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Susan C. Darrow
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The southern redbelly dace, *Phoxinus erythrogaster* (Rafinesque),

in Clark County, Illinois.

(TITLE)

BY

Susan C. Darrow

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Masters of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1988

YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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ABSTRACT

Population and feeding ecology of the southern redbelly dace, *Phoxinus erythrogaster* (Rafinesque), was studied at Rocky Branch Nature Preserve, sections 29 and 30, T12N, R12W in Clark County, Illinois. Three stations designated along the eastern portion of Rocky Branch stream were seined bimonthly July through September, 1987. The length/frequency distribution curve constructed for the 358 dace collected determined Age class 0 to be dace less than 39mm, age classes I and II were indistinguishable because of overlap of fish lengths, and age class III was determined to be dace between 69 and 74mm. Other species encountered in abundance during this two month period were *Ericybma buccata, Semotilus atromaculatus, Campostoma anomalum, Etheostoma nigrum*, and *Rhinichthys atratulus*.

Thirty-five southern redbelly dace were collected for age and sex determination and for a food analysis study. Scales and otoliths were collected from the dace, annuli were read, and dace were then sexed based on pectoral fin length. No more than a 2 mm difference existed between the two age-determination methods for age classes I and II. Males averaged smaller than females for both age classes I and II. Age class III otolith results more closely matched length/frequency than did scales, suggesting this may be a more accurate method for aging older dace.

Eight southern redbelly dace intestines were examined

for diet analysis. Thirteen out of the 15 most common food organisms belonged to the division Bacillariophyta. The diatom genus *Navicula*, along with many other known epipelic genera were found to be the most abundant food organisms, suggesting the dace feeds largely on bottom debris. *Gomphonema, Cocconeis*, and several other genera found in the diet were known to be epiphytic or epilithic, suggesting the dace graze on rocks and filamentous algae. The other diatom genera found in the diet were known plankters. These, along with the presence of *Pediastrum*, suggest the dace consume plankton, if only during respiration.

Analysis of plankton samples taken prior to seining on 10 September, 1987 indicated that *Navicula, Amphora,* and *Nitzschia* were the most common algal genera. Because sampling was done in shallow water where the stream bottom was soft, it is thought that these epipelic organisms enriched the plankton samples. Ranked fourth was *Ankistodesmus*. Because this truly planktonic organism was not found in any of the intestines examined, it is concluded that plankton is not an important part of the diet.

ACKNOWLEDGEMENTS

I wish to thank my committee members Dr. William A. Weiler, Dr. John Ebinger, and Dr. Kipp Kruse for their helpful suggestions in writing this paper. I'd especially like to thank Dr. Leonard Durham, my major advisor, for his guidance in conducting this study and in writing this manuscript.

I wish to express my sincere appreciation to Dr. Richard Smith for his help in identifying algae, Dr. Dewey Amos for his assistance in making a location map, and Mr. Phillip Fragassi for loaning needed equipment for sifting through plankton and fish samples. Finally, I'd like to thank Clint Fairow and Tony Shaw for their help with field work and all my friends and family who gave their support and encouragement when it was needed most.

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INTRODUCTION

The southern redbelly dace, *Phoxinus erythrogaster* (Rafinesque), is a small, brightly colored minnow. It was first encountered by the author during coursework at Eastern Illinois University, at which time an interest was sparked. Because it was found that information was lacking on the dace, and because it was locally abundant at Rocky Branch Nature Preserve, Clark County, Ill., this study was undertaken.

Description of Species and Habitat

Because they share common breeding grounds and are closely related, hybrids are known to occur between the southern redbelly dace and the redside dace (*Clinostomus elongatus*), common shiner (*Notropis cornutus*), and the central stoneroller (*Campostoma anomalum*) (Trautman 1957). The northern redbelly dace, *Phoxinus eos*, although closely related and morphologically similar, does not interbreed with the southern redbelly dace in streams where they occur together (Phillips 1969a). These two species belong to the same genus, *Phoxinus*, which was recently changed from *Chrosomus* because it was found that *Chrosomus* species were closely allied with the Old World genus *Phoxinus*. *Phoxinus* is readily identified from other cyprinid genera in that *Phoxinus* species have small and transparent scales, usually more than 75 in lateral series; the first dorsal ray is a thin splint, closely attached to the second ray; and there are no barbels on the mouth (Cooper 1983).

Northern and southern redbelly dace are distinguished by the obliqueness of the mouth, and by the length of the snout. Northern redbelly dace have a more strongly oblique mouth than the southern species, and the distance from the tip of the snout to the posterior margin of the eye is scarcely longer than the rest of the head. In the southern species this distance is noticeably longer than the rest of the head (Cooper 1983). Northern redbelly dace prefer bog ponds and lakes and sluggish mud-bottomed creeks and are more northerly distributed than southern redbelly dace (Hubbs and Cooper 1936). In those areas where they do occur together, it was found that a preference for different spawning habitats prevents interbreeding (Phillips 1969a). The northern redbelly dace spawns in filamentous algae, while the southern species prefers habitat that is sparce in vegetation and spawns in shallow gravelly areas (Becker 1983).

Distribution and Status

The southern redbelly dace, *Phoxinus erythrogaster* (Rafinesque), has a general range from southern Michigan south to Tennesse and northern Arkansas and Iowa east to western Pennsylvania (Becker 1983). Isolated populations occur outside this range in Kansas, Missisipi, New Mexico, and Colorado, suggesting a once wider range than at present (Phillips *et al.* 1982). The southern redbelly dace is currently listed as a fish of special concern in the states of Colorado, Iowa, and Kansas, and is legally protected in the states of Mississippi and New Mexico (Johnson 1987).

In Illinois, this dace species is abundant in wooded areas in the northern third of the state. In central Illinois it is found in isolated colonies in Illinois River drainages in the far west and in far eastern Wabash River drainages (Smith 1979). It is found in these areas where permanent springs feed wooded streams. The southern redbelly dace has disappeared in recent years in a few southern counties where it was previously found by Forbes (1909). Great fluctuations in the water table and the subsequent drying up of springs in recent decades probably account for this loss (Trautman 1957, Smith 1979). Trautman (1957) describes how certain formerly clear and wooded spring-fed streams in Ohio have become, with the fluctuating water table, intermittant streams with treeless banks that experience flooding and turbid waters. In this fashion, the dace habitat and subsequently the dace populations were lost in these areas.

DESCRIPTION OF STUDY AREA

Rocky Branch Nature Preserve is located in sections 29 and 30, T12N, R12W of Clark Co., Ill., about 1 kilometer northeast of Clarksville, Il. and approximately 9.7 km northwest of Marshall, Il. (Fig. 1). The stream, Rocky Branch, which runs through the preserve, originates as a central drainage for farmlands in the southern portion of section 30 and continues northeast, with the aid of a few springs, until it reaches the West Fork of Big Creek in the middle of section 29. The West Fork of Big Creek flows into Big Creek which eventually drains into the Wabash River. Rocky Branch, approximately 2.4 km in length, is a clear, shaded, shallow, and spring-fed stream; this is optimal habitat for the southern redbelly dace.

Rocky Branch gets its name from the steep-sided and picturesque sandstone bluffs bordering the stream on either side. The narrow valley was formed by the erosive action of the stream on surface rock. The preserve is located on the till of the Illinoian glacier about 16 km south of the Shelbyville Moraine, the terminal moraine of the Wisconsin glacier (Hellinga and Ebinger 1970). Being one of the few deep valleys with rock outcroppings in east-central Illinois that missed the Wisconsin glacier, it contains a remnant plant population (Hellinga and Ebinger 1970). Because of this, many botanical studies have been conducted at Rocky Branch Nature Preserve.

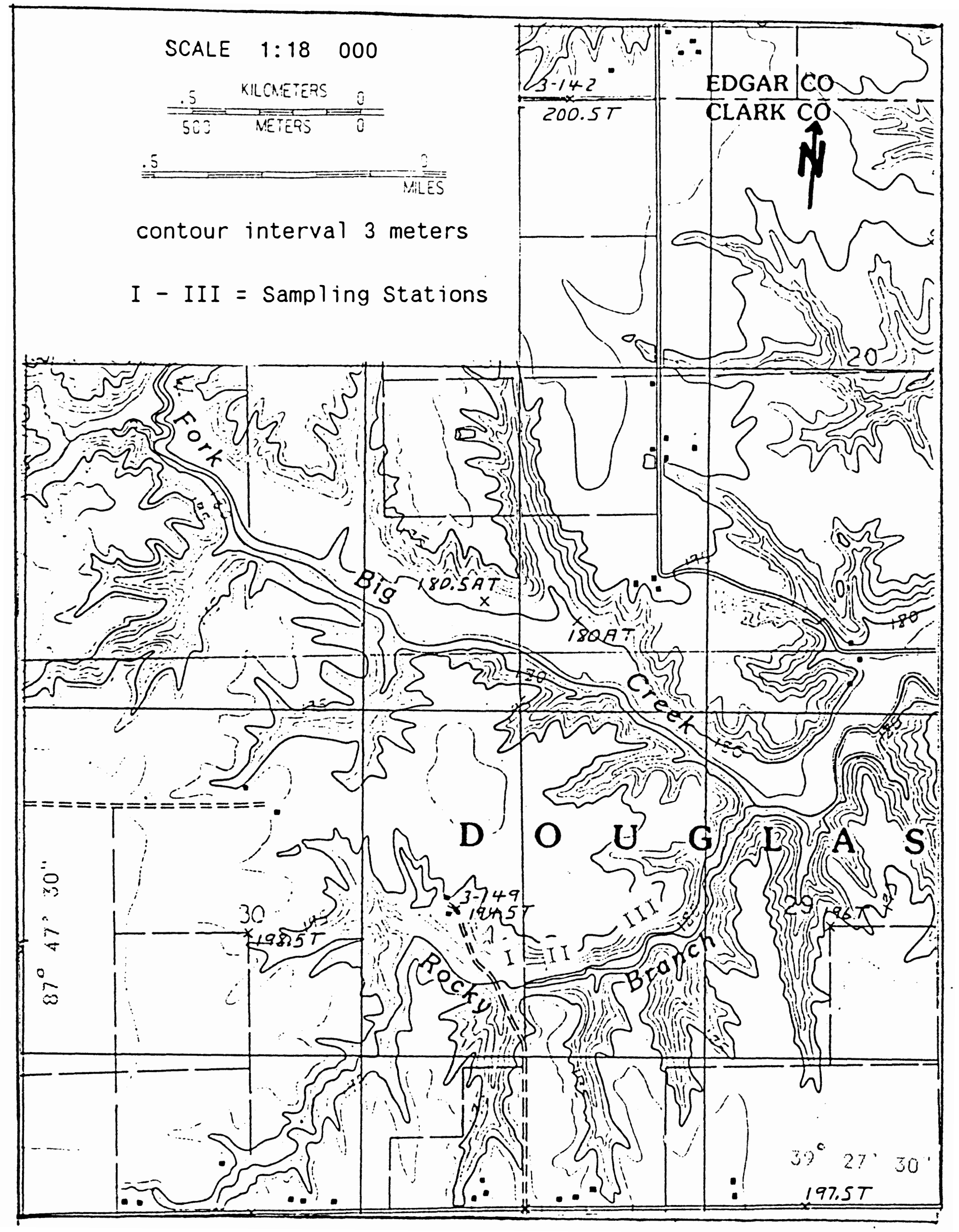

Figure 1. Location map of Rocky Branch stream and sampling stations, Clark Co., Illinois (map enlarged from USGS provisional map of Clarksville quadrangle 1984).

Eastern Illinois University was made a trustee of the 175 acre preserve after it was purchased by the Illinois Nature Conservancy in the early 1930's (Evers 1977). Since then, the university has been using the natural area for educational and research purposes. Over this fifty year period, a number of studies on the preserve have been published. Stover (1930) did the first vegetational survey of the region, finding an unusual aggregation of plants there. The area contains plants near the extreme limits of their geographical distribution. Some of these plants are tulip (*Liriodendron tulipifera*) and beech (*Fagus grandifolia*) trees, sphagnum moss (*Sphagnum sp.*), and partridge berry (*Mitchella repens*)(Stover 1930). Studies on the bryophytes of the area were undertaken by Vaughan (1941) and Arzeni (1947). Vegetational studies were done by Ebinger and Parker (1969), Hellinga and Ebinger (1970), and Hughes and Ebinger (1973). Wiedman and Whiteside (1975) studied the many lichen forms there.

The only study of the fauna of the area (Decker 1974) analyzed the water quality of the stream and surveyed the fish there. The study found that two of the four unusual fish species noted by Smith (1971) to occur in Big Creek, to which Rocky Branch is a tributary, were found at Rocky Branch. These species were the western blacknose dace (*Rhinichthys atratulus*) and the southern redbelly dace.

MATERIALS AND METHODS

The field study began in June of 1987 when an overview of the study site was taken: location of sampling stations decided; stream length, width, and depth at sampling stations measured; and notes about stream bed type, stream velocity, and stream bed and bank vegetation at sampling stations taken. The location of sampling stations was determined by accessability and all stations required a riffle and a pool area. Rough sketches of each sampling station were done describing stream bed, stream depth and velocity, and vegetation.

Also in June, fish sampling techniques were experimentally tested. It was thought by the author that a technique could be devised that would require only one individual for sampling. Using stones and small nets, an area of about 10 m long was isolated in the stream. A dip net was then used to scoop up and sample fish. Fish sampled were then put back in the stream outside the isolated area. Although some fish were sampled, this method proved to be tedious and inefficient; thus, it was abandoned for two-person seining.

The three designated study stations were seined bimonthly July through September. Fish caught in the seine were identified, using Smith (1979) and Becker (1983), and if the fish was a redbelly dace, the total length of the fish was measured in millimeters (accuracy was plus or minus 1mm). Next, the fish was sexed by color. Becker (1983) describes the male as having intense red on the lower sides, breast, abdomen, chin, lower head, and on the base of the dorsal fin; and the female as having occasionally red pigment around the base of the pectorals, and a reddish wash from above the pelvic fins to the base of the anal fin. Those dace, then, having red on the abdomen, breast, or chin were recorded as male; while those dace having no red in these areas were recorded as female or juvenile depending on size. Fish less than 50 mm were recorded as juvenile (Becker 1983).

After the data were recorded, the fish were returned to the stream. Other species caught were identified and the numbers present recorded. Water temperature and the time of day of seining were also recorded at each study station seined per trip. Seining was done by two people hauling a 2.4 m X .9 m X .2 cm mesh bag seine along the bottom of the stream at the study site. In shallow riffle areas where many very young fish were present, an aquatic dip net was used to sample the fish.

On 10 September, 1987, fish were collected and plankton samples were taken to compile data for a food analysis study. Both morning and evening samples were taken at each station. Plankton samples were taken at each station prior to seining. Plankton sampling was done by pouring 5 gallons (19 l) of stream water through a size 20 plankton net. Each sample was then carefully collected in a 30 ml vial, making about a 20 ml sample. One ml of formalin was added as a preservative. Any filamentous algae growing on rocks or the stream bed were sampled and kept wet in a plastic bag for later analysis.

Fish were collected at each station using the following guidelines to ensure a diversified sample: at least 1 fish under 50 mm, at least 2 fish between 50 and 60 mm, at least 2 fish between 60 and 70 mm, and ,if collected, any fish greater than 70 mm. Fish caught in the seine were measured and sexed by color; those chosen to be collected were placed in a labeled plastic bag and then put on ice in a cooler. Each station had its own labeled bag. The fish collected were used not only for diet analysis, but also for fin length measurements, scale samples, and otolith samples.

In the laboratory, fish were remeasured after freezing. Sex was verified using criteria from Becker (1983) by measuring the pectoral fin and the distance between the end of the pectoral fin and the origin of the pelvic fin. If the distance between fins was greater than 0.4 times the length of the pectoral fin then the fish was called female; if the distance was less than 0.25 times the length of the pectoral fin then it was called male. At this time scale samples were also taken.

Scales were collected by shaving the fish's side above the lateral line and behind the operculum with a small sharp knife. They were then stored in a small envelope labeled with the fish's size and sex, station collected, and date of collection. After scale sampling, the fish were then refrozen in separate labeled plastic bags. The labeling on these bags included the same information that was put on the envelopes. For scale analysis, the inside of the envelopes was scraped and the contents emptied onto a glass slide. A drop of water and a coverslip were then placed over the scales for viewing under a microprojector. Scales were projected onto white paper and annuli were read. Age was recorded along with the fish's size and sex.

The fish were next dissected for otoliths. Because of the tiny size of these bones, collection was done under a dissecting stereoscope. The skin and bone on the top of the head behind the eyes was first peeled away with forceps to reveal the brain. With a probe, the brain was gently lifted and pushed anteriorly to expose the tiny round sagittae located in the otic vescicles there. The bones were then dislodged with a forceps and rinsed in warm water. Next, they were mounted on a labeled slide with corn syrup. Any of the smaller lapilli bones found were also collected and mounted on the same slide as the sagittae. The fish were then refrozen for diet analysis. Twelve of the otoliths from a range of fish lengths were placed in a 2:3 glycerine and alcohol solution for clearing (Jearld 1983).

Otoliths were first viewed whole in clove oil under the 100x magnification of a light microscope. Clove oil is a clearing agent; it helps distinguish zones by enhancing the contrast between opaque and transluscent zones (Jearld 1983). If annuli were not apparent on whole mounts, then it was necessary to grind them to enhance year marks. Grinding was done by placing the otolith between two glass slides with a mild abrasive. The top slide was then gently rubbed back and forth against the otolith for about a count of ten. The otolith was then rinsed in water, blotted dry, and placed on a slide with clove oil. The bone was viewed again under 100x magnification. If annuli were now apparent, they were counted and recorded along with the fish's size and sex. If no annuli were apparent, the otolith was ground again in the same manner for a count of ten. This process was continued until annuli were noticeable.

For diet analysis, 8 partly frozen fish from two of the sampling stations were cut with a scissors along the belly from the tip of the jaw to the anus. The digestive tract was gently eased out of the body cavity with forceps and was cut at the esophagus and anus. The digestive tract was placed in a petri dish and gently teased apart until the loops were straightened out. Phillips (1969b) states that the difficulty in estimating relative volumes of the tiny organisms eaten by the southern redbelly dace, and the small percent of actual food items present in the tract because of the presence of mud, silt, or sand led him to use only quantitative data to describe the composition of the diet.

The present study used a sampling method similar to Phillips (1969b). Twenty millimeter sections of the tract were cut in the anterior, middle, and posterior portions of the tract. These sections were placed in a 50:50 solution of 90% isopropyl alcohol and water. Each section was separately sampled by placing the section in about 2 ml of the alcohol and water solution and macerating it; emptying the digestive tract's contents into the solution. An eyedropper was used to collect part of the sample and to drop it onto a glass slide with a coverslip for viewing under the microscope.

A light microscope with a 15x ocular and 10x and 43x objective lenses was used for viewing the intestine contents. The sample was first viewed under the 10x lens to search for larger organisms such as filamentous algae and entomastraca. Any of these larger organisms encountered were identified to genus using Tiffany and Britton (1952) and Needham and Needham (1962) and recorded on a sample sheet along with the fish's size and sex, collecting station number, and date. Next, the sample was viewed under 43x. For each 20 mm section 125 organisms were counted; making a total of 375 organisms counted per fish. Organisms were identified to genus using Tiffany and Britton (1952) and Dodd (1987) and recorded on a labeled sample sheet. Any organisms not identified were sketched on the sample sheet in hopes that they could later be identified. Most algae and diatoms identified were verified by Dr. Richard Smith, phycologist at Eastern Illinois University.

Plankton from the five stations sampled was analyzed using a Sedgewick-Rafter counting chamber. An eyedropper was used to collect a subsample from the vial and then to fill the counting chamber. Under 150x magnification, two or three lengthwise strips were counted for each of two subsamples taken per plankton sample. In each strip any organism encountered was identified using Needham and Needham (1962), Tiffany and Britton (1952), and Dodd (1987), and recorded on a labeled sampling sheet. To calculate the number of plankters per milliliter of sample, the following formula from Brower and Zar (1977) was used:

First the volume that was sampled in the two or three strips viewed (v) was calculated:

$$v = (k)(d)(w)(L)$$

where k = the number of strips counted (either 2 or 3)
d = the depth of the chamber (1 mm)
w = the width of the microscopic field (1.38 mm)
L = the length of the chamber (50 mm)

Next, this calculated volume was inserted into another formula to calculate the number of plankters found in one milliliter of sample (N):

$$N = (n)(V/v)(c)$$

where n = the number of individuals counted in the strips
V = the volume of sample in the chamber (1 ml)
v = the volume of the strips counted
c = the concentration factor (19 liters concentrated into 20 ml = 20/19000 = .001)

The number of plankters per genus was then individually calculated using this same formula to generate relative densities. Filamentous algae samples were not quantitatively analyzed, but were viewed under a microscope and identified along with any epiphytic organisms present.

DESCRIPTION OF SAMPLING STATIONS

Station I

A gravel farm road bisects Rocky Branch stream into an eastern and western portion. Station I began about 50 m east of this gravel road where a tributary from the south meets the main branch (Fig. 1). At this point, the stream was approximately 6 m in width and had a depth of 40-50 cm. This area was the largest of all the sections sampled on the stream, and seining was very successful here. Past this meeting place the stream gradually narrows into a gravelly riffle area. The depth of the stream here was 10-15 cm; this was the first area where the one-person sampling technique was attempted. The stream next became deeper as it made its way around two sugar maples (*Acer saccharum*). In this area the stream was 20-25 cm in depth and had a width of approximately 4.6 m; this area had successful seining hauls but the fish had room for escape in brush on the south bank.

The south bank was a cut bank overlaid with mosses, shrubs, and trees. Just behind the bank to the south was a steep sandstone bluff. The north bank was relatively flat and covered with a shrub-sapling community including sugar maple and musclewood (*Carpinus caroliniana*). The entire length of Station I was approximately 35 m.

Station II

Station II was located about 250 m downstream from Station I. The stream here was narrowest at the beginning of the station where a gravelly riffle opens into a larger area containing a semi-stagnant pool. The stream was approximately 3 m wide and 18 cm deep in the riffle area. Duckweed (*Lemna minor*) and scarce amounts of filamentous algae were found in the pool. The stream next flowed into a deeper but narrower area where large slate slabs and rock made up the bottom. In this area a large number of adult-sized dace congregated. The depth here was 30-35 cm. As the stream continued and bent around a large sycamore (*Platanus occidentalis*) tree, it soon became very shallow and fairly rapid, with the stream bed of sandy shale. Here many small dace gathered. In the final section of the station the stream gradually became deeper and wider again to a width of about 5 m and a depth of 35-40 cm.

The south bank of Station II began as a cut bank topped with grasses, virginia creeper (*Parthenocissus quinquefolia*), and a large sycamore tree. East of the sycamore tree the cut bank ended to become an area of sand deposition. Here *Equisetum* grew along with grasses and herbs. The north bank began fairly flat with grasses growing, but east of the sycamore tree became a cut bank topped with a shrub-sapling community. Trees here include elm (*Ulmus sp.*), osage orange (*Maclura pomifera*), sugar maple, and musclewood. The entire length of Station II was approximately 35 m.

Station III

Station III was located about 350 m downstream from Station II. Here the stream ran beneath a sandstone outcrop on the north bank. The stream flowed fairly straight over a sandy and gravelly bed with widths from .7-2 m and depths from 5-15 cm, until it began to turn eastward away from the bluff. After the bluff, the stream suddenly became deep and wider. The depth here was 45-50 cm and the width about a 2.5 m. This area was particularly good for seining.

The south bank was a cut bank overlaid with mosses, ferns, shrubs and trees. The north bank, with its sandstone bluff, supported lichens, mosses, ferns, shrubs, and even a few trees; showing primary succession in action. The entire length of Station III was approximately 30 m.

RESULTS AND DISCUSSION

During the six seining trips between 19 July and 10 September, 1987, a total of 358 southern redbelly dace were sampled and released. Of these 358, 211 were female, 107 were male, and 40 were juvenilles. Smith (1908) sampled a population of dace during spawning and discovered a sex ratio skewed towards males (1 : 6.5). The present study found that, between mid-July and mid-September, the sex ratio skewed towards females (66%). Perhaps the Rocky Branch population simply has a different sex ratio than the population Smith (1908) studied in Lake Forest, Ill. However, it could be that during the spawning season males seek out areas where females are abundant. After spawning, males leave for new female-abundant areas.

For the 358 southern redbelly dace sampled, other fish species collected and their relative numbers were: *Ericymba buccata* (114), *Semotilus atromaculatus* (67), *Campostoma anomalum* (33), *Etheostoma nigrum* (26), *Rhinichthys atratulus* (21), *Etheostoma flabellare* (16), *Notropis chrysocephalus* (15), *Pimephales notatus* (9), *Etheostoma caeruleum* (7), *Campostoma commersoni* (6), *Lepomis machrochirus* (3), *Ictalurus melas* (3), *Lepomis megalotis* (2), and *Micropterus salmoides* (1). Becker (1983) found southern redbelly dace in association with seven of these species in Wisconsin. Decker (1974), who also surveyed the fish at Rocky Branch, found all but the largemouth bass to be present, and rarely collected green sunfish (*Lepomis cyanellus*), western creek chubsuckers *(Erimyzon oblongus)*, and northern hogsuckers (*Hypentelium nigricans*).

The length/frequency distribution for the 358 dace sampled is charted in Figure 2. Length/frequency graphs from each seining trip yielded similar results. Of the 358, only 8 were greater than 70 mm total length. The largest dace collected was a 74 mm female; the smallest, collected in July with a dip net, was 22 mm. Both Trautman (1957) and Becker (1983) report age class I to begin at 38-40 mm total length. Using this information, the first peak in the graph at 36 mm indicates that dace of age class 0 are those fish less than 38 or 39 mm. The middle year classes are difficult to distinguish from the chart. Age class I could peak at 51 mm, 56 mm, or 60 mm, and age class II could peak at 56 mm, 60 mm, or 65 mm. Becker (1983) found dace to reach a maximum age of three years. He gives the range for age class III dace to be between 71 and 76 mm TL. From this information the peak after a lapse at 70 mm denotes the age class III peak. For the southern redbelly dace population at Rocky Branch, according to length/ frequency results, fish with lengths of 69 to 74mm belong to age class III.

The reason the length/frequency graphs did not yield useful information about age classes I and II is because, within the range of 51 to 64 cm, too much overlap occured in fish growth. Regardless, this length/frequency graph was valuable because it indicated the range of fish lengths

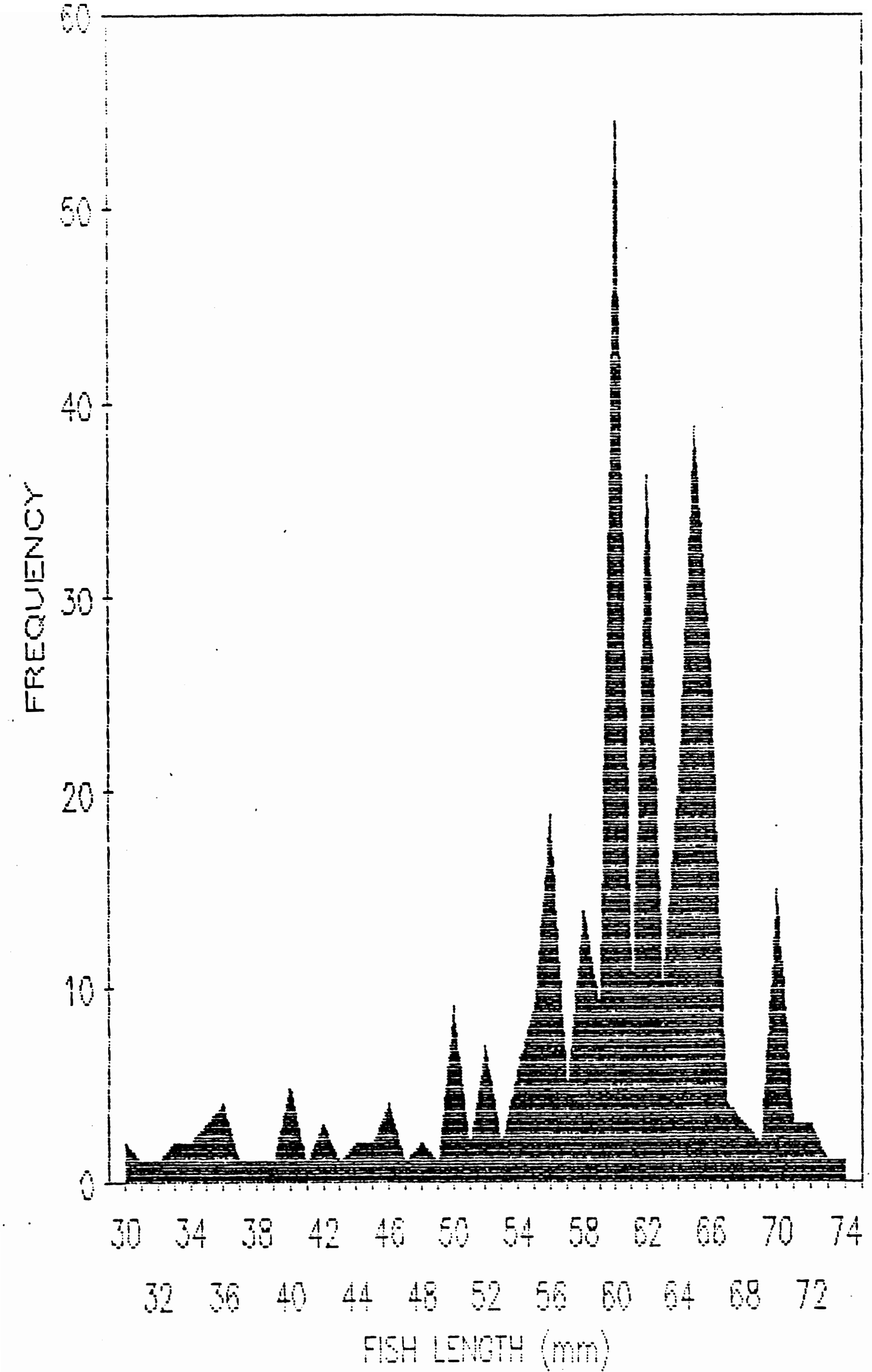

Figure 2. Length/frequency distribution for 358 southern redbelly dace sampled between July 19 and September 10, 1987 at Rocky Branch, Clark Co., Ill.

needed most to be sampled by scales and otoliths. This information decided the criteria for fish sampling: at least one under 50 mm, at least two between 50-60 mm, at least two between 60-70 mm, and any fish collected greater than 70 mm.

On 10 September, 1987, a total of 35 fish were collected for food analysis, sex determination, and age determination. Successful samples, meeting criteria, were taken at all stations except Station II in the p.m. Because dace had room to escape behind a large fallen tree, seining was not successful at Station II in the p.m. Because no fish were sampled, the plankton sample taken prior to seining was not analyzed.

Year classes as determined by scale and otolith analysis are presented in Table 1. These two methods yielded similar, though not exact, results for age classes I and II. For scales, length range and thus the average lengths for age classes I and II were slightly greater than ranges and averages as determined by otoliths. However, there was not more than a 2 mm difference between the two methods for either age class. Trautman (1957), who aged dace by scale analysis in Ohio, found age class I dace to be 25-46 mm. Becker (1983) found, by scale analysis, age class I dace to be 40-64 mm, and age class II dace to be 65-73mm. Data from the present study closely agrees with Becker (1983). No data on age determination using otoliths were found in the literature.

Table 1. Age classes of southern redbelly dace collected at Rocky Branch, Clarke Co., Ill. using scale and otolith analysis.

	Age Determination Method					
	Scales			Otoliths		
		TL (mm)			TL (mm)	
Age Class	# of Fish	Avg	Range	# of Fish	Avg	Range
I	15	51.5	39-64	11	51.0	39-63
II	15	63.5	57-70	12	62.5	57-68
III	1	68.0	68	2	69.5	69-70

Because of the small sample size of age class III individuals, it is difficult to draw conclusions, but it appears otoliths may be more accurate for aging older dace. By scale method both the 69 and 70 mm dace were aged at 2 years; whereas by reading otoliths they were determined to be 3 years. Comparing otolith and scale results for age class III to the length/frequency chart, it can be noted that the otoliths agree more with length/frequency results. Becker (1983) found age class III dace to be 71-76 mm, slightly larger than age class III dace at Rocky Branch.

Beamish and McFarlane (1987) state that older fish tend to be underestimated by the scale method when compared to otolith results. However, all examples cited by Beamish and McFarlane (1987) were fish that lived to be at least 5 years old. So, because of the small number of annulli in the southern redbelly dace (less than 4), the statement may not apply. Jearld (1983) gives four advantages of otolith age determination: 1) they form when fish are embryos, therefore they reflect all life history events, 2) they show age more clearly, especially in older fish, 3) a small sample size can be used, and 4) fish of the same species have otoliths of similar shape.

Fewer dace were age-determined by otoliths than by the scale method because a few of the otoliths that were stored in the clearing solution broke during the grinding process. Others, because of their tiny size (about a millimeter in diameter) were either not located in a fish, or were lost during the analysis process. The otolith technique required more skill and time than scale analysis, but it yielded results that better matched length/frequency for older dace.

Sex was determined, using Becker (1983) fin length criteria, for 28 of the dace collected. Seven of the dace collected were less than 50 mm; therefore they were assumed to be immature. Of the 28 fish measured, 21% had been wrongly sexed based on color. However, the number of males wrongly sexed (3) was equal to the number of females wrongly sexed (3). Also, it should be noted that the dace had been collected in September, at least a month after the spawning season had ended. At this time, breeding colors were fading. Therefore, although 21% appears to be a significant number wrongly sexed, it should be taken into consideration that a large portion of the seine hauls and sexing by color was done in July and August, when breeding colors were more apparent, and were probably more than 79% accurate.

Age and average length data for each of the sexes are compiled in Table 2. Males, in the southern redbelly dace population at Rocky Branch, averaged smaller than females for both age classes I and II. Becker (1983) found female dace in Wisconsin to average slightly smaller than males. Phillips *et al.* (1982) found female dace in Minnesota to have a maximum length of 4 inches (101mm) and males a maximum length of 3 inches (76mm). Although no other literature reviewed by the author reported a maximum for any dace, regardless of sex, to be greater than 76mm, Phillips *et al.* (1982) observations on length differences between the sexes agrees with this study.

Table 2. Age, sex, and average length of southern redbelly dace collected at Rocky Branch, Clarke Co., Ill. (age determined by otolith analysis).

	Age I		Age II	
	TL (mm)		TL (mm)	
Sex	Avg	Range	Avg	Range
Males	52.5	50-55	63.0	56-68
Females	56.0	50-62	65.5	63-68

Lagler *et al.* (1962) report that among the Cyprinidae of North America, the majority of species have larger females than males. They further state that the greater-sized sex is usually the more "important" parent. Smith (1908), who published observations on the spawning behavior of the southern redbelly dace, noted that during spawning one female pairs with two males. Because of this behavior, the female could be considered the more "important" parent and therefore explains the larger size. Hubbs and Cooper (1936) state that in minnow species that do not give parental care to released eggs, the females grow somewhat faster than males, and usually live to a greater age. Smith (1908) reports that redbelly dace do not use a nest for spawning; eggs are simply dispersed in a riffle and taken downstream where they could be buried or eaten. Because of this, it would be advantageous to produce many eggs; and because larger females produce more eggs than smaller females, this trait may have been naturally selected for because it was reproductively successful. Furthermore, males may seek out these larger females to the benefit of increasing both sexes reproductive success. It can be concluded that, in this study, females averaged greater lengths than males of the same age.

The digestive tracts of eight fish were examined for diet analysis. Because of the poor condition of many of the fish after measurements, and scales and otolith removal, it was decided that four fish in good condition from one of the stations in the a.m. and four fish in good condition from a station in the p.m. would be an adequate sample. Phillips (1969b) examined 5-10 fish per sampling date and got satisfactory results. For each of the seven full intestines examined, a total of 375 food organisms was counted. One of the dace in the p.m. sample had an empty stomach (less than

10 organisms in 5 strips). This fish was not included in the data compiled in Table 3 because a full sample of 375 organisms was not quantified.

Thirteen out of the 15 most common algal genera found in the digestive tracts of southern redbelly dace belong to the Class Bacillariophyceae (Division Chrysophyta), the diatoms (Table 3).

Table 3. Percent of the 15 most common algal genera eaten by southern redbelly dace collected from Rocky Branch, Clark Co., Ill. on 10 September, 1987.

Station/Time	3/a.m.	1/p.m.	$\bar{X}$
# of fish examined	4	3	
Mean TL of fish (mm)	62.2	54.7	
Navicula	38.6	39.8	39.1
Cocconeis	15.7	15.0	15.4
Pinnularia	9.2	5.1	7.4
Nitzschia	5.4	7.5	6.3
Amphora	4.9	7.9	6.2
Cymbella	4.8	2.3	3.7
Gomphonema	3.9	1.7	3.0
Gyrosigma	1.5	4.3	2.7
Caloneis	2.9	1.9	2.5
Synedra	1.5	3.6	2.4
Cyclotella	0.8	1.2	1.0
Trachelomonas	0.6	1.4	0.9
Melosira	1.0	0.2	0.6
Rhoicosphenia	1.0	0.2	0.6
Euglena	0.5	0.7	0.6
Other	2.1	1.4	1.8
Unidentified	6.1	6.7	6.4

The genus *Navicula* was found to be the most abundant food organism regardless of station or time of day. Phillips (1969b) found similar results in a study done in

Minnesota. Eight out of 10 of the most common algal genera present in Minnesota dace intestines belonged to the Class Bacillariophyta, with *Navicula* the most abundant.

The southern redbelly dace is known to feed mainly on the mud and slime of the stream bottom (Forbes 1914). This bottom ooze contains mostly diatoms (Starrett 1950). *Navicula* is a free floating diatom (Tiffany and Britton 1952), which is also commonly found in benthos (Hynes 1970). Hynes (1970) lists other common mud-inhabiting or epipelic algal genera. Among them are *Melosira, Gyrosigma, Caloneis, Amphora, Cymbella*, and *Nitzschia*. Each of these genera was found to be present in the diet of the southern redbelly dace in Rocky Branch stream. Phillips (1969b) estimated that 90% of the contents of a typical redbelly dace digestive tract consists of detritus, sand, and silt. Because intestines examined in this study contained large amounts of debris and mud, and contained several epipelic alga genera, it can be concluded that the dace at Rocky Branch feed on bottom sediments.

The genera *Cocconeis*, *Gomphonema*, *Synedra* and *Rhoicosphenia* were found to be second, seventh, tenth and fourteenth most common in the diet, respectively (Table 3). These genera are described by Tiffany and Britton (1952) and Hynes (1970) as being epiphytic on submerged aquatics. The only filamentous algal sample taken during the present study, *Rhizoclonium* from the semi-stagnant pool area of Station II, found all four of these genera to be epiphytically present. *Cocconeis placentula*, a species commonly seen in samples, and *Synedra* are listed by Hynes (1970) as being epilithic, or rock-inhabiting diatoms. Because *Cocconeis, Gomphonema, Synedra*, *Rhoicosphenia* together make up more than 20% of the diet it can be concluded that southern redbelly dace, in addition to bottom feeding, graze on rocks and filamentous algae.

The remaining Bacillariophyta genera listed in Table 3, *Pinnularia, Cyclotella*, and *Melosira*, are described by Tiffany and Britton (1952) as being free floating diatoms, as well as *Navicula, Nitzschia, Gyrosigma*, and *Caloneis*. These genera, then, are part of the plankton community. Coyle (1930) states that bottom feeders may ingest plankton when water is taken in for respiration. From this information, and the data in Table 3, it appears that plankton may make up a portion of the diet.

The other division commonly found in the diet was the Euglenophyta. The genera *Euglena* and *Trachelomonas* made up about 1.5% of the diet (Table 3). Organisms categorized under Other included the Bacillariophyta *Fragillaria* and *Epithemia*, the Cyanophyta *Chroococcus* and *Anabaena*, and the Chlorophyta *Oedegonium* and *Pediastrum*. Hynes (1970) describes *Pediastrum* as a "truly planktonic organism", further proof that the dace do, if only during respiration, consume plankton. Under the Unidentified category, unidentified plant and insect parts were found in a few of the dace, indicating that the dace eats insects when available. Also included in this category were diatoms that were viewed in girdle view; and thus were not easily identified.

Because southern redbelly dace feed on plankton organisms, along with bottom debris, data on the genera of plankters and their relative amounts in Rocky Branch stream were compiled (Table 4). The average number of plankters per

Table 4. Percent of the 15 most common plankters sampled from Rocky Branch, Clark Co., Ill. on 10 September, 1987.

Stations/Time	1,2,3/a.m.	1,3/p.m.	$\bar{X}$
Avg # of plankters/liter	751	163	457
Navicula	31.5	56.0	43.8
Amphora	6.8	9.7	8.3
Nitzschia	8.3	7.0	7.7
Ankistrodesmus	3.3	6.5	4.9
Cocconeis	3.4	3.2	3.3
Synedra	2.8	3.5	3.2
Euglena	4.8	1.3	3.1
Caloneis	4.8	1.1	2.7
Gomphonema	3.8	2.2	3.0
Melosira	2.9	2.4	2.7
Cymbella	2.8	1.4	2.1
Trachelemonas	0.5	2.6	1.6
Pinnularia	3.0	0.0	1.5
Gyrosigma	2.3	0.0	1.2
Anabaena	0.7	1.4	1.2
Other	11.5	0.5	5.9
Unidentified	5.8	1.3	3.6

milliliter for the a.m. sample was found to be much greater than for the p.m. sample. Decreasing light and temperature probably account for this differernce (Eddy 1934). *Navicula*, was, by far, the most common genus.

Plankton was collected near the shore, using a gallon jug, by emptying 5 gallons of stream water through a plankton net. Because of the shallow water and soft bottom, after the initial jug was collected the water began to turn murky. Even though a clear sample was attempted, it is the author's belief that epipelic organisms enriched the plankton sample. *Navicula*, *Amphora*, and *Nitzschia*, ranked first through third in the samples respectively, are known to be abundant in bottom debris (Hynes 1970).

Ankistrodesmus, an organism that was not found in any dace digestive tract, was ranked fourth. Perhaps this organism best exhibits the importance of plankton in the diet. Hynes (1970) describes *Ankistrodesmus* as "truly planktonic". If plankton was a major part of the dace's diet, then this fairly abundant organism should have been observed in the dace digestive tracts that were examined. Because this was not the case, it is concluded that plankton is not a significant part of the southern redbelly dace's diet.

Another plankton organism, *Cyclops*, was found in two of the plankton samples (under category Other, Table 4). Because no *Cyclops* were found in the digestive tracts of the dace, it appears that entomostraca, at least during the month of September, are not significant in the diet. Thus this study found bottom mud and slime and the organisms contained within to be the bulk of the southern redbelly dace's diet. Organisms obtained from grazing on rocks and submersed algae were next in importance. Finally, planktonic organisms consumed during respiration were minor contributors to the southern redbelly dace's diet at Rocky Branch.

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