for this species (Sec. 19, T1S, R19E). No effort was made to collect in the Muddy Boggy drainage.

From 1980-82, Stackhouse (1982) resurveyed the fishes of the Saline River in central Arkansas. A total of 115 collections from 50 localities were sampled. N. perpallidus was taken in 20 collections from 10 localities. Stackhouse (1982) reported taking 65 specimens of the shiner. During the summer of 1983, specimens were collected from all three localities sampled on the Saline River.

Although the shiner has been reported numerous times from four localities in the upper Ouachita River (Harris and Douglas, 1978), it was not collected from these sites during this investigation. However, extensive sampling during two separate trips to the area did yield four specimens from a locality from which *N. perpallidus* had not been reported previously. Similarly, collections made in the upper Caddo above DeGray reservoir and below the reservoir at the Interstate 30 bridge did not yield *N. perpallidus*. The region received record amounts of rainfall during the winter of 1983 and the locations sampled appeared to have been scoured initially by floods and subsequently by bulldozers to clear the channel. This may have affected the abundance of *N. perpallidus*. The locality at the Interstate 30 bridge was visited twice during the summer. During the first visit, water was being released from the reservoir and sampling was not possible. A collection was made during the second trip but the depauperate fauna was almost exclusively dominated by *Labidesthes sicculus* and no specimens of *N. perpallidus* were taken. Until six specimens were taken in 1975 (Robison, 1981), the shiner was believed to be extirpated from this locality as a result of the filling of Degray Reservoir in 1970. It is possible, however, that the fauna, now dominated by lentic species, may have changed due to the effects of the reservoir, again affecting the presence of *N. perpallidus*.

Notropis perpallidus is widespread in the Little Missouri River system. In a recent survey, Loe (1983) collected the shiner seven times at five locations, all of which were outside of the main river. Five of the collections were made from three locations in a boat ditch near the Terre Noir River. Specimens were also taken in the Terre Noir River and its small tributary, Bell Creek. Sampling conducted during this study yielded no specimens from the mainstream (two attempts) but collections were made in the boat ditch near the Terre Noir River and in the Antoine River near Antoine.

Macrohabitat

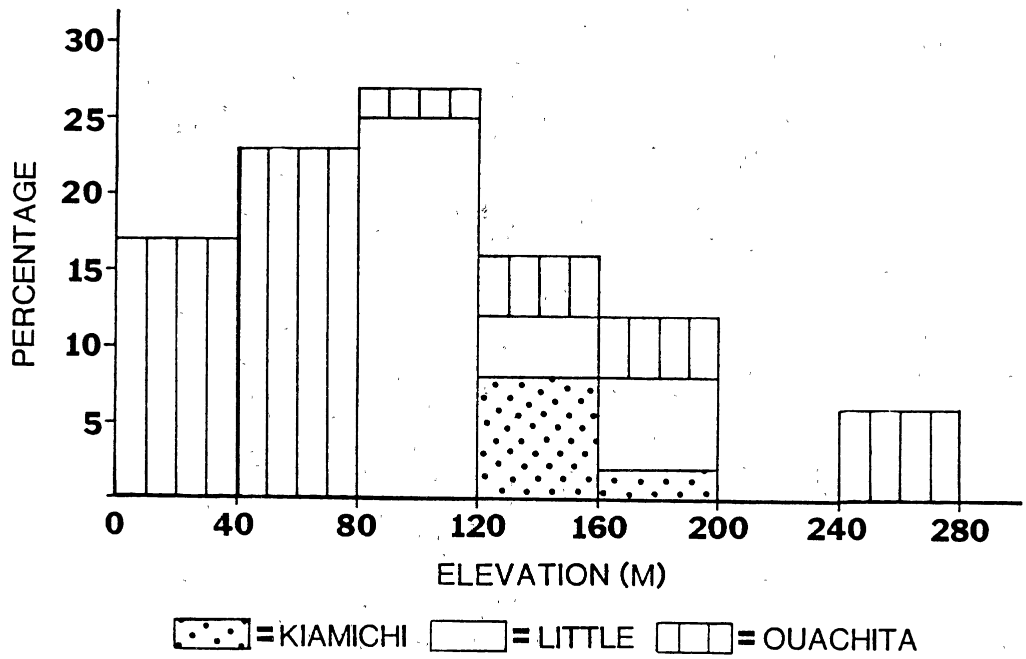
Literature

The literature refers to N. perpallidus as an inhabitant of small to moderate-sized, warm-water rivers (Snelson and Jenkins, 1973). To better define macrohabitat parameters, measurements of three variables, site elevation, stream order and gradient were made for known sites of N. perpallidus occurrence.

Results and Discussion

The elevation of localities supporting N. perpallidus ranged from 22 to 252 m (mean = 104.6) above mean sea level (msl) (Fig. 2). The minimum and maximum elevations both occurred in the Ouachita drainage. The highest elevation in the Saline River portion of the drainage was only 78 m. Mainstream sites of the Little Missouri River, the site below DeGray reservoir on the Caddo River, and the Ouachita River locality at the mouth of the Little Missouri River all were below 57 m. Higher elevations were in the tributaries of the Little Missouri River and in the Caddo River localities above DeGray reservoir. The upper Ouachita River, being entirely located in the Ouachita Mountain Province, represented the highest elevations at which the species occurs. The shiner occupied a narrow, moderately high, elevational

Figure 2. Site Elevation Use by <u>Notropis perpallidus</u> in Three Drainages



30
25
20
15
10
5
PERCENTAGE
0
40
80
120
160
200
240
280
ELEVATION (M)
= KIAMICHI
= LITTLE
= OUACHITA

range of 144-173 m, in the Kiamichi River. In the Little River system, N. perpallidus occurred at elevations from 88-192 m.

N. perpallidus has been taken at stream orders ranging from one to six. Most occurrence (78%) is in fourth or fifth order streams (Fig. 3). It appears that the shiner is found in streams in the Ouachita River drainage that are smaller than in either of the other two drainages. The utilization of lower order streams (1° and 3°) mainly occurs in the Little Missouri River system of the Ouachita drainage. The single male specimen caught in the first order tributary of the Little Missouri River, Bell Creek, is enigmatic but may be a result of unusually high water in 1982. The species is found in a sixth order stream in the lower Little River in southeastern Oklahoma. Attempts to take specimens further downstream in Arkansas where the Little River becomes very slow and deep have not been successful (Robison, 1981).

Stream gradients occupied by the peppered shiner ranged from 0.09 to 1.26 m/km, with a mean of 0.54 m/km (Fig. 4). N. perpallidus appeared to be using a similar distribution of site gradients in the Ouachita and Little River drainages, with use in the Kiamichi tending to be more restricted.

In conclusion, although N. perpallidus has a restricted geographic range, the species tends to use a wide range of macrohabitat situations. In Arkansas, it is found in very small to moderate-sized streams which range from the relatively high elevations of the Ouachita Mountains to the low elevations characteristic of Gulf Coastal Plain streams. In Oklahoma, N. perpallidus occurs in moderate-sized streams and at somewhat higher elevations than it does in Arkansas. Overall, N. perpallidus

Figure 3. Stream Order Use by _Notropis perpallidus_ in Three Drainages

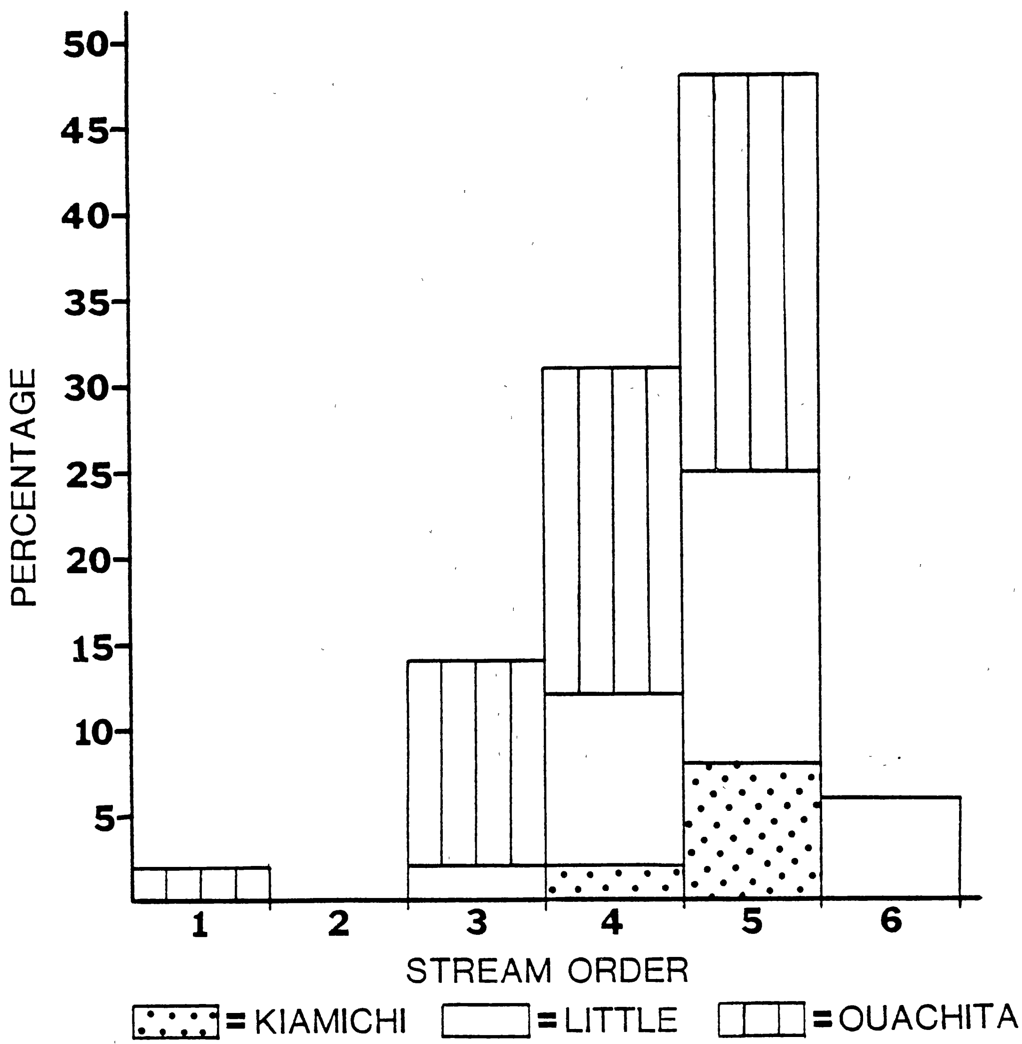
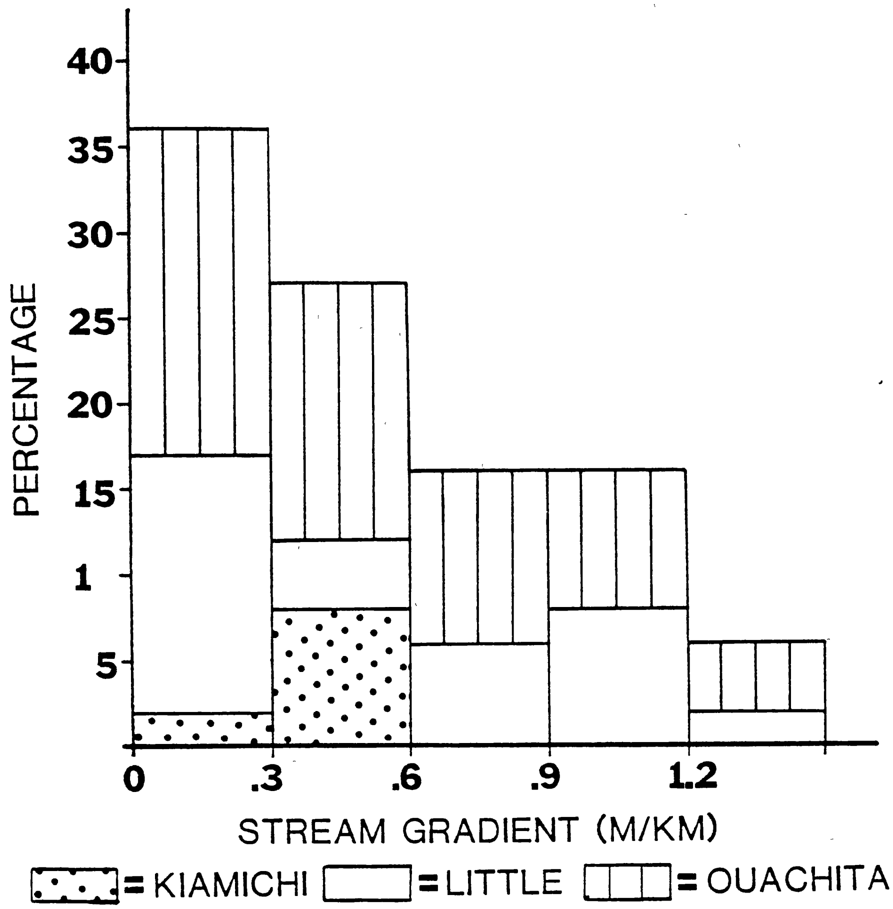

50
45
40
35
30
25
20
15
10
5
PERCENTAGE
1
2
3
4
5
6
STREAM ORDER
= KIAMICHI
= LITTLE
= OUACHITA

Figure 4. Site Gradient Use by *Notropis perpallidus* in Three Drainages



40
35
30
25
20
15
1
5
PERCENTAGE
0
.3
.6
.9
1.2
STREAM GRADIENT (M/KM)
= KIAMICHI
= LITTLE
= OUACHITA

occurs primarily at localities having moderate (0.8 m/km) to low (0.2 m/km) stream gradient.

Microhabitat Utilization

Literature

Knowledge of microhabitat requirements can provide valuable insight for efforts to protect rare species. Is the species rare simply because it has specialized needs that are limiting? If so, what are those needs? On the other hand, a species could be rare because it is limited by its own population dynamics and/or biotic interactions and yet it may be broadly distributed relative to microhabitat.

Microhabitat preferences of *N. perpallidus* are poorly known and available data are anecdotal and conflicting. John and Ruby Black caught the type specimens ". . . in a very silty, weedless backwater. . ." (Hubbs and Black, 1940). Reeves (1953) noted that specimens were collected in the lower portion of the Little River system ". . . near water willow beds in water ranging from 2 to 3 feet deep over a gravel bottom." Conversely, Finnel et al. (1956) reported two collections from cut-off pools with sand-silt bottoms and slightly turbid water, and a third collection from an area of bedrock bottom and swift current. Snelson and Jenkins (1973) noted that they collected *N. perpallidus* ". . . in slow or quiet water 2-4 feet deep, usually downstream from riffles and shoals."

In this study, microhabitat utilization by *N. perpallidus* is compared with that of seven congeneric species collected within the known range of *N. perpallidus*. This approach places the microhabitat responses of N. perpallidus in the context of relatively close relatives.

Results and Discussion

Principal components analysis of the 19 microhabitat variables revealed five components (microhabitat PC's) that provide helpful summarization of the variance in microhabitat among sampling stations. Table I shows the loadings of the original variables on each PC. Figures 5-9 show the adjusted frequency distributions of N. perpallidus and seven congeners on each PC. Because each PC is mathematically uncorrelated with (e.g., orthogonal to) all other PC's, each can be treated as independent dimensions in calculations of niche breath (Table II). Figures 5-9 also show the relative frequency of seine hauls within each increment of the five dimensions of niche space; this allows visualization of sampling effort within each increment and provides a subjective assessment of confidence in the corresponding abundances of the fishes. To aid in interpretating the multivariate analysis, Table III provides distributions of the eight species in relation to three univariate habitat variables (substrate, current and depth).

PC I was the only PC on which N. perpallidus shows the same pattern of distribution across the three drainages Fig. 5). As indicated by the loadings shown in Table I, scores on PC I primarily represent a contrast between shallow, faster-flowing waters (positive values) and deeper, slower-moving waters (negative values). Stations with negative scores on PC I also tended to have higher scores for emergent vascular plants (e.g., water willow) and for reduced substrate size. At least 75 percent of the specimens of N. perpallidus and two additional species,

TABLE I

HABITAT PRINCIPAL COMPONENTS FROM THE ANALYSES OF HABITAT VARIABLES. THE VALUE IN PARENTHESES IS THE VARIANCE EXPLAINED BY EACH PRINCIPAL COMPONENT

	Factor				
	I (18.6)	II (12.7)	III (9.9)	IV (8.2)	V (6.8)
Current					
1	-.86				
2	.39	.32		.58	
3	.74	.33			
4	.76			-.34	
5	.56			-.52	
Depth					
1	.52		-.70		
2	-.45			.33	
3	-.41	.38	.62		
4	-.35	.36	.43		-.30
Substrate					
Sand	-.40	.42	-.31		.44
Gravel		.64			-.45
Rubble		-.61			
Boulder		-.48	.40		
Bedrock					.37
Vegetation/brush					
Emergent vascular	-.51		.39		
Submergent vascular			.32		
Detritus	-.38			-.41	.42
Brush		.44			.41

TABLE II

OCCURRENCE AND HABITAT NICHE BREADTH OF EIGHT *NOTROPIS* SPECIES

Species	Collection Localities	Seine Hauls	Number of Specimens	Breadth PC I	PC II	PC III	P IV	PC V	Overall Breadth
Notropis boops	27	183	6516	7.81	8.26	10.87	8.00	9.26	5.19×10^4
N. perpallidus	19	43	172	3.51	6.99	4.88	7.35	5.32	4.68×10^3
N. rubellus	15	52	766	4.95	5.49	3.46	6.17	3.51	2.04×10^3
N. sp.	8	36	1974	2.86	2.17	3.43	3.37	5.95	4.27×10^2
N. umbratilis	21	63	517	4.83	6.25	7.58	6.33	6.54	9.47×10^3
N. venustus	8	39	195	4.85	2.88	5.08	4.48	5.59	1.78×10^3
N. volucellus	10	34	248	4.06	5.59	6.06	3.18	5.71	2.50×10^3
N. whipplei	26	160	1090	7.30	6.99	9.26	5.29	10.64	2.66×10^4

TABLE III

DISTRIBUTION OF EIGHT *NOTROPIS* SPECIES ALONG CURRENT, DEPTH AND SUBSTRATE GRADIENTS*

	Number of Collections	N.boo	N.per	N.rub	N.sp.	N.umb	N.ven	N.vol	N.whi
Current (cm/sec)									
1 (0-.10)	121	15.37	22.22	43.02	34.69	29.41	6.56	25.71	13.06
2 (.11-.20)	35	34.45	40.74	20.93	32.84	45.10	18.03	60.00	12.16
3 (.21-.30)	24	20.57	29.63	2.33	2.58	23.53	18.03	2.86	13.51
4 (.31-.40)	21	12.39	3.70	29.07	1.48	0.00	3.28	2.86	22.97
5 (.41-.50)	16	10.16	3.70	1.16	12.92	1.96	3.28	8.57	8.11
6 (.41-.60)	8	3.10	0.00	0.00	11.07	0.00	32.79	0.00	27.03
7 (≥.61)	19	3.97	0.00	3.49	4.43	0.00	18.03	0.00	3.15
$\bar{X}$**		2.93	2.26	2.38	2.72	2.00	4.49	2.09	3.95
Depth (cm)									
1 (0-10)	6	1.34	0.00	0.89	0.00	1.28	27.45	0.00	3.95
2 (11-20)	46	11.62	7.69	14.29	0.88	17.95	15.69	3.85	7.91
3 (21-30)	52	13.48	5.77	46.43	1.55	19.23	9.80	7.69	19.77
4 (31-40)	47	21.76	5.77	2.68	15.49	5.13	1.96	28.85	10.73
5 (41-50)	38	8.28	1.92	5.36	15.49	2.56	13.73	5.77	17.51
6 (51-60)	20	13.48	15.38	6.25	2.65	2.56	0.00	3.85	3.39
7 (61-70)	18	20.29	9.62	12.50	53.98	15.38	3.92	21.15	11.30
8 (71-80)	9	1.34	36.54	11.61	0.00	28.21	0.00	23.08	5.65
9 (≥81)	8	8.41	17.31	0.00	9.96	7.69	27.45	5.77	19.77
$\bar{X}$**		5.03	6.70	4.20	6.29	5.46	4.39	5.83	6.41

TABLE III (continued)

Substrate									
1 (Sand)	25	13.21	20.69	11.88	1.20	35.48	50.00	12.50	10.13
2 (Gravel)	88	24.66	34.48	52.48	5.78	30.65	44.12	21.43	38.61
3 (Rubble)	95	11.99	20.69	20.79	25.30	24.19	5.88	8.93	13.29
4 (Boulder)	26	32.35	10.34	5.94	62.17	0.00	0.00	44.64	23.42
5 (Bedrock)	10	17.87	13.79	8.91	5.54	9.68	0.00	12.50	14.56
$\overline{X}$**		3.17	2.62	2.47	3.65	2.17	1.60	3.23	2.94

* N.boo = *Notropis boops*
N.per = *N. perpallidus*
N.rub = *N. rubellus*
N.umb = *N. umbratilis*
N.ven = *N. venustus*
N.vol = *N. volucellus*
N.whi = *N. whipplei*

** $\overline{X}$ = The weighted average of the codes for habitat variable categories (e.g., 1, 2, 3, etc.). Computed by weighting each code by the adjusted number of fish in that code, summing across all categories for a habitat variable and dividing by the number of categories.

Figure 5. Distribution of Eight *Notropis* Species on Microhabitat Principal Component I. Histograms for the species represent the adjusted percent occurrent in each interval (see text for computation). The histogram for seine hauls shows the percent of the total number of seine hauls (244) that was made in each interval.

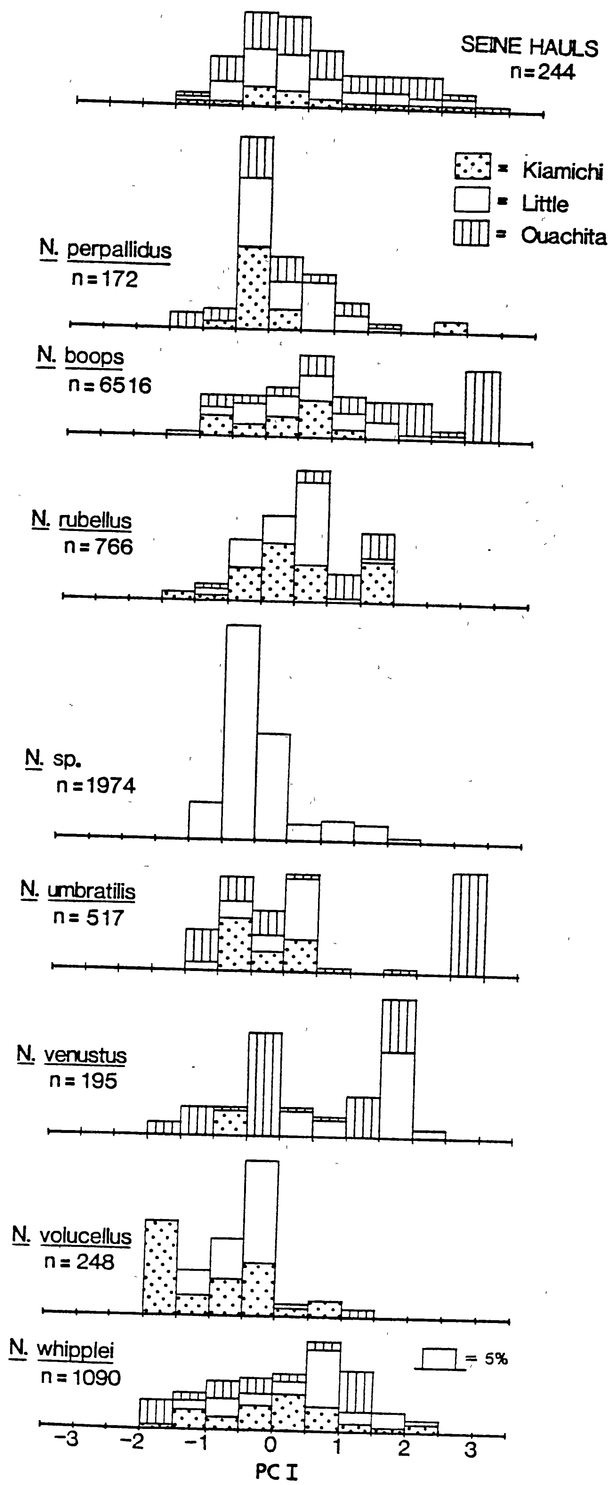

SEINE HAULS
n=244
= Kiamichi
= Little
= Ouachita
N. perpallidus
n=172
N. boops
n=6516
N. rubellus
n=766
N. sp.
n=1974
N. umbratilis
n=517
N. venustus
n=195
N. volucellus
n=248
N. whipplei
n=1090
= 5%
-3
-2
-1
0
1
2
3
PC I

Figure 6. Distribution of Eight *Notropis* Species on Microhabitat Principal Component II. See Fig. 5 for rest of legend.

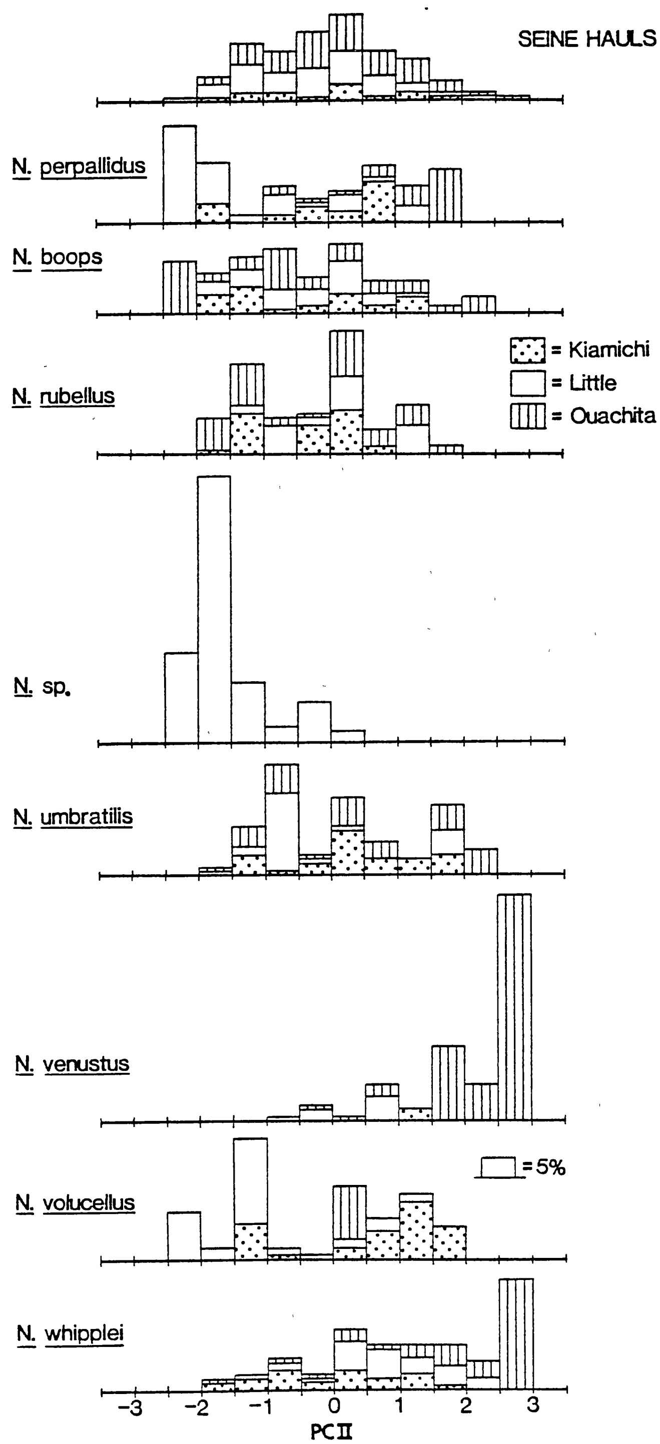

SEINE HAULS
N. perpallidus
N. boops
= Kiamichi
= Little
= Ouachita
N. rubellus
N. sp.
N. umbratilis
N. venustus
= 5%
N. volucellus
N. whipplei
-3
-2
-1
0
1
2
3
PC II

Figure 7. Distribution of Eight *Notropis* Species on Microhabitat Principal Component III. See Fig. 5 for rest of legend.

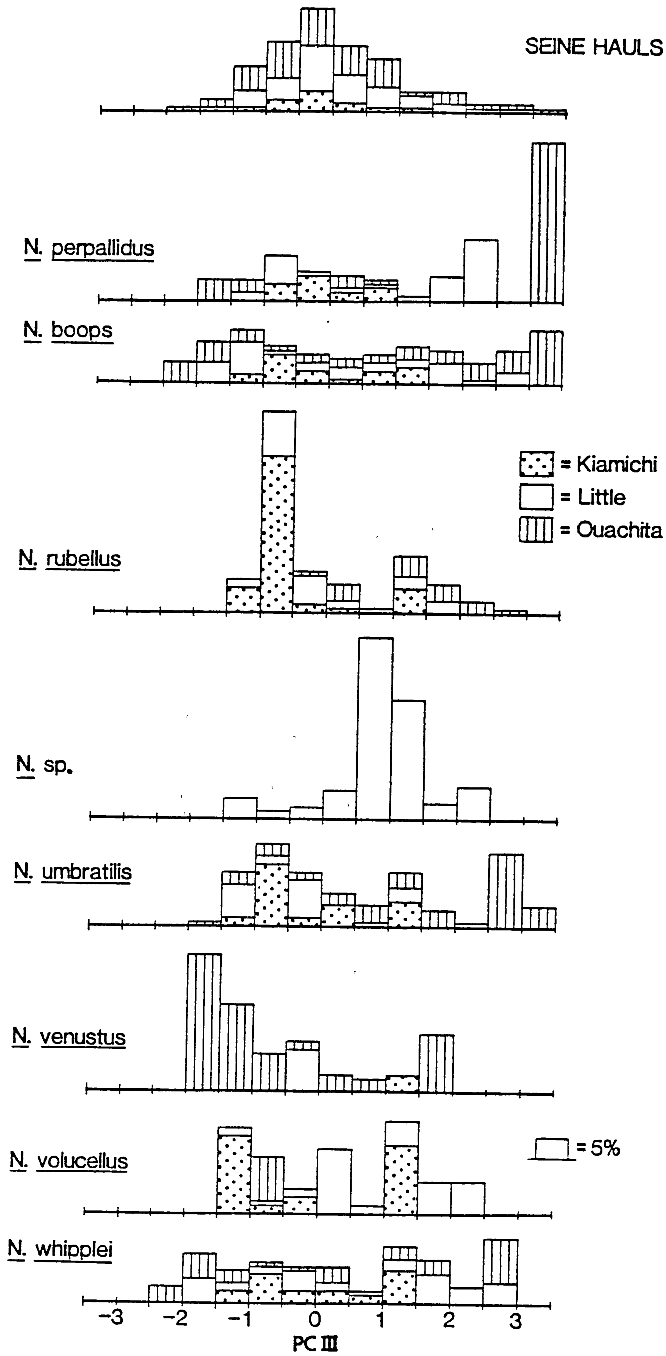

SEINE HAULS
N. perpallidus
N. boops
= Kiamichi
= Little
= Ouachita
N. rubellus
N. sp.
N. umbratilis
N. venustus
N. volucellus
= 5%
N. whipplei
−3
−2
−1
0
1
2
3
PC III

Figure 8. Distribution of Eight *Notropis* Species on Microhabitat Principal Component IV. See Fig. 5 for rest of legend.

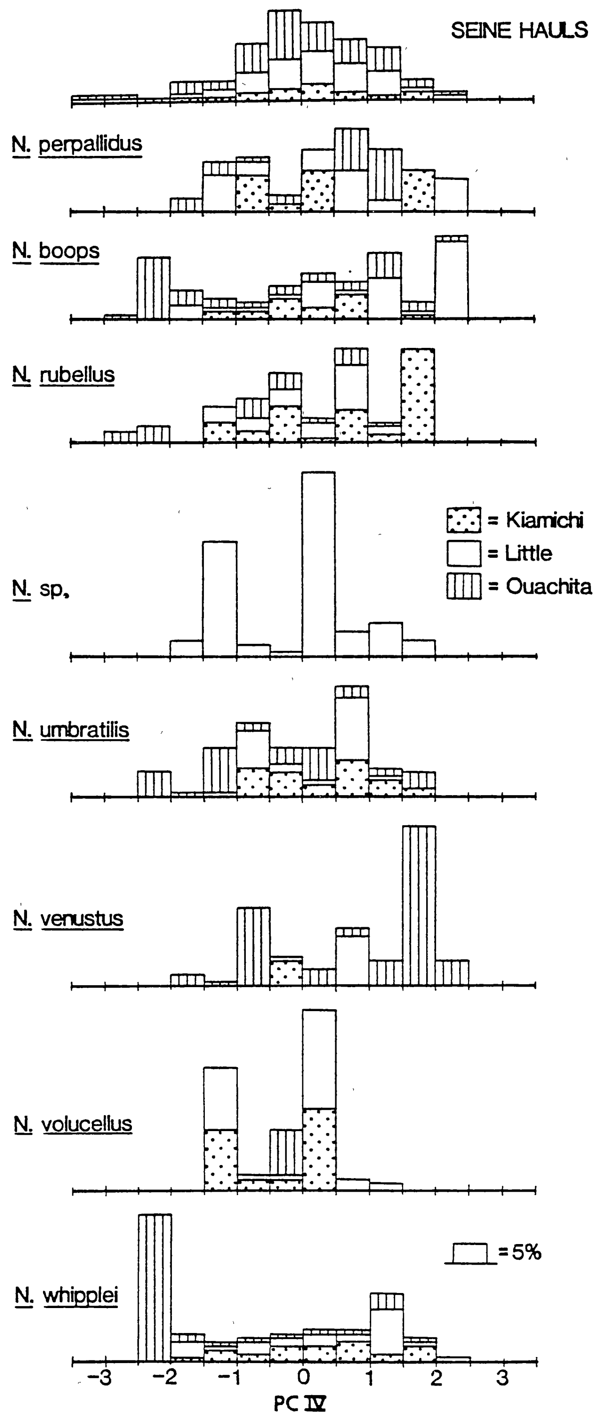
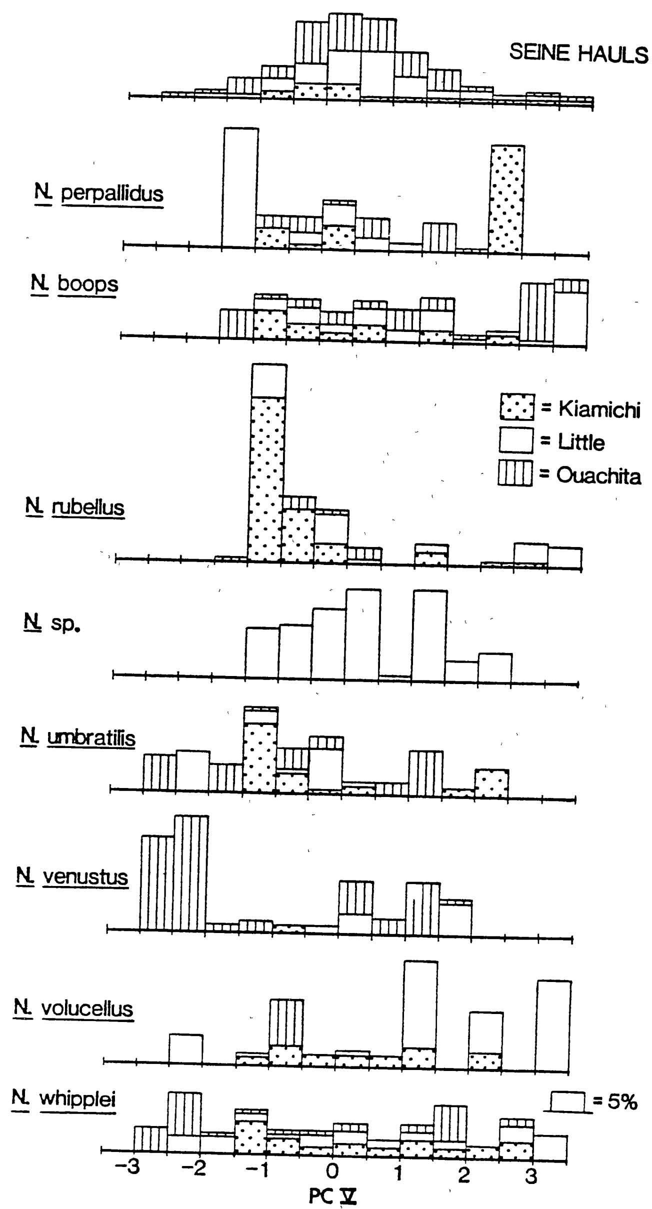

SEINE HAULS
N. perpallidus
N. boops
N. rubellus
= Kiamichi
= Little
= Ouachita
N. sp.
N. umbratilis
N. venustus
N. volucellus
=5%
N. whipplei
-3
-2
-1
0
1
2
3
PC IV

Figure 9. Distribution of Eight *Notropis* Species on Microhabitat Principal Component V. See Fig. 5 for rest of legend.


SEINE HAULS
N. perpallidus
N. boops
= Kiamichi
= Little
= Ouachita
N. rubellus
N. sp.
N. umbratilis
N. venustus
N. volucellus
N. whipplei
= 5%
−3
−2
−1
0
1
2
3
PC V

N. sp. (an undescribed member of the subgenus Lythurus [Snelson, 1968b]), and N. volucellus, were from sampling stations that had negative scores. In contrast 50 percent or more of the specimens of the remaining five species were from stations with positive scores on PC I. Also, the latter group of five species had broader distributions on PC I and correspondingly larger niche breadth values (Table II).

Examination of the univariate distribution, in combination with the multivariate results, reveals that N. perpallidus, N. sp., N. volucellus and N. umbratilis used slower current speeds than did the other species (Table III). Similarly, the slower-water group of minnows were found in deeper water, which may reflect the lack of independence of current and depth in a stream situation. The two species with the largest niche breadths, N. boops and N. whipplei, both had fairly even distributions along the depth and current axes, except for a tendency to avoid extremely swift-flowing and shallow water.

The PC II ordination of sampling stations is strongly affected by substrate variables (Table I). Variables with the highest positive loadings were gravel, brush and sand; those with the highest negative loadings were rubble and boulder. Stations with positive scores tended to have high values for those variables with positive loadings and low values for those variables with negative loadings; stations with negative scores showed the reverse pattern. Across the three drainages, N. perpallidus had the second largest PC II niche breadth value. Thus, it appears that the microhabitat distribution of N. perpallidus is relatively independent of substrate. The distribution of N. perpallidus along the univariate substrate axis is fairly even, thus supporting the idea that the microhabitat use by the species is essentially independent of substrate (Table III). Five of the other *Notropis* species examined show similar trends in habitat use. Except for *N.* sp. and *N. venustus*, the species are widely distributed on PC II (Fig. 6). *N.* sp. and *N. venustus* were taken primarily from the Little River and the Ouachita River systems, respectively. Sample localities in the former drainage had a high frequency of stations with negative scores on PC II while the latter had a high proportion with positive scores; the PC II distributions of *N.* sp. and *N. venustus* show the corresponding patterns (Fig. 6). Distribution of these two species along the univariate substrate gradient adds credence to this observation, since *N.* sp. is not found often over sand and gravel, and *N. venustus* is not found over boulder and bedrock. *N. perpallidus* appeared be opportunistic, since it used larger substrates in the Little River and smaller substrates in the Ouachita River drainage.

PC III provides a contrast of shallow, sandy-bottomed habitat (negative scores) versus deeper waters with boulders and/or aquatic vegetation (positive scores). Superficially, *N. perpallidus* appears strongly shifted toward the latter condition (Fig. 7); however, this appears to be a consequence of the structure of the histogram. If the distribution is averaged over two intervals, the mode on the right hand side of the graph is lost, leaving no well developed mode for *N. perpallidus* on PC III. Three species, however, had strong modes on PC III: *N.* sp. is shifted toward positive scores, and *N. rubellus* and *N. venustus* are shifted toward negative scores. These results are consistent with the univariate trends in which *N.* sp. is found in deeper, slower-flowing water and *N. venustus* occupies shallow, small-substrate microhabitats. *N. rubellus* appears to utilize microhabitats similar to N. venustus since the former had the lowest mean value for depth use and a tendency to be found over smaller substrates. Correspondingly, the last three species have relatively small niche breadth values on PC III (Table II).

No habitat variables had high loadings on PC's IV and V (max = 0.58) and there was no apparent pattern to the distributions of N. perpallidus on those dimensions (Figs. 8-9). In general, the other species showed a similar lack of pattern on PC's IV and V. Along PC IV, N. volucellus showed a narrowly clumped distribution centered near the middle of the axis, and, on PC V, N. rubellus and N. venustus showed a trend toward negative scores. The low loadings of habitat variables on these two PC's make interpretations tenuous.

For N. perpallidus, the composite index of niche breath over the five PC dimensions was an order of magnitude smaller than those for N. boops and N. whipplei (Table II). The composite index demonstrated by N. perpallidus was of a similar order of magnitude to that in four of the remaining species, albeit somewhat smaller than in N. umbratilis; it was one order of magnitude larger than in N. sp.

It should be kept in mind that for N. perpallidus the niche breadth values are near the actual, realized niche breadth over its entire geographic range of occurrence. Conversely, values for the other species are lower than would have been obtained in a random sampling effort over their total geographic ranges. For example, in the Little River drainage of central Texas, N. venustus is one of the dominant species in upland streams, but in areas where N. venustus occurs with N. whipplei (as in the present study), the former is more restricted to lowland tributaries (Rose and Echelle, 1981). Thus, in a global sense, the realized habitat niche breadth of N. perpallidus is at least as restricted as that of any of the other species examined. However, within its geographical range, N. perpallidus is no less broadly distributed than 4-5 other species of Notropis. In fact, for a rare fish, N. perpallidus shows a suprisingly broad habitat distribution, ranging from the low gradient, shifting, sandy-bottomed streams, typical of the Gulf Plains, to the smaller, clearer, coarse-substrate streams of the Ouachita Plateau.

The striking difference in niche breadth between N. perpallidus and those of N. boops and N. whipplei seems primarily due to distribution along PC's I, III and V, with N. perpallidus being the more narrowly distributed of the three species. The distributions on PC I and the univariate gradients for current and depth suggest that, relative to the other two species, the abundance of N. perpallidus is shifted toward deeper water (>50 cm) and slower currents (0-0.3 m/sec). With respect to use of current and depth, the distributions of N. perpallidus are most similar to those of N. sp., N. umbratilis and N. volucellus, and most dissimilar to those of N. venustus (Table III).

The distribution of N. perpallidus varies on PC's III and V depending on the drainage of occurrence. These differences probably result from either macrohabitat variables (e.g., watershed characteristics) or unknown biotic interactions. They probably do not reflect genetically determined, adaptive differences in microhabitat preferences of N. perpallidus, because there is no notable between-drainage difference in morphology of the species (Snelson and Jenkins, 1973).

Species Associates

Introduction

In 12 general collections from the Ouachita River drainage in Arkansas that contained *N. perpallidus*, Robison (1981) collected a total of 64 species of fishes. Six species were described as common associates of *N. perpallidus*: *N. boops*, *N. whipplei*, *Campostoma anomalum*, *Pimephales notatus*, *Percina copelandi*, and *Etheostoma zonale*. Within the range of *N. perpallidus* certain species listed by Robison (1981), such as *E. zonale*, *E. blennoides*, *Pimephales tenellus*, and *Fundulus catenatus*, are restricted to the upper Ouachita River drainage.

Results and Discussion

In the present study, 41 species of fishes were collected at sites where *N. perpallidus* was taken (Appendix D). All of these species were listed by Robison (1981), except *N. volucellus*, *N. ortenburgeri*, *N.* sp. (Ouachita Mountain shiner), *E. spectabile* and *Lepisosteus osseus*.

To define species associations on a finer scale, product-moment correlation coefficients were calculated between the abundance of *N. perpallidus* and the abundances of 20 other fish species (Table IV). Differences in geographic distribution were essentially eliminated by considering only sites where both *N. perpallidus* and the second species being examined were collected. Abundances of *N. umbratilis*, *N. boops* and *Fundulus notatus* showed significant positive correlations with the abundance of *N. perpallidus*.

According to Snelson and Pflieger (1975), *N. umbratilis* prefers deep, quiet pools and avoids strong currents. This general habitat

TABLE IV

PRODUCT-MOMENT CORRELATIONS BETWEEN THE ABUNDANCE OF NOTROPIS PERPALLIDUS AND SELECTED SPECIES*

Species	Number of Collections	Correlation Coefficient
Campostoma anomalum	55	-.039
Etheostoma spectabile	35	-.047
Fundulus notatus	31	.682**
F. olivaceous	83	-.092
Gambusia affinis	79	-.077
Labidesthes sicculus	143	.044
L. macrochirus	62	-.046
L. megalotis	146	.044
Micropterus punctulatus	66	-.004
M. salmoides	27	.280
N. boops	152	.204**
N. rubellus	88	.119
N. sp	53	.111
N. umbratilis	122	.386**
N. venustus	67	.053
N. volucellus	77	.099
N. whipplei	156	-.031
Percina copelandi	52	-.090
Pimephales notatus	93	.027
P. vigilax	48	.507

*Only those species occurring in 10% or more of the of sample stations were examined.

**Significant at .05 level.

description is consistent with the distribution of this shiner and N. perpallidus along PC's I, II and III. The microdistribution of the distantly related Fundulus notatus was significantly positively correlated with N. perpallidus, further emphasizing that N. perpallidus prefers sluggish-water microhabitats (cf. Miller and Robison, 1973).

The positive correlation between the abundance of N. boops and N. perpallidus provides little insight into the preferences of the latter because N. boops has the broadest microhabitat distribution of the Notropis species I examined. Felley and Hill (1983) consider N. boops in northeastern Oklahoma to be "characteristic of quiet water and areas with cover." In Missouri, Pflieger (1975) reports that N. boops is found in streams with "large permanent pools" and that it "avoids strong currents and water that is continuously cool." My data suggest that, when compared with the congeners I examined, N. boops is a microhabitat generalist.

N. perpallidus was taken with at least one other Notropis species in every seine haul except one in the Saline River. Least-square regression shows that the number of N. perpallidus increased with the number of Notropis species collected in the same seine haul [$P < .005$; $r^2 = .20$; N. perpallidus abundance = $-1.126 + (1.56 \times$ number of Notropis species$)$]. Mendelson (1975) suggests that Notropis species, being mutually responsive, take on characteristics of a multispecific school. Such aggregations may provide protection to individuals without the disadvantage of intense intraspecific competition, but only if resource segregation is occurring among the species (Mendelson, 1975; Baker and Ross, 1981). Also, there might be a range of microhabitat characteristics that the *Notropis* strategy is best suited for, which promote multispecific aggregations. On the other hand, these aggregations may be more apparent than real since there is much opportunity for segregation within a complex microhabitat -- for example, in the vertical dimension (Baker and Ross, 1981) and on the basis of substrate patches. This points out the need for underwater, visual observations of the structure of these multispecific aggregations.

In summary, *N. perpallidus* associates with species typical of quieter-water microhabitats. The abundance of the species appears to increase with the number of *Notropis* species it is taken with, although causation is debatable.

Abundance

Discussion

The number of collections and sampling stations producing *N. perpallidus* during this study, in combination with the number of specimens taken, indicate that within its geographic range, *N. perpallidus* is the least abundant of the eight shiners examined (Table II). Although three other species, *N.* sp., *N. venustus*, and *N. volucellus*, occurred in fewer seine hauls, all three were taken in greater numbers than *N. perpallidus*. Thus, even where it occurs, population densities of *N. perpallidus* are relatively low. Furthermore, a series of random samples would show *N. perpallidus* to be much rarer than indicated in Table II, since most of the collection localities were chosen because they represented known locations of the occurrence of *N. perpallidus*. For example, a recent survey (1981-82) of 156 localities, primarily in smaller streams, produced no specimens of *N. perpallidus* from the Little River drainage (D. A. Rutherford, pers. comm.).

The largest series previously reported was 35 specimens (NLU 35231) from the upper Ouachita River at the McGuire Public Access Area, 2.4 km south of SH 88, Polk County, Arkansas (Robison 1981). However, J. Pigg (pers. comm.) collected a series of 53 specimens (OSH329 and OKSU uncatalogued) at a low-water bridge near the Little River Ranch (Sec. 14, T2S, R20E), Pushmataha County, Oklahoma.

Robison (1981) inferred from his collection data that the largest populations of *N. perpallidus* occur in Arkansas, primarily the Ouachita River above Lake Ouachita. During this study, extensive sampling of five localities on two separate occasions yielded only four specimens from the upper Ouachita River. Although a persistent population of *N. perpallidus* occurs in this area, there may be some reason to question its stability since population levels apparently have declined.

Resurveys of the Saline (Stackhouse, 1982) and the Little Missouri Rivers (Loe, 1983) also have established the presence of viable populations of *N. perpallidus*. Stackhouse (1982) captured 65 specimens in 20 collections, while Loe (1983) took 77 specimens in seven collections from five localities. Efforts to collect *N. perpallidus* in the mainstream of the Little Missouri River were unsuccessful (Loe, 1983). During this study, in 1983, *N. perpallidus* was collected at all sample sites in the mainstream of the Saline River and in tributaries of the Little Missouri River, but not in the mainstream of the Little Missouri.

N. perpallidus previously maintained a stable population in the Caddo River (Snelson and Jenkins, 1973; Robison, 1981). However, only 17 specimens have been taken in the Caddo River since the completion of DeGray Reservoir (Dewey and Moen, 1978). During this study, no specimens of *N. perpallidus* were collected at two sampling locations above or at a single locality below DeGray Reservoir. Previous collecting sites above the reservoir had been severely affected by the 1983 floods and large areas had been bulldozed in order to clear debris. This alteration may be at least in part responsible for the inability to find specimens of *N. perpallidus* in the upper Caddo River.

The abundance of *N. perpallidus* in southeastern Oklahoma has been considered low compared to that in Arkansas (Snelson and Jenkins, 1973; Robison, 1981). This may be due, in part, to difference in collection efforts aimed specifically at *N. perpallidus*. Robison (1981) listed only 11 collections from nine Oklahoma localities, with a total of 65 specimens. Subsequent reports, along with collections made during this study, raise the numbers to 50 collections from 25 localities which yield approximately 381 specimens (Table V). Previous to this study, no specimens had been reported from above Pine Creek Reservoir on the Little River (Snelson and Jenkins, 1973; Robison, 1981). Now, eight collections from four localities, including 76 specimens, have been recorded by J. Pigg (pers. comm.) in 1978, and by myself during this study. Similarly, only one collection of five specimens was known from the Glover River (Robison, 1981), but now there are seven known collections of 133 specimens from three localities. During this study, 50 specimens in seven collections at four localities were taken in the Little River. No specimens of N. perpallidus were taken downstream from the Wright City water plant on the Little River.

In the Kiamichi River, Robison (1981) reported only 15 specimens of N. perpallidus in three collections from separate localities. In 1983, we collected 45 specimens from four localities above Hugo Reservoir. Two of the four locations were sampled a second time in 1983, but no specimens were collected. At one of the two sites, the area in the stream where specimens were previously taken had been altered by a gravel removal operation.

In summary, previous statements that the largest populations of N. perpallidus exist in Arkansas seem equivocal. Of the 55 known collection localities, 30 are from Arkansas and 25 are from Oklahoma Table V). Of the total number of specimens, 442 are from Arkansas (54%) and 381 are from Oklahoma (46%). In Arkansas, most specimens are from the Saline, Little Missouri and Ouachita Rivers. Population levels may have declined in the upper Ouachita River. Historically, the Caddo River supported a population of N. perpallidus but, despite collecting efforts, specimens have not been taken from there since 1975 (Dewey and Moen, 1978), thus indicating a possible decline in abundance of the species. The Glover and Kiamichi rivers and the upper Little River seem to have viable populations of N. perpallidus. McGee Creek of the Muddy Boggy River drainage may also support a population but further sampling is required. No specimens have been collected in the Mountain Fork River since 1967, and N. perpallidus may have been extirpated from that river. Also, in recent years, N. perpallidus may have declined in

TABLE V

NUMBER OF COLLECTIONS, LOCALITIES AND SPECIMENS OF *NOTROPIS PERPALLIDUS* FROM RIVERS IN OKLAHOMA AND ARKANSAS

State	River	Number of Collections	Number of Localities	Number of Specimens
Oklahoma	Glover	7	3	133
	Kiamichi	8	5	53
	Little	28	13	175
	McGee Creek	1	1	3
	Mountain Fork	6	3	17
Subtotal		50	25	381
Arkansas	Caddo	12	5	89
	Little Missouri	14	8	120
	Ouachita	18	5	122
	Saline	36	12	111
Subtotal		80	30	442
TOTAL		130	55	823

the Little River below Pine Creek reservoir. In the past, J. Pigg (pers. comm.) often collected N. perpallidus at the Highway 70 bridge north of Idabel (Sec. 14, T7S, R24E), but recent efforts have been unsuccessful.

Life History Aspects

Reproduction

Information regarding the reproductive biology of N. perpallidus is restricted primarily to brief treatment by Snelson and Jenkins (1973). Females show evidence of egg development in April, when larger males have slightly enlarged testes. Females are gravid from May through August, suggesting a protracted spawning period (Snelson and Jenkins, 1973). From late May through early August, males are tuberculate (Snelson and Jenkins, 1973). Male specimens collected in this study were tuberculate from June through August, but no specimens were collected in May. Robison (1981) noted that specimens taken in September from the upper Ouachita River were not in reproductive condition. Snelson and Jenkins (1973) reported 6 August as the earliest known date of capture of a young-of-year specimen (SL = 18.6 mm). The smallest known specimen (SL = 16.4 mm) was taken in the upper Ouachita on 8 April (NLU 35265); this individual probably was from a late spawn the previous year.

Growth

Snelson and Jenkins (1973) discussed growth patterns for N. perpallidus. Most rapid growth occurs in the first year of life when individuals can reach 22-25 mm by early October. Growth slows considerably in winter and spring. Growth rate and size were not apparently different between the sexes. Although growth rate data were not possible to obtain due to a paucity of specimens, length measurements were taken on 115 specimens (Appendix E).

Food Habits

Morphological characters of *N. perpallidus*, such as raptorial teeth, short intestine and silvery peritoneum, suggest a carnivorous diet. Food items from the gut contents of 10 specimens (Snelson and Jenkins, 1973) and 11 other specimens (Robison, 1981) indicate a preference for aquatic insects, and infer that feeding occurs in all parts of the water column.

CHAPTER IV

STATUS

Historical

Many authors have considered the status of *N. perpallidus* although the species is not officially recognized as a federally threatened or endangered species. Snelson and Jenkins (1973) suggested federal listing of the species since habitat alterations could only add to the problems associated with a small population size and a restricted distribution.

Buchanan (1974) assigned an endangered (rare) classification to *N. perpallidus* in Arkansas, while in Oklahoma, Robison *et al*. (1975) listed it as rare. Seehorn (1975) listed *N. perpallidus* as threatened in the Ouachita National Forest. More recently, Deacon (1979) and Robison (1981) considered *N. perpallidus* to be threatened over its entire range.

Environmental Impacts

Hubbs and Pigg (1976) consider reservoir construction to be the major factor threatening the survival of the native fish fauna of Oklahoma. *N. perpallidus* may be particularly susceptible to effects of reservoirs since impoundments are often constructed on the small to intermediate-sized rivers that it inhabits (Snelson and Jenkins, 1973).

Since 1966, seven reservoirs (e.g., Broken Bow, Clayton, DeGray, Hugo, Lake Ouachita, Millwood, and DeQueen) have been constructed in the known range of N. perpallidus. No specimens of N. perpallidus have ever been taken in a reservoir.

The population of N. perpallidus in Mountain Fork River below Broken Bow Reservoir apparently has been exterminated. Taylor and Wade (1972) predicted that, over time, an increase in reservoir-affiliated species would occur below Broken Bow Reservoir. They erroneously listed N. perpallidus as a species that might increase over time. Hypolimnetic water released from the dam may have been a major factor in eliminating the population. During a visit on 21 July, the water in the Mountain Fork River east of Broken Bow was 19° C, 9.5° cooler than the Little River at the Highway 289 bridge (28.5° C). On 4 August, a difference of 12° C was noted between the water temperature in the Little River above and below the mouth of the Mountain Fork River (30° C at Idabel and 18° C north of Goodwater).

The Caddo River population below DeGray Reservoir probably is being affected by the reservoir. On two occasions, we visited the Caddo River at the Interstate 30 bridge. A water release from the reservoir prohibited sampling on the first occasion but the second sample included only six species with Labidesthes sicculus as the decided dominant. The water temperature was relatively warm (30.5° C) so the effect of the dam on the Caddo River may not be the same as that on the Mountain Fork River.

New reservoirs are planned or under construction on McGee Creek and the upper Kiamichi River. Lukfata Dam on the Glover River is also being reconsidered. Proposals have been made in the past to construct a reservoir on the Saline River in Arkansas but no definite plan has been approved. Due to the widespread construction of reservoirs within the limited range of N. perpallidus, dams may indeed pose the single largest threat to the existence of this species.

Pollution may also be a threat to populations of N. perpallidus. J. Pigg (pers. comm.) has collected N. perpallidus numerous times at the Highway 289 bridge on the Little River. Recent efforts have not established the presence of this species at that site. Effluent from a chicken-processing plan on Lukfata Creek just above the sample site may have caused the observed decline in N. perpallidus (J. Pigg, pers. comm.). Robison (1981) reported chemical spills that cause fish kills over several miles of habitat in the range of N. perpallidus.

Gravel removal and other types of stream alteration are other threats to populations of N. perpallidus. Often, private, and sometimes public agencies remove large amounts of gravel from streambeds (Robison, 1981). While sampling on the Kiamichi where specimens of N. perpallidus had been collected on an earlier trip, we noticed evidence of gravel removal activities at our sample site. Despite extensive sampling, N. perpallidus were not collected.

Pollution and gravel removal are localized problems that tend to be more transitory in nature if actions are taken to forestall permanent problems. Reservoirs, on the other hand, represent a relatively permanent change in the available habitat, and thus represent the major threat to N. perpallidus.

Recommended Status

When compared to its congeners, the distribution of *N. perpallidus* is very patchy (Snelson and Jenkins, 1973; Robison, 1981; see Fig. 1), and population densities are relatively low (Table II). Nonetheless, viable, low density populations occur in the Saline, Little, Missouri, and Ouachita Rivers in Arkansas, and in the Glover, Little, Kiamichi and Muddy Boggy Rivers in Oklahoma. These areas encompass three major drainages of the Red River. Thus, it seems unlikely that the species will be threatened with extinction in the near future.

Although I do not recommend placing *N. perpallidus* on the federal endangered species list, the species does deserve special attention. There is good evidence to suggest that reservoirs are causing the extant populations to decline. Plans for several new reservoirs increase the danger of extirpation of *N. perpallidus* from areas within its range. As Snelson and Jenkins (1973) noted, small population size makes the species more susceptible to environmental impacts and chance extirpation.

Critical Habitat

Critical habitat is a designation that is used by public agencies to denote habitat that is important for the survival of a particular species. Any modification of the designated habitat areas must be carefully evaluated to prevent adverse effects on the continued survival of the species of concern. Official critical habitat has not been designated for *N. perpallidus* because it is not a federally listed species, however, the following portions of stream should be considered critical for the survival of N. perpallidus:

Ouachita River Drainage:

1. Saline River: Main channel of the Saline River from the Interstate 30 bridge near Benton, Arkansas, to 9.6 km southeast of Johnsville.

2. Ouachita River: Mainstream of the upper Ouachita River from McGuire Public Access area (Sec. 22, T2S, R28W) downstream to Highway 298 bridge.

3. Little Missouri River: Mainstream of Little Missouri River from the mouth of the Antoine River downstream to the confluence with the Ouachita River. Terre Noir Creek and the Antoine River, below Antoine, tributaries to the Little Missouri River.

Little River Drainage

1. Glover River: Mainstream of the Glover River from Weyerhauser logging road 7100 (Sec. 9, T5S, R23E) to the mouth of the Little River.

2. Little River: Mainstream of the Little River from 1.6 km southeast of Nashoba, Oklahoma (Sec. 15, T1S, R20E) downstream to the Oklahoma/Arkansas border, excluding Pine Creek reservoir.

Kiamichi River Drainage

1. Kiamichi River: Mainstream of the Kiamichi River from near Kiamichi, Oklahoma (Sec. 23, T2N, R20E) downstream to 27 km north of Antlers, Oklahoma (Sec. 19, T1S, R17E).

Muddy Boggy River Drainage

1. McGee Creek: McGee Creek near Highway 43 bridge (Sec. 33, T1N, R14E ?). The extent of this population needs to be documented.

Management Recommendations

1. I recommend a long term, continuing effort to monitor the population levels of *Notropis perpallidus*, particularly in areas where reservoirs are being constructed within its range. Included in this effort should be an exploration of the life history of *N. perpallidus* with an emphasis on spawning strategy and requirements.

2. The Saline and Glover Rivers are the only undammed streams within the range of *N. perpallidus*. If these streams could be protected then existing populations could be better preserved. Construction of new reservoirs anywhere in the range of *N. perpallidus* should be considered in terms of the potential effect on populations of this species.

3. Pollution input into the streams must be closely monitored. Persistent point sources should be eliminated.

4. The extent and duration of gravel-removal operations should be monitored. Effects of short term operations on the survival of populations may not be as important as extensive long-term gravel removal.

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APPENDIX A

MUSEUMS WITH COLLECTION RECORDS OF

NOTROPIS PERPALLIDUS

Abbreviation	Museum
CU	Cornell University
FWS	U.S. Fish and Wildlife Service
NLU	Northeast Louisiana University
OHS	Oklahoma Department of Health Sciences (J. Pigg)
OKS	Oklahoma State University Museum of Natural and Cultural History
OU	University of Oklahoma Museum of Zoology
SAU	Southern Arkansas University
TU	Tulane University
UF	University of Florida
UMM (UMMZ)	University of Michigan Museum of Zoology
USN (USNM)	National Museum of Natural History
UTU	University of Tulsa

APPENDIX B

DESCRIPTION OF CATEGORIES USED IN

MEASURING STREAM HABITAT

Dimension		Category number and description					
		1	2	3	4	5	6
Depth	Range (cm)	0-30	30-60	60-90	>90		
	Description	shallow	moderate	deep	very deep		
Current	Velocity (m/s)	0-2	.2-4	.4-.6	.6-.8	>.8	
	Description	very slow	slow	moderate	fast	torrent	
Substrate	Diameter (mm)*	<.06	.06-2	2-64	64-256	>256	large mass of solid rock
	Description	mud	sand	gravel	rubble	boulder	bedrock
Biotic structure	Description	emergent vascular	submergent vegetation	detritus	brush		

*Adapted from Gorman and Karr (1978).
**Adapted from Modified Wentworth particle size scale (Bovee and Cochnauer, 1977).

APPENDIX C

A LIST OF KNOWN COLLECTIONS OF *NOTROPIS PERPALLIDUS* INCLUDING LOCATION, LEGAL DESCRIPTION, DATE, MACROHABITAT DATA AND NUMBER OF SPECIMENS

OBS	ST	CO	DR	RIV	SITE	SECTION	MU	COLL	D	MO	Y	TY	SP	GRAD	ELE	S
1	AR	CLAR	CAD	CADDO	AT RT.182 BRIDGE 2.3 KM N AMITY	S.22T.5S.R.23W.	NLU	16637	28	6	70	NO	20	1 05	138	4
2	AR	CLAR	CAD	CADDO	ST.HWY. 84 BR., 4.6 KM E OF AMITY	S.24T.5S.R.23W.	FWS	0	0	0	0	NO	0	1.26	131	4
3	AR	CLAR	CAD	CADDO	AT I-30 BRIDGE, 6 4 KM N ARKADELPHIA	S.3T.6S.R.19W.	FWS	0	0	0	0	NO	0	0.81	57	4
4	AR	CLAR	CAD	CADDO	AT I-30 BRIDGE 6.4 KM N OF ARKADELPHIA	S.3T.6S.R.19W.	NLU	17435	7	10	70	NO	15	0.81	57	4
5	AR	CLAR	CAD	CADDO	AT I-30 BRIDGE 6.4 KM N OF ARKADELPHIA	S.3T.6S.R.19W.	NLU	18704	4	4	71	NO	3	0.81	57	4
6	AR	CLAR	CAD	CADDO	CADDO R. BETWEEN HWY. 67 AND I-30	S.3T.6S.R.19W.	NLU	24218	5	8	72	NO	5	0.81	57	4
7	AR	CLAR	CAD	CADDO	CONTROL DAM SPILLWAY, 3.2 KM W CADDO VALLEY	S.35-36T.6S.R.19W.	NLU	18748	4	4	71	NO	15	0.81	60	4
8	AR	CLAR	CAD	CADDO	BELOW CONTROL DAM SPILLWAY, 3.2 KM W CADDO V.	S.35-36T.6S.R.19W.	NLU	17848	12	2	71	NO	1	0.81	60	4
9	AR	CLAR	CAD	CADDO	CONTROL DAM SPILLWAY, 3.2 KM W CADDO VALLEY	S.35-36T.6S.R.19W.	NLU	18435	19	2	71	NO	1	0.81	60	4
10	AR	CLAR	CAD	CADDO	CA. .4 KM BELOW REGULATING POOL DAM	S 36T.6S.R.19W.	FWS	0	0	0	0	NO	0	0.81	59	4
11	AR	CLAR	CAD	CADDO	.5 KM BELOW DEGRAY DAM	S.36T.6S.R.19W.	NLU	18182	12	2	71	NO	1	0.81	59	4
12	AR	CLAR	CAD	CADDO	.5 KM BELOW DEGRAY DAM	S.36T.6S.R.19W.	NLU	18298	19	2	71	NO	6	0.81	59	4
13	OK	PUSH	KIA	KIAMIC	CA. 17 MI. N ANTLERS (8.5 MI. S STANLEY)	S.19T.1S.R.17E.	OKS	0	4	8	83	NO	5	0.29	144	5
14	OK	PUSH	KIA	KIAMIC	KIAMICHI R. NEAR KIAMICHI	S.23T.2N.R.20E.	OU	40660	0	0	65	NO	6	0.48	173	4
15	OK	PUSH	KIA	KIAMIC	NEAR KIAMICHI	S.23T.2N.R.20E.	OKS	0	11	6	83	NO	30	0.48	173	4
16	OK	PUSH	KIA	KIAMIC	KIAMICHI .4 KM N .6 KM E OF STANLEY	S.24T.1N.R.17E.	OO	0	0	0	0	NO	0	0.53	151	5
17	OK	PUSH	KIA	KIAMIC	.4 KM N 1.1 KM E OF STANLEY ON DIRT ROAD	S.24T.1N.R.17E.	OKS	0	10	4	83	NO	1	0.53	151	5
18	OK	PUSH	KIA	KIAMIC	KIAMICHI R. 5.6 KM SW STANLEY	S.3T.1S.R.17E.	OU	0	0	0	0	NO	0	0.53	147	5
19	OK	PUSH	KIA	KIAMIC	KIAMICHI 1.6 KM SE OF CLAYTON, HWY. 2 BRIDGE	S.7T.1N.R.19E.	OHS	937	1	7	82	NO	1	0.44	160	5
20	OK	PUSH	KIA	KIAMIC	KIAMICHI 1.1 KM SE CLAYTON, HWY 271 BRIDGE	S.7T.1N.R.19E.	OKS	0	9	4	83	NO	10	0.53	151	5
21	OK	MCCU	LIT	GLOVER	AT HWY. 7 AND 3	S.28T.5S.R.23E.	UTU	4866	5	6	78	NO	1	1.24	116	5
22	OK	MCCU	LIT	GLOVER	ON HWY. 7 AND 3, W OF BROKEN BOW	S.28T.5S.R.23E.	OU	0	16	7	82	NO	36	1.24	116	5
23	OK	MCCU	LIT	GLOVER	AT HWY 3 AND 7 BRIDGE	S.28T.5S.R.23E.	OKS	0	20	7	83	NO	1	1.24	116	5
24	OK	MCCU	LIT	GLOVER	CA. .8 KM W OF GLOVER	S.33T.5S.R.23E.	SAU	0	0	0	0	NO	0	0.82	113	5
25	OK	MCCU	LIT	GLOVER	AT GLOVER	S.33T.5S.R.23E.	OU	49721	6	6	72	NO	43	0.82	113	5
26	OK	MCCU	LIT	GLOVER	W OF GLOVER S OF BRIDGE	S.33T.5S.R.23E.	OKS	0	20	7	83	NO	16	0.82	113	5
27	OK	MCCU	LIT	GLOVER	LOW WATER BRIDGE ON WEYERHAUSER RD. 71000	S.9T.5S.R.23E.	OKS	0	8	6	83	NO	36	0.97	126	5
28	OK	MCCU	LIT	LITTLE	2 MI. N OF GOODWATER	NOT AVAILABLE	UTU	2432	8	5	74	NO	2	0.22	91	6
29	OK	MCCU	LIT	LITTLE	7 MI. S OF BROKEN BOW ON HWY. 259(ADAMS 502)	S.14T.7S.R.24E.	UTU	0	0	3	65	NO	3	0.23	97	5
30	OK	MCCU	LIT	LITTLE	BETWEEN ANTLERS AND BROKEN BOW ON STATE 7	S.14T.7S.R.24E.	UTU	496	14	5	65	NO	7	0.00	0	0
31	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N IDABEL (11 SPEC. -OKS UNCAT)	S.14T.7S.R.24E.	OSH	148	8	6	77	NO	2	0.23	97	5
32	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N IDABEL	S.14T.7S.R.24E.	OSH	189	13	7	77	NO	3	0.23	97	5
33	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N OF IDABEL	S.14T.7S.R.24E.	OSH	475	2	2	78	NO	2	0:23	97	5
34	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N OF IDABEL(5 SPEC.-OKS UNCAT)	S.14T.7S.R.24E.	OSH	333	5	6	78	NO	2	0.23	97	5

OBS	ST	CO	DR	RIV	SITE	SECTION	MU	COLL	D	MO	Y	TY	SP	GRAD	ELE	S
35	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N OF IDABEL	S.14T.7S.R.24E.	OKS	0	25	10	78	NO	1	0.23	97	5
36	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N OF IDABEL	S.14T.7S.R.24E.	OKS	0	27	10	79	NO	3	0.23	97	5
37	OK	MCCU	LIT	LITTLE	HWY. 70 BRIDGE N IDABEL	S.14T.7S.R.24E.	OSH	913	10	10	81	NO	2	0.23	97	5
38	OK	MCCU	LIT	LITTLE	AT ARKANSAS BORDER	S.16T.7S.R.27E.	UTU	0	0	5	63	NO	1	0.22	88	6
39	OK	MCCU	LIT	LITTLE	.4 KM E 2.4 KM N CERROGORDO AT STATE LINE	S.16T.7S.R.27E.	OKS	0	6	6	78	NO	2	0.22	88	6
40	OK	MCCU	LIT	LITTLE	ABOVE MOUTH OF SUGAR CR. (ALSO S.18-20)	S.17T.7S.R.26E.	CU	24424	16	8	50	NO	2	0.22	95	5
41	OK	MCCU	LIT	LITTLE	ABOVE MOUTH OF SUGAR CR. (ALSO S.18-20)	S.17T.7S.R.26E.	UMM	164597	16	8	50	NO	10	0.22	95	5
42	OK	MCCU	LIT	LITTLE	ABOVE MOUTH OF SUGAR CR. (ALSO S.18-20)	S.17T.7S.R26E.	TU	10574	16	8	50	NO	5	0.22	95	5
43	OK	MCCU	LIT	LITTLE	CUTOFF POOL, NW OF IDABEL	S.19T.7S.R.24E.	OU	29596	25	7	55	NO	7	0.16	99	5
44	OK	MCCU	LIT	LITTLE	CUTOFF POOL, NW OF IDABEL	S.19T.7S.R.24E.	OU	30999	25	7	55	NO	4	0.16	99	5
45	OK	MCCU	LIT	LITTLE	2 KM E MOUND GROVE BARNETT FARM	S.25T.5S.R.21E.	OKS	0	4	6	78	NO	2	0.21	110	4
46	OK	MCCU	LIT	LITTLE	2.4 KM N GARVIN BELOW BRIDGE	S.5T.7S.R.23E.	OKS	0	5	6	78	NO	1	0.17	102	5
47	OK	MCCU	LIT	LITTLE	NEAR LOW WATER BR. AT WRIGHT CITY WATER PLANT	S.7T.6S.R.22E.	OKS	0	5	9	82	NO	20	0.21	109	4
48	OK	MCCU	LIT	LITTLE	S. LOW WATER BR AT WRIGHT CITY WATER PLANT	S.7T.6S.R.22E.	OKS	0	4	8	83	NO	13	0.21	109	4
49	OK	MCCU	LIT	LITTLE	S. LOW WATER BR. AT WRIGHT CITY WATER PLANT	S.7T.6S.R.22E.	OKS	0	22	10	83	RE	4	0.21	109	4
50	OK	MCCU	LIT	LITTLE	4 KM E 3.2 KM N GOODWATER	S.7T.7S.R.27E.	OSH	276	18	7	78	NO	1	0.42	89	6
51	OK	PUSH	LIT	LITTLE	LOW WATER CROSSING NEAR LITTLE R. RANCH	S.14T.2S.R.20E.	OSH	329	3	6	78	NO	2	1.08	173	4
52	OK	PUSH	LIT	LITTLE	SAME COLLECTION AS OSH 329	S.14T.2S.R.20E.	OKS	0	3	6	78	NO	51	1.08	173	4
53	OK	PUSH	LIT	LITTLE	CA. 1.6 KM SE NASHOBA (OKS UNCAT 4 SPEC.)	S.15T.1S.R.20E.	OSH	303	1	6	78	NO	2	1.02	192	3
54	OK	PUSH	LIT	LITTLE	CA. 1.6 KM SE NASHOBA	S.15T.1S.R.20E.	OKS	0	10	4	83	NO	1	1.02	192	3
55	OK	PUSH	LIT	LITTLE	6.7 KM E CLOUDY	S.3 T.3S.R.20E.	OKS	0	3	6	78	NO	6	1.20	156	4
56	OK	PUSH	LIT	LITTLE	6.7 KM E OF CLOUDY	S.3T.3S.R.20E.	OKS	0	9	6	83	NO	4	1.20	156	4
57	OK	PUSH	LIT	LITTLE	1.6 KM N 4.8 KM NE CLOUDY TOWER(OKS UNCAT-9)	S.35T.1S.R.20E.	OSH	372	1	6	78	NO	2	0.84	184	4
58	OK	PUSH	LIT	LITTLE	1 MI. N 5 MI. E CLOUDY TOWER, ROAD 84000	S.35T.1S.R.20E.	OKS	0	10	6	83	NO	7	0.84	184	4
59	OK	PUSH	LIT	LITTLE	1 MI. N 5 MI. E CLOUDY TOWER, ROAD 84000	S.35T.1S.R.20E.	OKS	0	23	10	83	NO	1	0.84	184	4
60	OK	MCCU	LIT	MOUNTF	MOUNTAIN FORK R. AT DAM, BEAVER'S BEND S.P.	NOT AVAILABLE	OKS	597	6	6	47	NO	1	0.00	0	5
61	OK	MCCU	LIT	MOUNTF	MOUNTAIN FORK R. E OF BROKEN BOW	NOT AVAILABLE	CU	52231	12	5	67	NO	6	0.84	103	5
62	OK	MCCU	LIT	MOUNTF	MOUNTAIN FORK R. NEAR MOUTH,W OF FORKED LAKE	S.10T.7S.R.26E.	OU	26248	20	8	48	NO	2	0.42	91	5
63	OK	MCCU	LIT	MOUNTF	MOUNTAIN FORK R. NEAR MOUTH,W OF FORKED LAKE	S.10T.7S.R.26E.	OU	29301	2	6	55	NO	2	0.42	91	5
64	OK	MCCU	LIT	MOUNTF	MOUNTAIN FORK R. AT CUTOFF POOL NEAR MOUTH	S.10T.7S.R.26E.	OU	37334	17	6	55	NO	5	0.42	91	5
65	OK	MCCU	LIT	MOUNTF	AT MOUTH OF MOUNTAIN FORK RIVER	S.10T.7S.R.26E.	OKS	5592	32	12	57	NO	1	0.42	90	5
66	OK	ATOK	MUD	MCGEE	MCGEE CR. HWY 43 BRIDGE (S 33T.1N.R.14E.?)	NOT AVAILABLE	OKS	0	0	0	0	NO	3	0.86	200	3
67	AR	PIKE	LMR	ANTOIN	ANTOINE R AT ANTOINE	S.23T.8S.R.23W.	NLU	17017	2	8	70	NO	1	0.77	103	3
68	AR	PIKE	LMR	ANTOIN	ANTOINE R. AT ANTOINE, HWY. 26	S.23T.8S.R.23W.	NLU	26252	19	6	73	NO	5	0.77	103	3

OBS	ST	CO	DR	RIV	SITE	SECTION	MU	COLL	D	MO	Y	TY	SP	GRAD	ELE	S
69	AR	PIKE	LMR	ANTOIN	ANTOINE R. AT ANTOINE, HWY 26	S.23T.8S.R.23W.	OKS	0	3	8	83	NO	5	0.77	103	3
70	AR	OUAC	LMR	LITTMO	AT OUACHITA R. BRIDGE, 17 KM NE CHIDESTER	S.1T.11S.R.18.W.	NLU	26560	6	7	73	NO	1	0.27	34	5
71	AR	OUAC	LMR	LITTMO	16 KM NE OF CHIDESTER	S.3T.11S.R.18W.	NLU	23789	27	8	72	NO	0	0.27	37	5
72	AR	OUAC	LMR	LITTMO	LITTLE MISSOURI R., CA. 16 KM NE CHIDESTER	S.3T.11S.R.18W.	NLU	24789	27	8	72	NO	8	0.27	37	5
73	AR	OUAC	LMR	LITTMO	LITTLE MISSOURI R., CA. 16 KM NE CHIDESTER	S.3T.11S.R.18W.	NLU	24108	28	7	72	NO	14	0.27	37	5
74	AR	CLAR	OUA	BELL	BELL CREEK 2-2.25 MI. W HOLLYWOOD ON HWY 26	S.31T.7S.R.21W.	NLU	52053	5	6	82	NO	1	1.26	72	1
75	AR	MONT	OUA	OUACHI	AT CHASEWOOD LANDING 1.6 KM E OF HWY. 298	S.28T.1S.R.25W.	NLU	34746	2	10	76	NO	1	0.79	192	5
76	AR	MONT	OUA	OUACHI	OUACHITA R. AT U.S. HWY. 270	S.32T.1S.R.25W.	SAU	0	0	0	0	NO	0	0.82	200	5
77	AR	MONT	OUA	OUACHI	OUACHITA R. AT HWY. 270	S 32T.1S.R.25W.	SAU	0	0	0	0	NO	0	0.82	200	5
78	AR	MONT	OUA	OUACHI	OUACHITA R., RT.270 BR., 8 AIR KM NW MT. IDA	S.32T.1S.R.25W.	CU	52317	30	5	67	NO	21	0.82	200	5
79	AR	MONT	OUA	OUACHI	OUACHITA R., RT.270 BR., 8 AIR KM NW MT. IDA	S.32T.1S.R.25W.	USN	206218	14	6	70	NO	7	0.82	200	5
80	AR	MONT	OUA	OUACHI	OUACHITA R , RT.270 BR., 8 AIR KM NW MT. IDA	S.32T.1S.R.25W.	UF	18006	8	6	71	NO	19	0.82	200	5
81	AR	MONT	OUA	OUACHI	OUACHITA R. AT HWY. 270 BR., ROCKY SHOALS	S 32T.1S.R.25W.	NLU	35612	23	5	77	NO	2	0.82	200	5
82	AR	MONT	OUA	OUACHI	OUACHITA R. 1.1 KM S HWY 88 E OF PINE RIDGE	S 9T.2S.R.27W.	OKS	0	19	6	83	NO	4	0.93	231	5
83	AR	POLK	OUA	OUACHI	11.2 KM FROM CHERRY HILL OFF HWY.88	S.?T.2S.R.29W.	NLU	34311	19	6	76	NO	1	0.00	0	4
84	AR	POLK	OUA	OUACHI	1.1 KM S OF CHERRY HILL	S.16T.2S.R.28W.	NLU	34652	11	9	76	NO	2	0.91	252	4
85	AR	POLK	OUA	OUACHI	1.1 KM S OF CHERRY HILL	S.16T.2S.R.28W.	NLU	35265	8	4	77	NO	8	0.91	252	4
86	AR	POLK	OUA	OUACHI	1.1 KM S OF CHERRY HILL	S.16T.2S.R.28W.	NLU	35630	23	5	77	NO	1	0.91	252	4
87	AR	POLK	OUA	OUACHI	OUACHITA R. 1.1 KM S. OF CHERRY HILL	S.16T.2S.R.28W.	NLU	34336	17	7	82	NO	0	0.91	252	4
88	AR	POLK	OUA	OUACHI	MCGUIRE PUBLIC ACCESS, 3.2 KM S HWY 88	S.22T.2S.R.19W.	NLU	35231	8	4	77	NO	35	0.91	249	4
89	AR	POLK	OUA	OUACHI	2 3 KM S OF ST.HWY. 88, 5.6 KM S CHERRY HILL	S.22T.2S.R.28W.	SAU	0	0	0	0	NO	0	0.91	249	4
90	AR	POLK	OUA	OUACHI	2.3 KM S OF ST.HWY. 88, 5.6 KM S CHERRY HILL	S.22T.2S.R.28W.	SAU	0	0	0	0	NO	0	0.91	249	4
91	AR	POLK	OUA	OUACHI	2 4 KM S OF HWY. 88, 5.6 KM S CHERRY HILL	S.22T.2S.R.28W.	NLU	34907	5	11	76	NO	3	0.91	249	4
92	AR	POLK	OUA	OUACHI	2.4 KM S OF ST HWY. 88	S.22T.2S.R 29W.	NLU	35641	23	5	77	NO	18	0.91	249	4
93	AR	ÇLAR	OUA	TERRE	1 MI. E ARK. HWY 53, 3 MI. NE I-30	S.13T.8S.R.21W.	NLU	53243	10	6	83	NO	1	0.35	57	3
94	AR	CLAR	OUA	TERRE	TERRE NOIRE R., 8 KM SE CURTIS, IN BOAT DITCH	S.17T.9S.R.19W.	NLU	51135	17	7	82	NO	6	0.39	46	3
95	AR	CLAR	OUA	TERRE	TERRE NOIR R., 5 MI. SE CURTIS IN BOAT DITCH	S.17T.9S.R.19W.	OKS	0	2	8	83	NO	9	0.39	46	3
96	AR	CLAR	OUA	TERRE	TERRE NOIR R., 5 MI. SE CURTIS IN BOAT DITCH	S.17T.9S.R.19W.	NLU	53134	7	5	83	NO	11	0.39	46	3
97	AR	CLAR	OUA	TERRE	2.5 MI. S. OAK GROVE ON U.S. HWY 67	S.2T.9S.R.20W.	NLU	52363	18	9	82	NO	4	0.44	48	3
98	AR	CLAR	OUA	TERRE	3 MI. W. OAK GROVE ON GRAVEL RD, BOAT DITCH	S.3T.9S.R.20W.	NLU	52067	17	7	82	NO	33	0.44	48	3
99	AR	CLAR	OUA	TERRE	2.5 MI W. OAK GROVE	S.34T.8S.R.20W.	NLU	52117	17	7	82	NO	21	0.48	52	3
100	AR	ASHL	SAL	SALINE	CA. 8 KM S OF JOHNSVILLE	S.26T.16S.R.9W.	NLU	24176	5	8	72	NO	2	0 09	22	5
101	AR	ASHL	SAL	SALINE	8 KM S OF JOHNSVILLE	S.26T.16S.R.9W.	NLU	24509	9	8	72	NO	2	0.09	22	5
102	AR	ASHL	SAL	SALINE	8 KM S OF JOHNSVILLE	S.26T.16S.R.9W.	NLU	24379	26	7	72	NO	6	0.09	22	5

OBS	ST	CO	DR	RIV	SITE	SECTION	MU	COLL	D	MO	Y	TY	SP	GRAD	ELE	S
103	AR	ASHL	SAL	SALINE	8 KM S OF JOHNSVILLE OFF ARK. HWY. 160	S.26T.16S.R.9W.	NLU	28103	8	9	73	NO	1	0.09	22	5
104	AR	BRAD	SAL	SALINE	8 KM N WARREN	NOT AVAILABLE	UMM	125991	20	6	39	HO	1	0.12	32	5
105	AR	BRAD	SAL	SALINE	8 KM N WARREN	NOT AVAILABLE	UMM	125992	20	6	39	PA	1	0.12	32	5
106	AR	BRAD	SAL	SALINE	1.6 KM DOWNSTREAM HWY. 15, N OF WARREN	NOT AVAILABLE	NLU	37457	5	8	77	NO	3	0.21	32	5
107	AR	BRAD	SAL	SALINE	BLUE SPRINGS CA. 8 KM SE OF WARREN	S.10T.13S.R.9W.	NLU	47933	1	8	81	NO	3	0.21	28	5
108	AR	BRAD	SAL	SALINE	BLUE SPRINGS CA. 8 KM SE OF WARREN	S.10T.13S.R.9W.	NLU	47838	27	6	81	NO	2	0.21	29	5
109	AR	BRAD	SAL	SALINE	END CO. RD. S HWY 4, 1.6 KM E JCT. HWY.15 &4	S.15T.13S.R.9W.	NLU	50990	19	6	82	NO	2	0.21	28	5
110	AR	BRAD	SAL	SALINE	1.6 KM E OF HWY. 189, 11.2 KM N JOHNSVILLE	S.26T.14S.R.9W.	NLU	50998	20	6	82	NO	2	0.10	28	5
111	AR	BRAD	SAL	SALINE	CA. 9.6 KM SE OF JOHNSVILLE	S.26T.16S.R.9W.	SAU	0	0	0	0	NO	0	0.09	22	5
112	AR	BRAD	SAL	SALINE	9.6 KM S OF JOHNSVILLE	S.26T.16S.R.9W.	NLU	28741	30	9	73	NO	1	0.09	22	5
113	AR	BRAD	SAL	SALINE	AT BRIDGE 4.8 KM E WARREN	S.3T.12S.R.9W.	NLU	16533	21	6	70	NO	9	0.21	29	5
114	AR	BRAD	SAL	SALINE	AT HWY. 15 BRIDGE 8 KM N OF WARREN	S.3T.12S.R.9W.	NLU	51001	19	6	82	NO	1	0.12	32	5
115	AR	BRAD	SAL	SALINE	N. OF WARREN ON HWY 15	S.3T.12S.R.9W.	OKS	0	23	7	83	NO	1	0.21	32	5
116	AR	BRAD	SAL	SALINE	AT HWY. 4 BRIDGE 3.2 KM E OF WARREN	S.3T.13S.R.9W.	NLU	51005	19	6	82	NO	7	0.21	29	5
117	AR	CLEV	SAL	SALINE	CA. 9.6 KM NW OF RYE	S.6T.11S.R.9W.	NLU	16044	9	4	70	NO	1	0.14	34	5
118	AR	CLEV	SAL	SALINE	T.A.R. 6.4 KM SW OF HERBINE	S.6T.11S.R.9W.	NLU	51470	28	8	82	NO	0	0.14	34	5
119	AR	DREW	SAL	SALINE	AT OZMENT'S BLUFF AT END OF ST.HWY. 172	S.14T.14N.R.9W.	SAU	0	0	0	0	NO	0	0.11	26	5
120	AR	DREW	SAL	SALINE	OZMENTS BLUFF, 22 KM SW MONTICELLO ON RT. 172	S.14T.14N.R.9W.	NLU	16004	2	7	69	NO	4	0.11	[illegible]	[illegible]
121	AR	DREW	SAL	SALINE	AT END OF HWY. 172	S.14T.14S.R.9W.	TU	38312	0	0	0	NO	0	0.11	26	5
122	AR	GRAN	SAL	SALINE	HWY. 270 2.4 KM W OF PRATTSVILLE	NOT AVAILABLE	NLU	51107	10	7	82	NO	0	0.30	61	4
123	AR	GRAN	SAL	SALINE	3 MI. E OF POYEN ON HWY 270	S.2T.5S.R.15W.	OKS	0	22	7	83	NO	13	0.30	61	4
124	AR	GRAN	SAL	SALINE	U.S. HWY. 270, 8 KM W OF PRATTSVILLE	S.2T.5S.R.9W.	NLU	48848	22	11	81	NO	1	0.30	61	4
125	AR	GRAN	SAL	SALINE	AT U.S. HWY. 270, 4.8 KM E OF POYEN	S.26T.5S.R.15W.	SAU	0	0	0	0	NO	0	0.30	61	4
126	AR	GRAN	SAL	SALINE	2.5 MI. S OF TRASKWOOD ON HWY 229	S.4T.4S.R.15W.	OKS	0	22	7	83	NO	11	0.32	70	4
127	AR	GRAN	SAL	SALINE	CA. 8 KM N POYEN ON RT. 229	S.4T.4S.R.15W.	NLU	16905	6	8	70	NO	7	0.32	70	4
128	AR	GRAN	SAL	SALINE	4 KM S TRASKWOOD AT HWY. 229	S.4T.4S.R.15W.	NLU	44017	3	11	79	NO	3	0.32	70	4
129	AR	GRAN	SAL	SALINE	ST. HWY 229, .8 KM S OF SALINE CO. LINE	S.4T.4S.R.15W.	NLU	51106	10	7	82	NO	14	0.32	70	4
130	AR	GRAN	SAL	SALINE	4 KM E LEOLA ON RT. 46 JENKINS FERRY	S.8T.6S.R.14W.	NLU	16366	31	5	70	NO	1	0.21	55	5
131	AR	GRAN	SAL	SALINE	HWY. 46, CA. 4 KM NE LEOLA AT JENKINS FERRY	S.8T.6S.R.14W.	NLU	45562	6	7	80	NO	2	0.21	55	5
132	AR	GRAN	SAL	SALINE	ST. HWY. 46, 4.5 KM E LEOLA, JENKINS FERRY SP	S.8T.6S.R.14W.	NLU	48211	6	9	81	NO	2	0.21	55	5
133	AR	GRAN	SAL	SALINE	2.5 MI. E LEOLA ON RT. 46 JENKINS FERRY	S.8T.6S.R.14W.	OKS	0	23	7	83	NO	1	0.21	55	5
134	AR	SALI	SAL	SALINE	NEAR BENTON, JUST ABOVE R.R. BRIDGE,YEAR 1884	NOT AVAILABLE	UMM	197684	0	0	0	NO	4	0.48	78	4
135	AR	SALI	SAL	SALINE	ON CO. RD. 3.2 KM E RT.67, 2.2 S OF I-30	S.21T.2S.R.15W.	NLU	16418	28	5	70	NO	1	0.48	78	4
136	AR	SALI	SAL	SALINE	ST. HWY. 229, .8 KM S OF SALINE CO. LINE	S.4T.4S.R.15W.	NLU	48826	22	11	81	NO	12	0.32	70	4

LEGEND:

OBS = Observation
ST = State
CO = County
DR = Drainage
RIV = River
SITE = Locality

SECTION = Legal location
MU = Museum
COLL = Museum collection number
D = Collection day
MO = Collection month
Y = Collection year

TY = Specimen type: HO - holotype
PA - paratype
NO - no type
SP = Number of specimens
GRAD = Stream gradient (m/km)
ELE = Site elevation (m)
S = Stream order

APPENDIX D

LIST OF SPECIES COLLECTED AT LOCALITIES

NOTROPIS PERPALLIDUS

Species	Number of Stations	Number of Specimens
Campostoma anomalum	13	62
Etheostoma blennioides	1	14
E. collettei	1	1
E. nigrum	1	1
E. radiosum	3	9
E. spectabile	6	10
E. zonale	1	8
Fundulus catenatus	1	2
F. notatus	7	12
F. olivaceus	33	85
Gambusia affinis	17	89
Hybognathus nuchalis	2	5
Hybopsis x-punctata	1	1
Hypentelium nigricans	2	8
Labidesthes sicculus	81	766
Lepisosteus osseus	1	1
Lepomis cyanellus	6	9
L. humilis	2	4
L. macrochirus	13	27
L. megalotis	48	254
Micropterus dolomieui	3	6
M. punctulatus	17	28
M. salmoides	7	8
Notropis atherinoides	5	22
N. boops	111	4129
N. chrysocephalus	8	99
N. emiliae	1	1
N. fumeus	3	126
N. perpallidus	43	172
N. ortenburgeri	1	1
N. rubellus	40	720
N. sp. (undescribed)	30	1916
N. sp. (young-of-year)	9	28
N. umbratilis	36	369
N. venustus	39	195
N. volucellus	33	243
N. whipplei	116	899
Noturus nocturnus	1	2
Percina copelandi	8	17
P. sciera	1	1
Pimephales notatus	24	52
P. vigilax	16	75
Pomoxis nigromaculatus	1	1

APPENDIX E

STANDARD LENGTH MEASUREMENTS OF *NOTROPIS PERPALLIDUS* FROM COLLECTIONS IN 1983. UNDER EACH MONTH THE DATE OF CAPTURE IS FOLLOWED BY THE NUMBER OF SPECIMENS IN PARENTHESES

Standard Length (mm)	April 9(10) 10(2)	May 7(11)	June 5(1) 9(11) 11(30) 8(36) 10(1) 19(4)	July 20(10)
18	1			
21		1		
23	3	4	1	
24	4			
25	2		3	
26	2		1	
27			7	
28			4	
29			14	
30			18	
31			12	
32			12	4
33		2	4	3
34			1	
35			3	
36		1	1	1
37			1	
38			1	
39				
40				
41				1
42				1

2

VITAE

Bruce Alan Wagner

Candidate for the Degree of

Master of Science

Thesis: STATUS AND HABITAT UTILIZATION OF THE PEPPERED SHINER, *NOTROPIS PERPALLIDUS* (PISCES: CYPRINIDAE)

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