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ABSTRACT

Twenty-two sites were sampled for southern redbelly dace in Warren and Tallahatchie counties, Mississippi. Dace were collected at six sites and dace abundance was generally low at all sites. No dace were collected from Hatcher Bayou (Warren Co.) and southern redbelly dace are now believed to be extirpated from this stream. The only remaining populations in west-central and northwest Mississippi occur in Murphy Branch (Tallahatchie Co.), Bliss Creek and Skillikalia Bayou (both in Warren Co.), all part of the Yazoo drainage. Comparisons with other dace populations indicate that populations from the Yazoo drainage have a similar age structure and length-weight relationship. We speculate that the low abundance of dace may be attributed in part to degraded habitat quality and competitive interaction with other herbivorous minnows. Abundance of *Semotilus atromaculatus* was consistently high at all dace sites, while the abundances of *Campostoma anomalum*, *Pimephales notatus* and *Phoxinus erythrogaster* varied from site to site. Dace abundance was lower at sites with high abundances of *C. anomalum* and *P. notatus*, and dace abundance was typically higher at sites where either *C. anomalum* and/or *P. notatus* were absent or less abundant.

INTRODUCTION

The southern redbelly dace, *Phoxinus erythrogaster*, occurs in upland streams of the Great Lakes and Mississippi River basins from Minnesota to western New York, south to the Ozark highlands of Arkansas and Oklahoma and the lower Tennessee River drainage of Tennessee, Alabama and Mississippi (Starnes and Starnes, 1980). Disjunct populations also occur in Arkansas, Colorado, Kansas, Mississippi, New Mexico and Oklahoma (Miller and Robison, 1973; Page and Burr, 1991). The disjunct populations in Mississippi represent the most southern extent of its range (Hemphill, 1957; Cashner et al., 1979) with very localized occurrences in small tributaries of the Lower Mississippi S and Yazoo drainages[1] within Warren, Wilkinson and Tallahatchie counties (Ross and Brenneman, 1991) (Fig. 1). Southern redbelly dace are only reported from single locations in Hatcher Bayou (a Mississippi River tributary) and Murphy Branch (a tributary of the Tallahatchie River system); however, numerous collections of southern redbelly dace are reported for Clark Creek (Wilkinson Co.), Bliss Creek and Skillikalia Bayou of the Yazoo River

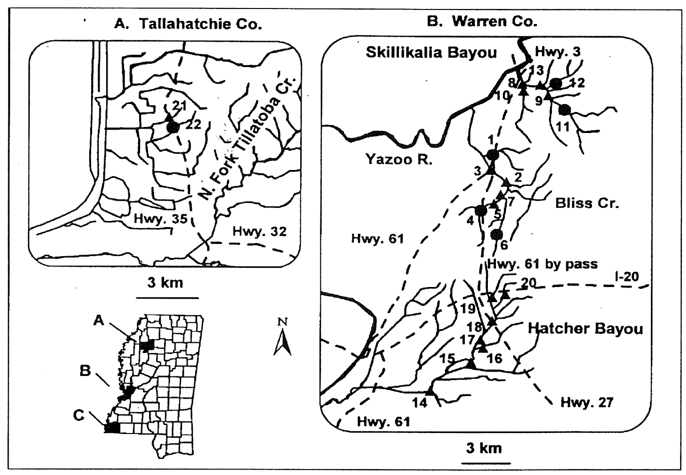

Figure 1. Mississippi counties which contain disjunct populations of *Phoxinus erythrogaster* (inset) and specific sampling sites (1-22) surveyed for *P. erythrogaster* (A: Tallahatchie Co.; B: Warren Co.; C: Wilkinson Co.). Sites where dace were present are indicated by solid circles. Triangles note sites where dace were absent. Additional information regarding each site is included in the Appendix.

Our categorization of water bodies follows the hierarchical arrangement proposed by Jenkins et al. (1971) and modified by Ross and Brenneman (1991) for Mississippi streams. Ross and Brenneman (1991) recognize two basins within Mississippi (Mississippi River and Gulf of Mexico). Each basin contains a number of distinct drainages and within each drainage, specific stream systems are recognized. For example, the Mississippi River basin consists of five drainages including the Lower Mississippi N, Lower Mississippi S and Yazoo. The Lower Mississippi S drainage is composed of seven systems (Lower Mississippi S, Thompson Creek, Bayou Sara, Buffalo River, Homochitto River, Coles Creek and Bayou Pierre). The Yazoo drainage also contains seven systems (Yazoo River, Steele Bayou, Deer Creek, Sunflower River, Yalobusha River, Tallahatchie River and Coldwater River).

system (Warren Co.) (Hemphill, 1957; Cashner et al., 1979; Ross and Brenneman, 1991).

In 1979, Cashner et al. reported on the status of the Clark Creek population and suggested that this was an 'extremely viable' population. However, they reported that the Bliss Creek population had declined since it was first reported by Hemphill (1957), presumably due to increased urban development in the Vicksburg vicinity. Efforts by Neil H. Douglas and students in 1991, indicated that the Bliss Creek population remained extant, with a total of 13 individuals collected from two localities (NLU 65180B and 65436). However, USM collecting efforts in April 1992, at Bliss Creek and Skillikalia Bayou localities yielded no southern redbelly dace. Considering the uniqueness of such a fragmented distribution, the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) deemed the dace populations in Tallahatchie, Warren and Wilkinson counties as 'endangered' (MDWFP, 1984), and further recommended the need for a status survey before any conservation agenda could be addressed (MDWFP, 1992). As a consequence, the objectives of our study were to conduct a basic survey for southern redbelly dace in Hatcher Bayou and streams of the Yazoo and Tallahatchie River systems that contained historic localities and to report on the current status of these populations.

METHODS

Within Hatcher Bayou and the Yazoo and Tallahatchie River systems we identified seven historic sites for southern redbelly dace based on Ross and Brenneman (1991) and comments in Cashner et al. (1979). A number of additional historic sites were noted from collection records, but we could not determine specific localities for these sites due to vague descriptions or discrepancies in the available locality information. We selected 22 sampling sites using USGS 1:24,000 topographic maps and field determination of habitat suitability. Included in these sites were the seven historic localities. All sampling occurred along the Loess Hills region that forms the eastern border of the Mississippi Alluvial Plain (Cross et al., 1974).

Primary sampling efforts focused on 100 m stream reaches extending upstream and downstream from each sampling site (i.e., bridge crossing). Block nets were placed at the upstream and downstream border of each 100 m sample reach to prevent fishes from leaving the sampling area. Three 10-m long subreaches were randomly chosen within each 100 m sample reach. Each subreach was also isolated with block nets prior to sampling. Sampling within each subreach consisted of 10-15 seine hauls within a 10-20 minute time period. After the three subreaches were sampled, efforts focused on sampling habitats within the entire 100 m reach specifically for *P. erythrogaster*. Representative voucher collections from all subreach samples were preserved in the field and returned to USM for enumeration and identification. All species except *P. erythrogaster* were preserved and all material was curated and deposited in the USM Museum of Ichthyology. No voucher material was preserved from the 100 m generalized samples. This sampling protocol was followed at all historic sites. If sites were not appropriate for this sampling design, a designated length of stream was selected (50-100 m) and sampling consisted of general seining through all possible habitats without the designation of subreaches or the use of block nets. These sampling efforts were also standardized with number of seine hauls and time spent sampling. All sites were sampled with a 1.8 x 3.1 m seine with 3.2 mm Ace mesh.

Captured southern redbelly dace were anesthetized with MS-222 (tricaine methanesulfonate, Finquel®). Fish were measured to the nearest 0.5 mm standard length (SL) using a 150 mm plastic ruler and weighed to 0.01 g using a portable electronic field balance (Ohaus®, model CT 200-S). Individuals were categorized as male, female or juvenile based on reported coloration and external morphological differences as described by Settles and Hoyt (1978). Settles and Hoyt (1978) noted that differences in coloration are most evident during the reproductive season (April-June); however, sexual dimorphic coloration patterns were not very distinct during our sampling. Therefore, we relied more on differences in external morphology. The size and appearance of the pectoral fins provided the most dependable means of sexing southern redbelly dace >35 mm SL. Males have relatively longer pectoral fins which are rounded distally while those of females are conspicuously shorter and pointed distally (Settles and Hoyt, 1978). Following all measurements, several scales were removed from adult fish along the dorsolateral region beneath the dorsal fin (Jearld, 1983). Fish were then transferred to a container of fresh stream water containing anti-stress medication (Stress Coat®) and observed until they had resumed normal activity. After recovery, dace were released at the point of original collection. Species abundance at each site was standardized as the number of fish per seine haul.

RESULTS

We sampled southern redbelly dace from 18 July to 24 September 1994, and spent 17.2 total hours actively surveying for dace at 22 sites. Combined collections from the 22 sampling sites yielded 2,932 individuals representing 32 species and eight families (Table 1). Southern redbelly dace were collected at six sites (Fig. 1) representing a total of 147 individuals. Sites where dace had previously been reported, and thus considered as historic localities, included Sites 1, 4, 6, 10, 11, 18 and 22. Dace were not present at Sites 10 and 18, and we report Site 12 as a new locality.

The five numerically abundant species over all sites, based on standardized abundance, comprised 70% of the individuals collected and included *Semotilus atromaculatus* (29%), *Campostoma anomalum* (11%), *Pimephales notatus* (11%), *Cyprinella lutrensis* (11%) and *Etheostoma caeruleum* (8%). *Phoxinus erythrogaster* ranked eighth in overall abundance (4%) (Table 1). Only 12 species were documented from sites at which dace were collected, and the five numerically dominant species constituted approximately 95% of the total

Table 1. Standardized abundance of species collected from sites in Hatcher Bayou and the Yazoo and Tallahatchie River systems of west-central and northwest Mississippi. Abundance is reported as the number of fish collected per seine haul. Actual numbers can be computed by multiplying standardized abundance by the number of seine hauls for a given site. Specific collecting information is included in the Appendix. Location of specific sampling sites are indicated in Fig. 1.

	Sampling Sites																					
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Cyprinidae																						
Campostoma anomalum	1.57	0.13	---	1.22	0.40	1.42	0.83	0.07	1.10	---	0.35	0.50	1.36	---	---	0.16	---	0.09	0.53	0.40	---	---
Cyprinella lutrensis	---	0.77	0.37	0.08	---	0.07	0.80	0.77	0.80	---	0.12	---	5.09	0.50	---	---	---	0.28	---	---	---	---
Cyprinella venusta	---	---	---	---	---	---	---	0.23	---	---	---	---	0.09	0.06	---	---	---	---	---	---	---	---
Cyprinus carpio	---	---	0.03	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.01	---	---	---	---
Hybognathus nuchalis	---	---	0.03	---	---	---	---	0.13	---	---	---	---	1.36	---	---	---	---	0.01	---	---	---	---
Hypophthalmichthys nobilis	---	---	---	---	---	---	---	0.03	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Luxilus chrysocephalus	---	---	---	---	---	---	---	0.03	0.27	---	---	---	0.73	---	---	---	---	---	---	---	---	0.03
Lythrurus umbratilis	---	---	---	---	---	---	---	---	---	---	---	---	---	0.17	0.13	---	---	---	---	---	---	---
Notemigonus crysoleucas	---	---	---	---	---	---	---	0.03	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Notropis atherinoides	---	---	---	---	---	---	---	0.07	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Phoxinus erythrogaster	0.37	---	---	0.12	---	0.35	---	---	---	---	0.67	0.80	---	---	---	---	---	---	---	---	---	0.94
Pimephales notatus	0.02	0.77	0.67	1.37	0.50	0.88	0.60	---	0.20	---	0.02	0.27	0.55	0.33	1.07	0.37	0.13	1.03	0.20	---	---	---
Semotilus atromaculatus	2.85	---	0.03	2.12	1.10	1.80	0.67	0.17	0.07	0.04	2.72	2.63	0.18	---	---	0.79	---	---	1.13	3.00	3.67	3.86
Catostomidae																						
Erimyzon oblongus	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.05	---	0.12	---	---	---	---
Ictaluridae																						
Ameiurus melas	---	---	---	---	---	---	---	---	---	---	---	---	0.36	---	---	---	---	0.07	---	---	---	---
Ameiurus natalis	0.02	---	0.10	0.02	---	---	0.03	---	0.03	---	---	---	---	---	---	---	---	0.03	---	---	---	---
Ictalurus punctatus	---	---	---	---	---	---	---	0.03	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Aphredoderidae																						
Aphredoderus sayanus	0.02	---	0.03	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Fundulidae																						
Fundulus notatus	---	---	---	---	---	---	---	---	---	---	---	---	---	0.11	1.20	---	0.27	---	---	---	---	---
Fundulus olivaceus	---	0.03	0.17	---	---	---	---	0.03	---	---	---	---	---	0.22	0.73	0.26	---	0.47	---	---	---	---
Poeciliidae																						
Gambusia affinis	0.02	---	0.57	---	---	---	---	0.53	---	---	---	---	---	0.11	0.53	0.11	0.20	0.42	1.27	---	---	1.11
Centrarchidae																						
Lepomis cyanellus	---	0.17	0.10	---	---	0.02	---	---	0.03	---	---	---	---	0.17	0.07	---	0.33	0.39	0.20	---	---	---
Lepomis gulosus	---	---	---	---	---	---	---	0.07	---	---	---	---	---	---	---	---	---	0.03	---	---	---	---
Lepomis humilis	---	---	---	---	---	---	---	0.17	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lepomis macrochirus	---	---	0.03	---	---	---	---	0.13	---	---	---	---	---	0.39	0.07	0.16	0.27	0.38	---	---	---	---
Lepomis megalotis	---	0.07	0.27	0.02	---	0.02	0.03	---	---	---	---	---	---	0.22	0.13	---	---	---	---	---	---	---
Micropterus punctulatus	---	---	---	0.02	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Micropterus salmoides	---	---	0.10	---	---	---	0.03	---	---	---	---	---	---	0.06	---	0.11	---	0.03	0.07	0.10	---	---
Percidae																						
Etheostoma caeruleum	---	---	---	---	---	---	---	0.27	1.50	0.12	---	---	5.18	---	---	---	---	---	---	---	---	---
Etheostoma gracile	0.02	---	0.10	---	---	---	0.03	---	---	0.04	---	---	---	---	---	---	---	---	---	---	---	---
Etheostoma parvipinne	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.07	0.40
Etheostoma whipplei	0.42	---	---	1.77	0.33	0.65	0.07	---	0.33	---	0.92	0.10	0.36	---	---	0.11	---	---	---	---	0.13	0.49

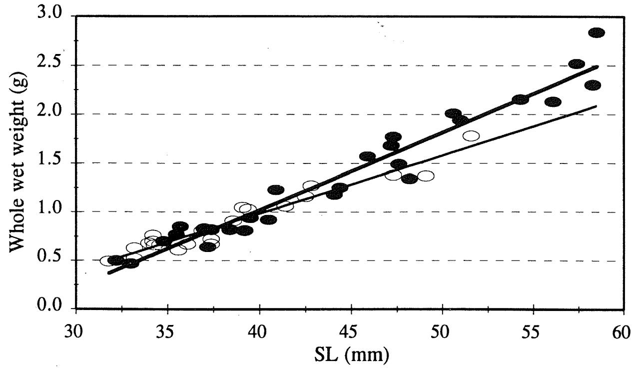

Figure 2. Length-weight regressions for male and female southern redbelly dace >30 mm SL (male: thick line and solid circles; female: thin line and open circles). Data are for post-spawning individuals sampled July-September, 1994. Point of crossover is approximately 38 mm SL.

Table 2. Number of *Phoxinus erythrogaster* collected from Bliss Creek, Murphy Branch and Skillikalia Bayou. Total number of dace from each site are further broken down by sex and direction of sampling from bridge.

Sampling station	Direction from bridge	Juvenile	Sex Male	Female	Total
Site 1	downstream	1			1
	upstream	4	8	9	21
	TOTAL	5	8	9	22
Site 4	downstream	2	2	1	5
	upstream	2			2
	TOTAL	4	2	1	7
Site 6	downstream	4	3	2	9
	upstream	12			12
	TOTAL	16	3	2	21
Site 11	downstream	22	1		23
	upstream	17			17
	TOTAL	39	1		40
Site 12	downstream	24			24
	TOTAL	24			24
Site 22	downstream	7	4	5	16
	upstream	3	9	5	17
	TOTAL	10	13	10	33
TOTAL DACE		98	27	22	147

number of individuals collected at those sites. Again *S. atromaculatus* ranked highest (53%) followed in decreasing abundance by *C. anomalum* (18%), *E. whipplei* (11%), *P. erythrogaster* (7%) and *P. notatus* (6%). The total number of species per site varied with numbers ranging from 3-16 at all sites and 5-9 at dace sites. In most cases, dace comprised a relatively small percentage of the total abundance with *S. atromaculatus*, *C. anomalum* and *P. notatus* often being 2-3 times more abundant (Table 1). Standardized abundance for *S. atromaculatus* was consistently high among all dace sites while standardized abundance for the remaining species varied from site to site. When abundances of *C. anomalum* and *P. notatus* were high, dace abundance was minimal. Increased dace abundance was generally associated with decreased abundances of *C. anomalum* and *P. notatus*. Dace abundance was highest at Site 22, in the absence of *C. anomalum* and *P. notatus*. Site-specific data including locality information, total collecting time and amount of sampling effort are listed in the Appendix.

Dace typically occurred along narrow stream reaches that meandered primarily over gravel, pebble and sand substrata. Plunge pools and chutes at the base of shallow riffles and runs were common along undercut clay banks. Sites where dace were more abundant usually had several long, slow flowing pools. The water was usually clear and cool, and the stream was often completely covered with overhead riparian canopy. Habitat quality varied from site to site and the impacts of local disturbances, such as erosion, headcutting and alterations due to highway construction, have had an impact at a number of sites. Degraded habitat was most evident at Sites 1 (downstream of road crossing) and 4 (upstream of road crossing), and likely linked to the low abundance of dace along these reaches (Table 2). Unimpacted areas, such as Sites 11 and 22, were characterized by relatively pristine habitat and dace abundance was high.

Males had a greater mean SL ($\bar{x}$=44.2; sd=8.1; range 32.2-58.5 mm SL) than females ($\bar{x}$=38.4; sd=5.4; range 31.8-51.6 mm SL). Juveniles had a mean SL of 22.8 mm (sd=3.9) and ranged in size from 16.4 to 36.8 mm SL. Approximately 93% of those categorized as juveniles were <30 mm SL. Combined data for fish >30 mm SL (male=27, female=22) showed that males and females had different length-weight relationships (Fig. 2). Since our sampling was conducted after the reproductive season (April-June), this relationship may differ from that of pre-spawning individuals. Males weighed less than females of similar length in fish <38 mm SL. After attaining a length >40 mm SL, the relationship reversed with males becoming increasingly heavier as length increased. The slopes depicting length-weight relationships between sex categories were significantly different ($F_{(1,45)}=10.98$, $P=0.002$). Sites with the greatest abundance of dace in both categories (Table 2, Sites 1 and 22) were compared for differences in their length-weight relationships. There was no significant difference in slopes between these two sites when each sex was compared separately (female: $F_{(1,15)}=0.922$, $P=0.352$; male: $F_{(1,17)}= 0.0004$, $P=0.984$). This indicates that despite the geographical distance between the two populations, the sex-specific length-weight relationships do not differ. The overall relationship between length and weight for the dace populations represented in the current study is $W=2.1832 \times 10^{-5}(SL^{2.889})$ or $\log W=-4.6609 + 2.889(\log SL)$, where W=wet weight (g) and SL=standard length (mm). The relationship was strong with $r_{(125)}=0.975$, $P<0.005$.

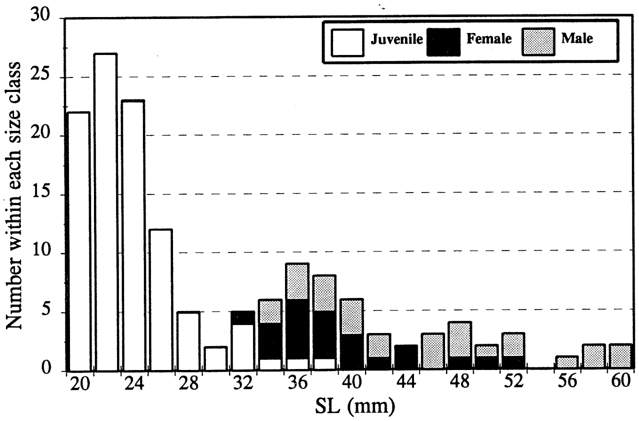

Figure 3. Length frequency histogram of 147 *Phoxinus erythrogaster* collected from Skillikalia Bayou, Bliss Creek and Murphy Branch in west-central and northwest Mississippi, 1994. Histogram represents data pooled from six populations sampled from July-September. Individuals are categorized as juvenile, male or female, and the number within each category is depicted for each size class.

Collectively, the data on *P. erythrogaster* indicate the presence of at least three age classes (Fig. 3) although each site was not equally represented by all categories (Table 2). The data suggest a fourth age class, but closer examination reveals the presence of larger males taken from several sites. Scales were examined in an attempt to validate age classes, but this classification was uninformative. Since we were using pooled data representing several populations and because sampling occurred over a three-month period, we were concerned that our length frequency distribution may be influenced by growth in dace occurring between July and September causing a shift in the frequency distribution. Data were pooled for sites sampled in July (1, 4 and 6), August (11 and 12) and September (22). Each pooled group had representatives in each tentative age class and we saw no appreciable shift in the distribution. Therefore, based on the pooled length frequency data we categorized fish <30 mm SL as Age 0, 30-45 mm SL as Age I and >45 mm SL as Age II.

DISCUSSION

Of the seven historic localities sampled, dace were absent at two, Sites 10 (Skillikalia Bayou) and 18 (Hatcher Bayou). We speculate Site 10 is the historic locality documented by Smith-Vaniz (USNM 2000048; 14 March 1966). His collection records note that dace (n=4) were collected at the base of small waterfalls approximately 200 yards from Highway 61, along with *C. anomalum*, *P. notatus*, *S. atromaculatus*, *Ameiurus natalis* and *E. whipplei*. We sampled a 100 m reach downstream of the bridge behind Redwood Elementary School and collected few fishes [*E. caeruleum* (3), *E. gracile* (1), *S. atromaculatus* (1)]. The habitat seemed good downstream of the bridge with the exception of rip-rap placed along the W bank behind the school to foster bank stabilization. Canopy cover was mixed with most areas of the reach partially to fully covered. In addition, we arbitrarily sampled upstream from the bridge to a small waterfall at the base of a hard clay stream reach. We believe this to be the waterfall described by Smith-Vaniz. Erosion, as the result of headcutting, was very evident from the bridge upstream to the waterfall. The stream bed was wide (5-6 m) though the actual stream channel width was only 1.5-2 m. There was little to no canopy cover along this reach. Air temperature was 29 C and water temperature 28 C (at 1330). Very few fishes were collected along this reach with most coming from the pool (1-1.5 m deep) at the base of the waterfall (*C. lutrensis*, *Hybognathus nuchalis*, *C. anomalum*, *S. atromaculatus*, *Ictalurus punctatus* and *A. melas*). This site may have once contained favorable dace habitat, but headcutting and subsequent erosion has rendered it unfavorable.

Site 18 is the only reported locality for dace in Hatcher Bayou and is represented by a single individual collected by Hemphill and Webb in 1952 (UAIC 249.02). Unfortunately, extensive urban development has progressed since Hemphill's survey, including the construction of Warren Central High School (completed in 1964) within 200 m of the stream at this site. We worked over 500 m of stream in this area, in addition to several sites both upstream and downstream of Site 18. No dace were collected at any of these sites and observations regarding the deteriorating habitat along these stream reaches leaves us to suspect that *Phoxinus erythrogaster* is probably extirpated from Hatcher Bayou.

The dace population from the only locality in the Tallahatchie River system (Murphy Branch, Site 22) seems viable given the relatively greater numbers of dace and the presence of both adult and juvenile fish. However, this population occurs directly along the bluff line and such a localized population could be easily destroyed if agricultural and logging practices, as well as future plans for urban development, are not reviewed before implementation. Clearcutting or selective logging along the bluff region in the vicinity of the stream may have detrimental effects by reducing canopy cover and increasing sediment loads. This may be followed by an increase in water temperature, runoff and drainage (Gordon et al., 1992), and result in changes in the stream assemblage (Berkman and Rabeni, 1987; Rutherford et al., 1992; Stout et al., 1993; Urlich et al., 1993).

Settles and Hoyt (1976) provided age and size estimates for a Kentucky population of southern redbelly dace based on length frequency data and verified by scale examination. They reported three age classes (overall classification) with Age 0 individuals ranging from 20-45 mm SL, Age I individuals ranged from 37-60 mm SL and Age II individuals ranged from 56-65 mm SL. Dace were considered sexually mature at lengths >40 mm SL. Becker (1983) reported four age classes for Wisconsin southern redbelly dace taken in July based solely on scale examination. Age 0 individuals were <40 mm SL, Age I individuals ranged 40-64 mm SL, Age II individuals ranged 65-73 mm SL and Age III fish were 71-76 mm SL.

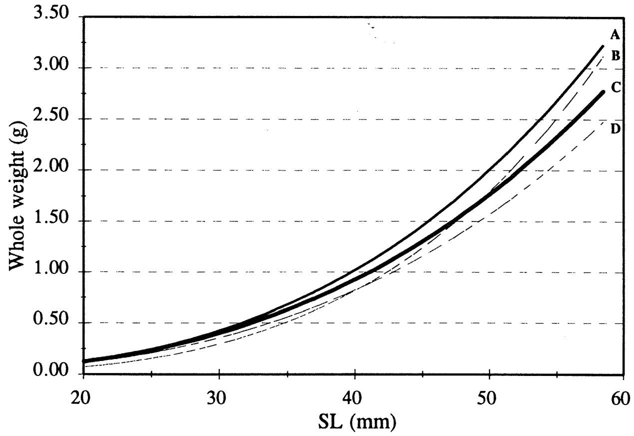

Figure 4. Curvilinear length-weight relationships for *Phoxinus* populations (A: Kentucky population of *P. erythrogaster*; B: male *P. cumberlandensis*; C: current study; D: female *P. cumberlandensis*).

Most dace >50 mm SL were sexually mature. Hill and Jenssen (1968) assessed age structure for an Oklahoma population of southern redbelly dace sampled in July using meristics and the acquisition of secondary sexual characteristics. Fish <24 mm SL were categorized as Age 0, individuals 30-39.5 mm SL were Age I and individuals 40-55 mm SL were Age II. Based on the length frequency data, we categorized fish <30 mm SL as Age 0, individuals 30-45 mm SL as Age I and fishes >45 mm SL as Age II. The classification of Age 0 individuals (juveniles) corresponded well with our field determination of sex category (juvenile, male, female) as is evident from Fig. 3, although the miscategorization of some individuals >30 mm SL is probable.

Our age data most closely resemble the age structure reported for the Kentucky and Oklahoma populations. Discrepancies between data sets may be attributed to several factors, including our inability to validate age classes. Because all of our information regarding dace size and age was based on live material and because very few individuals were preserved, we lacked any other means of validation. Secondly, because our sampling period was July-September, we may have missed older age classes. Settles and Hoyt (1976; 1978) reported few Age II individuals among their July-September samples and attributed this to reproduction early in the season (April-May) with dace dying soon afterwards. Sampling earlier in the year and the subsequent inclusion of the older age classes may have provided greater resolution to our age classification. Finally, our study may not adequately represent the entire age structure due to habitat segregation between juvenile and adult age classes. There is little evidence from the literature to suggest distinct habitat segregation between juvenile and adult dace, although Starnes and Starnes (1981) reported adult *P. cumberlandensis* were only collected in deeper habitats with ample cover, while juveniles frequently occurred in shallower pools along the same stream reach. Settles and Hoyt (1978) did not discuss habitat segregation between juveniles and adults, but they did report taking juveniles (14-15 mm SL) from a shallow riffle at the mouth of a small feeder stream. In our study, stream reaches of 100 m were diverse in habitats, often containing numerous riffles, runs, chutes and pools. Dace were generally distributed throughout the entire reach and usually in association with favorable habitat. Consequently, it is unlikely that habitat segregation was occurring among age groups.

Visual comparisons of length-weight relationships were made to other populations of *Phoxinus* as taken from the literature. Settles and Hoyt (1976) provided overall length-weight relationships for a Kentucky population of *Phoxinus erythrogaster* and Starnes and Starnes (1981) provided separate relationships for male and female *Phoxinus cumberlandensis*, a species endemic to the upper Cumberland River drainage of Kentucky and Tennessee. Dace from the present study appeared to follow the same pattern as these populations although weight for dace in our study was slightly less than the Kentucky population in fish larger than 35 mm SL (Fig. 4).

In general, we feel that populations of southern redbelly dace from the Yazoo drainage are not doing well at any site, but our observations suggest that those sites where they are more abundant are generally less disturbed. There is evidence of successful recruitment at some sites as given by the number of juveniles collected, but we doubt that recruitment levels are sufficient to maintain high population densities. We have considered a number of scenarios that might explain the low abundance of dace at our sites and we present the following hypotheses:

1) Historically, dace may never have been abundant within these systems. Hemphill (1957), in the original description of the Bliss Creek population, reported only 51 individuals from three collections (11, 36 and 4). Cashner et al. (1979) reported 77 in 1964 at one Bliss Creek site, 2 in 1968 but only 1 in 1974. Dace abundances from our study, although never as high as reported in 1964 (Cashner et al., 1979), are comparable to those reported by Hemphill (1957). This would suggest that dace abundance in these streams is typically low and that the abundance levels represented by our survey approximate historic levels. The variability in species abundance may be due to seasonal and/or annual variability in climatic conditions as has been postulated or noted for other stream fishes (Starrett, 1951; Grossman et al., 1982; Ross and Baker, 1983; Grossman et al., 1990).

2) The influence of disturbance, either due to erosion or increased urban development, has resulted in low dace abundance. We have noted obvious differences in habitat quality among sites, and at those areas most affected by erosion or anthropogenic influences, dace abundance was low or altogether absent (Slack et al., 1994). These influences may directly impact the species, either by altering the availability of critical habitat and/or by instigating a shift in community structure thereby increasing the role of competition or predation within these sites. Species of *Phoxinus* are known to spawn over nests or mounds of *Semotilus*, *Campostoma* and *Nocomis* (Smith, 1908; Raney, 1947; Settles and Hoyt, 1978; Starnes and Starnes, 1981) and thus the presence of these species provides an important link to successful reproduction. Although the presence of *S. atromaculatus* may confer some increased risk of predation on dace (Cerri, 1983; Fraser et al.,

1987), it is not likely to be a major factor in limiting dace abundance, but rather a key to successful reproduction by offering more potential nest sites for dace.

Based on previous surveys, Cashner et al. (1979) reported that the combined abundances of *S. atromaculatus*, *C. anomalum* and *P. notatus* represented 78% of the total abundance in Bliss Creek, while in Clark Creek (Wilkinson Co.) they comprised only 37%. In our study, we found that 79% of the total abundance among the six dace sites was represented by the three species. In addition, we noted that standardized abundance for *S. atromaculatus* was consistently high among all dace sites while standardized abundance for the remaining species varied from site to site. In addition, Cashner et al. (1979) speculated that the low abundance of dace in Bliss Creek in comparison to the Clark Creek population may be linked to the drastic differences in species composition between the two systems, and that these differences, in combination with the limited carrying capacity of such a small stream, would enhance competitive interactions among fishes of similar trophic guilds (i.e., *C. anomalum*, *P. notatus* and *P. erythrogaster*). Our data strongly agree with this speculation as the proportions of *S. atromaculatus*, *C. anomalum* and *P. notatus* are much higher in Bliss Creek and the remaining dace sites than those reported from other populations of southern redbelly dace (Becker, 1983). Sites with high abundances of *C. anomalum* and *P. notatus* had relatively low abundances of dace. Sites where either *C. anomalum* and/or *P. notatus* were absent or few, typically had more dace. Site 22 had neither species of the potential competitors; abundances of *S. atromaculatus* and *P. erythrogaster* were highest at this site.

3) Our sampling represents the downstream extent of the populations. Dace undoubtedly exist in the upper reaches of the sampled streams in which they were found. Unfortunately our sampling in these areas was hampered because we either lacked adequate road access or stream access was on private property. Data from regional ichthyological collections (>80,000 records) compiled by Ross and Brenneman (1991), indicate few collections have been made along stream reaches upstream from our sites.

We propose continued monitoring of these populations and further suggest that future sampling efforts focus primarily along the upper stream reaches of present dace sites to get a more adequate estimation of population status, and thus a better idea of what conservation or management plans should or should not be implemented. In addition, these systems provide an ideal case for studying both biotic and abiotic influences of disturbance, namely erosion as a result of headcutting, on the stability and persistence of perhaps a unique stream assemblage.

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APPENDIX

Site	Field Number	Date	County	System	Water Body	Location	Total Sampling Time (min)	Number of Seine Hauls	Length of Sampled Reach (m)
1	WTS94-016; 017	7/18/1994	Warren	Yazoo River	tributary to Bliss Creek	170 m N of Marylin Road on Hwy 61 N,1.5 km N of Bliss Creek T17N, R04E, Sec 15 UTMX: 704800 UTMY: 3590900	83	60	200
2	WTS94-021	7/19/1994	Warren	Yazoo River	Bliss Creek	tributary crossing at end of Wells Road T17N, R04E, Sec 27 UTMX: 705800 UTMY: 3587500	31	30	100
3	WTS94-020	7/19/1994	Warren	Yazoo River	Bliss Creek	bridge crossing at Hwy 61 & Hwy 61 Bypass jct. T17N, R04E, Sec 28 UTMX: 704400 UTMY: 3589600	35	30	100
4	WTS94-018; 019	7/18/1994	Warren	Yazoo River	tributary to Bliss Creek	2.5-3 km S of Hwy 61 & Hwy 61 Bypass jct. on Hwy 61 Bypass T17N, R04E, Sec 39 UTMX: 704200 UTMY: 3587000	96	60	200
5	WTS94-025	7/21/1994	Warren	Yazoo River	tributary to Bliss Creek	end of Childs Road, 1.0 km NE of Hwy 61 Bypass crossing T17N, R04E, Sec 39 UTMX: 705300 UTMY: 3587300	21	30	100
6	WTS94-022; 023	7/19/1994	Warren	Yazoo River	tributary to Bliss Creek	crossing on Bowie Road 0.65 km W of jct. with Boy Scout Road T16N, R04E, Sec 4 UTMX: 705300 UTMY: 3585400	87	60	200
7	WTS94-024	7/20/1994	Warren	Yazoo River	tributary to Bliss Creek	Boy Scout Road N of Bowie Road at confluence of two tributaries T17N, R04E, Sec 39 UTMX: 705600 UTMY: 3587700	28	30	100
8	WTS94-031	8/ 8/1994	Warren	Yazoo River	Skillikalia Bayou	Old Hwy 3 crossing N of Hwy 6 & Hwy 3 jct. T17N, R04E, Sec 3 UTMX: 706300 UTMY: 3595750	47	30	200
9	WTS94-030	8/ 4/1994	Warren	Yazoo River	Skillikalia Bayou	1.6 km SSW of Hwy 61 & Hwy 3 jct. on Redwood School Road T17N, R04E, Sec 2 UTMX: 707950 UTMY: 3594950	40	30	100
10	WTS94-026	7/21/1994	Warren	Yazoo River	tributary to Skillikalia Bayou	0.25 km E of Hwy 61 behind Redwood Elementary School T17N, R04E, Sec 3 UTMX: 706400 UTMY: 3595300	16	25	100
11	WTS94-028; 029	8/ 4/1994	Warren	Yazoo River	Skillikalia Bayou	3.5 km SSE of Hwy 61 & Hwy 3 jct. on Redwood School Road T17N, R04E, Sec 9 UTMX: 709000 UTMY: 3593650	89	60	200
12	WTS94-027	7/21/1994	Warren	Yazoo River	tributary to Skillikalia Bayou	1.5 km NE on Jeffers Hollow Road; 2.5 km E of Hwy 61 & Hwy 3 jct. T17N, R04E, Sec 2 UTMX: 708750 UTMY: 3595900	29	30	100
13	WTS94-032	8/ 8/1994	Warren	Yazoo River	Skillikalia Bayou	700 m E of Whatley Road, 1.4 km E of Hwy 61 & Hwy 3 jct. T17N, R04E, Sec 2 UTMX: 707600 UTMY: 3595400	21	11	100
14	WTS94-033	8/ 8/1994	Warren	Lower Mississippi River S	Hatcher Bayou	on Fisher Ferry Road 1.2 km E of jct. with Halls Ferry Road T15N, R04E, Sec 7 UTMX: 701750 UTMY: 3574500	37	18	100
15	WTS94-034	8/ 8/1994	Warren	Lower Mississippi River S	Hatcher Bayou	2.0 km NNW of Christian Home Church on Lee Road T15N, R04E, Sec 5 UTMX: 704200 UTMY: 3576600	29	15	100
16	WTS94-036	8/ 8/1994	Warren	Lower Mississippi River S	Hatcher Bayou	Old Hwy 27 crossing 0.4 km NW of jct. with Warriors Trail T16N, R04E, Sec 35 UTMX: 704900 UTMY: 3577600	23	19	100
17	WTS94-035	8/ 8/1994	Warren	Lower Mississippi River S	Hatcher Bayou	Old Hwy 27 bridge crossing just E of Paxton Road T16N, R04E, Sec 34 UTMX: 704700 UTMY: 3578150	27	15	100
18	WTS94-039; 040; 041; 042	8/11/1994	Warren	Lower Mississippi River S	Hatcher Bayou	on Hwy 27, 1.7 km S of Clay Street at Warren Central High School T16N, R04E, Sec 30 UTMX: 705250 UTMY: 3579200	103	76	405
19	WTS94-038	8/ 8/1994	Warren	Lower Mississippi River S	Hatcher Bayou	on Clay Street 0.6 km E of jct. with Hwy 27 T16N, R04E, Sec 23 UTMX: 704800 UTMY: 3580500	16	15	100
20	WTS94-037	8/ 8/1994	Warren	Lower Mississippi River S	Hatcher Bayou	on Clay Street 1.2 km E of jct. with Hwy 27 T16N, R04E, Sec 23 UTMX: 705400 UTMY: 3580500	10	10	50
21	WTS94-045	9/24/1994	Tallahatchie	Tallahatchie River	unnamed tributary	7.56 km N of Charleston (Hwy 35 & Hwy 32 jct.) on Hwy 35 T25N, R02E, Sec 4 UTMX: 769000 UTMY: 3773300	77	15	200
22	WTS94-046; 047	9/24/1994	Tallahatchie	Tallahatchie River	Murphy Branch	6.92 km N of Charleston (Hwy 35 & Hwy 32 jct.) on Hwy 35 T25N, R02E, Sec 4 UTMX: 769200 UTMY: 3772800	86	35	200