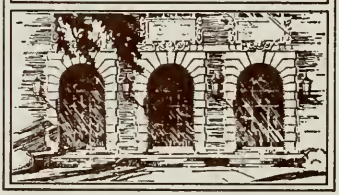
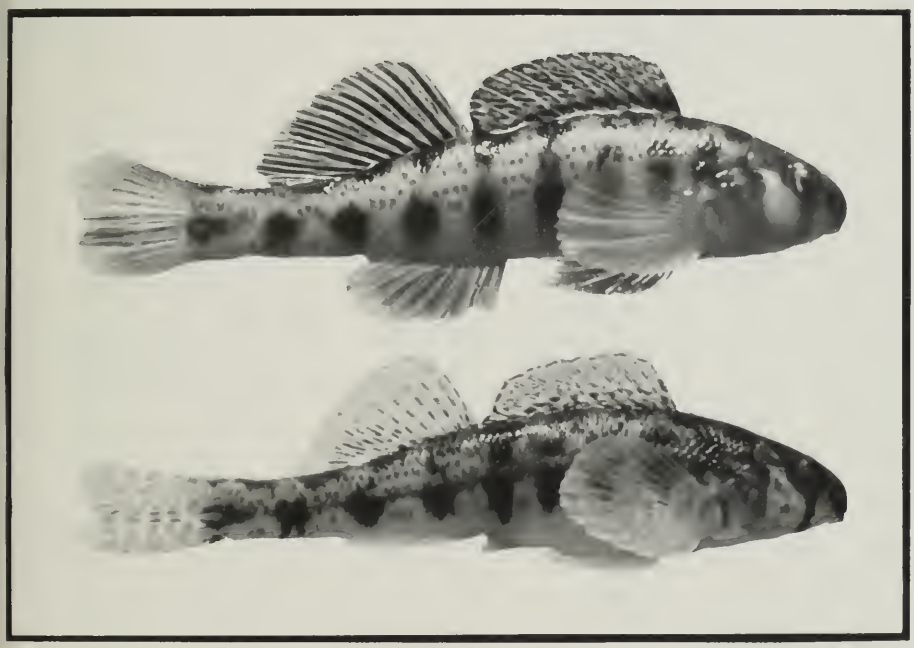


THE LIFE HISTORY OF THE TENNESSEE SNUBNOSE DARTER, *Etheostoma simoterum* IN BRUSH CREEK, TENNESSEE

Lawrence M. Page and Richard L. Mayden



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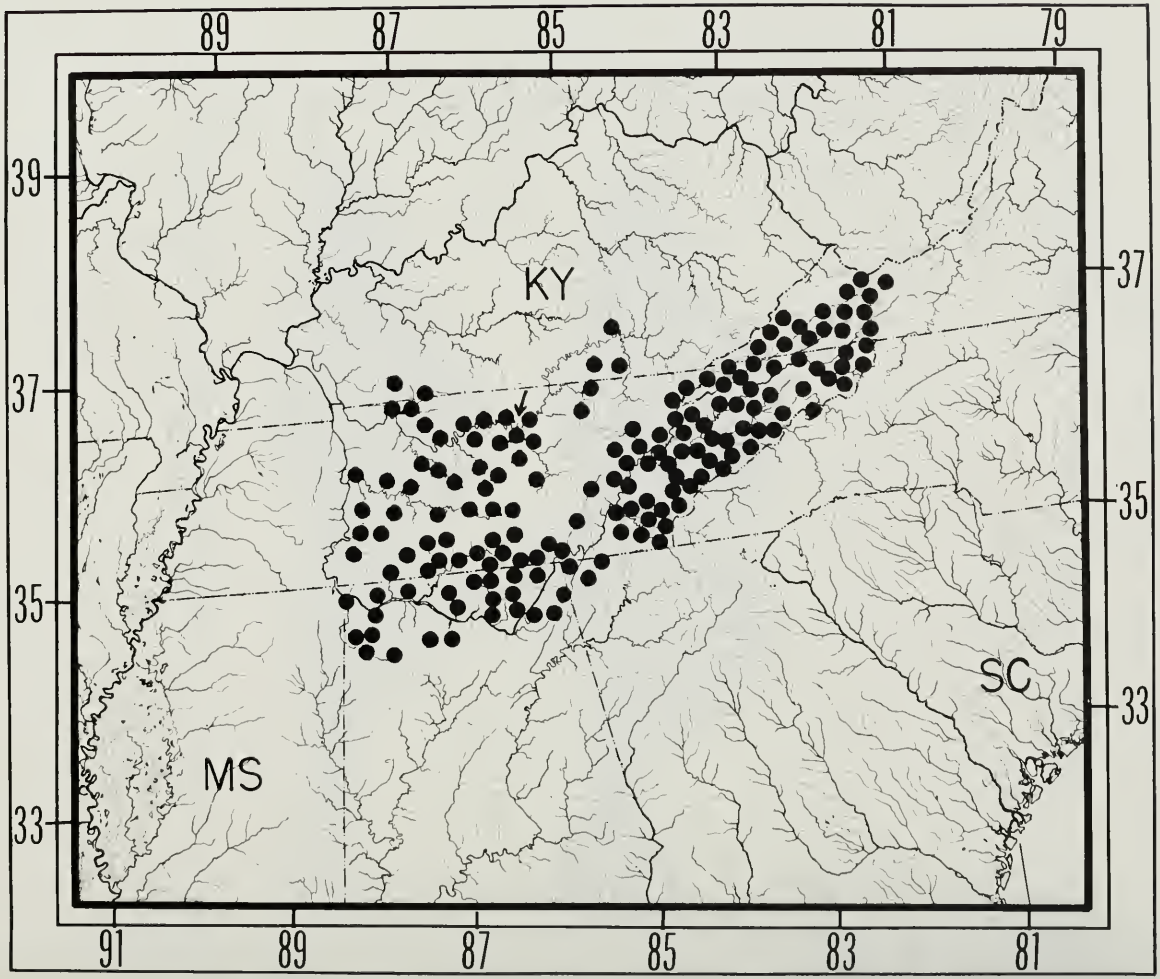

Fig. 1.—Distribution of *Etheostoma simoterum*. The arrow points to the study site.

The Life History of the Tennessee Snubnose Darter, *Etheostoma simoterum*, in Brush Creek, Tennessee

Lawrence M. Page and Richard L. Mayden

The Cumberland snubnose darter, described as *Arlina atripinnis* by D. S. Jordan in 1877 from specimens collected near Nashville, Tennessee, has been determined recently to be at most only intraspecifically distinct from the Tennessee snubnose darter, *Etheostoma simoterum* (Cope) (D. A. Etnier, personal communication), as suggested by Bouchard (1977:129). *Etheostoma simoterum,* described as *Hyostoma simoterum* from the Holston River, Virginia, by E. D. Cope in 1868 thus ranges throughout most of the Tennessee River system and much of the Cumberland River system (Fig. 1).

The subgenus *Nanostoma* of *Etheostoma* encompasses *Etheostoma zonale* and all species previously referred to the subgenus *Ulocentra* (Page 1981), including *E. simoterum.* Except for *E. zonale* and *E. coosae,* all species in *Nanostoma* are poorly known ecologically. The lack of information on these species is in part because 9 of the 15 recognized species in the subgenus are undescribed taxonomically; without names, species remain unknown except to a few specialists. Ecological data on *E. zonale* are included in Forbes & Richardson 1908:306; Lachner et al. 1950; Miller & Robison 1973:216; Wehnes 1973; Adamson & Wissing 1977; Pflieger 1975:312; Lutterbie 1979:24; Bryant 1979; and Cordes & Page 1980. The life history of *E. coosae* was studied recently in Barbaree Creek, Clay County, Alabama (O'Neil & Boschung 1980:53). Bouchard (1977) discussed the habitats utilized by *E. etnieri.*

For aid in collecting specimens we are grateful to B. M. Burr and M. A. Morris. Illustrations were prepared by Illinois Natural History Survey Illustrator Lloyd LeMere and Survey Photographer Les Woodrum. The manuscript was typed by Alice Adams and Bernice Sweeney and edited for publication by Shirley McClellan, Assistant Technical Editor at the Survey. Dr. William J. Matthews, University of Oklahoma; Dr. Wayne C. Starnes, University of Tennessee; Dr. Glen C. Sanderson and Dr. John Tranquilli, Illinois Natural History Survey, reviewed and improved the manuscript. This study was supported in part by National Science Foundation grant DEB 76-15542.

STUDY AREA AND METHODS

Etheostoma simoterum was studied in Brush Creek, Smith County, Tennessee at the same site used in the life-history study of *E. olivaceum* and described by Page (1980:3–5). The Brush Creek population of *E. simoterum* is referred to by Page (1980) as *E. atripinne.*

Methods of study were the same as those employed in the study of *E. olivaceum* (Page 1980:3–5). Minnow-seine collections were made at about 2-month intervals; the first collection was made on 3 March 1977, the last on 30 January 1979. A total of 10 collections were made and 425 specimens were preserved and examined. Specimens collected for study were preserved in 10-percent formalin. Collections were recorded as being made in riffles, bedrock pools, or slab pools. Potential predators captured during seining operations were preserved for later examination of stomach contents. Ambient stream conditions were recorded at each visit.

In the laboratory each specimen was measured (unless stated otherwise, all lengths given in the text are standard lengths), sexed by examining the genital papilla or when necessary the gonads, and aged. Aging to year class was done by counting annuli on scales removed from the dorsum; aging to month was done by using April, the month of the greatest breeding activity, as month zero. Thus a darter collected in July and having one scale annulus was estimated to be 15 months old. For some comparisons, darters were divided into young (through 12 months) and adult (over 12 months) age groups. Ninety-seven specimens of various lengths were weighed to the nearest 0.001 g; functional regressions of weight on standard length were computed following Ricker (1973).

A representative sample of each collection was dissected to identify stomach contents and endoparasites and to note the conditions of the gonads. Weights of the ovaries of 34 females and of the testes of 14 males collected in various months were obtained and recorded as proportions of the total body (including the gonads) weights and of the adjusted body weights (the specimen minus the ovaries, stomach, intestine, and liver); the latter weight is intended to remove variation resulting from the weights of recently ingested food. Mature ova in 10 breeding females were counted. The relative survival of the second-year class was calculated by expressing the number of individuals in that year class as a proportion of the number of individuals in the first-year class. Breeding behavior was observed in individuals transferred to aquaria during the breeding season.

HABITAT

E. simoterum lives in rock- and gravel-bottomed pools, often near riffles and with moderate current, in small to medium-sized streams. In Brush Creek, individuals were

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Cover Illustration.—*Etheostoma simoterum* collected in Brush Creek, Smith County, Tennessee, 16 April 1978. Upper, 52-mm male; lower, 51-mm female.

most common in bedrock pools below riffles and in deep (to 20 cm) crevices in the bedrock (Fig. 2). Few individuals were found in riffles or in slab-rock pools along the margins of the stream.

Fig. 2.—Gravel-strewn crevice in bedrock substrate of Brush Creek, Smith County, Tennessee, 16 April 1978. Crevices are occupied by *Etheostoma simoterum*.

Clean pools with moderate current over bedrock, cobble, or gravel are the characteristic habitat of the adults of most species of *Nanostoma* although Bouchard (1977:124) found *E. etnieri* to be most common in riffles and runs, and *E. zonale* inhabits rocky and usually vegetated riffles. O'Neil & Boschung (1980) stated that *E. coosae* occupies raceways, riffles, and pools over cobble or gravel.

REPRODUCTION

Reproductive Cycle of the Male

During most of the year, the genital papilla of the male is a small conical structure. Between January and April the papilla gradually elongates and becomes tubular (Fig. 3). Testes of breeding males are large, white, and spongy; those of nonbreeding males are small and translucent. The mean testes-to-total-body (including the testes) weight ratio increased from 0.002 (N = 3 males) in October to a high of 0.017 (N = 3) in April. From June to September, when males were postreproductive, the testes were too small to weigh accurately (i.e., less than 0.001 g). The relationship between the mean weight of the testes divided by the adjusted body weight (specimen's body weight after removal of the gonads, stomach, intestine, and liver) and the month, with October = 6 and April = 12, was log Y = 0.697 + 0.169X, with r = 0.986 (Fig. 4).

All April-collected males (N = 19) were 1 year old, had enlarged testes and were considered sexually mature. They ranged from 40.1 to 55.7 and averaged 49.1 mm in length. Sexual maturity at 1 year is usual among darters, although in some species a few individuals may not be large enough by the first breeding season to mature sexually, and in northern populations of some species (e.g., *E. zonale*) individuals may not mature until their second year (Lutterbie 1979:24).

Breeding colors began developing in the largest males in January and by April all males were brightly colored. The breeding male is deep green or blue-green with bright red or red-orange spots on the body and bright red dorsal fins. The red spots on the body sometimes coalesce into suffusions of red or red-orange. Breeding tubercles do not develop.

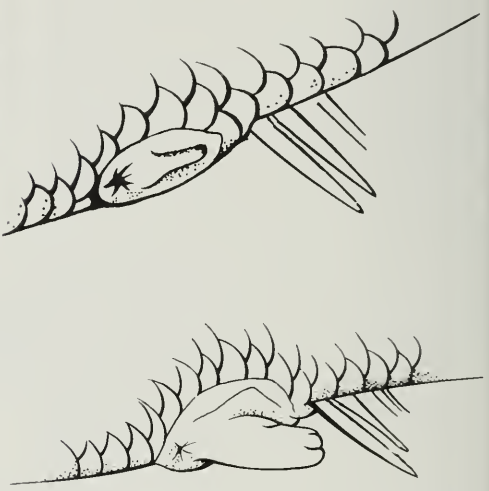

Fig. 3.—Genital papillae of *Etheostoma simoterum* collected in Brush Creek on 16 April 1978. Upper, breeding male; lower, breeding female. Both specimens were 1 year old.

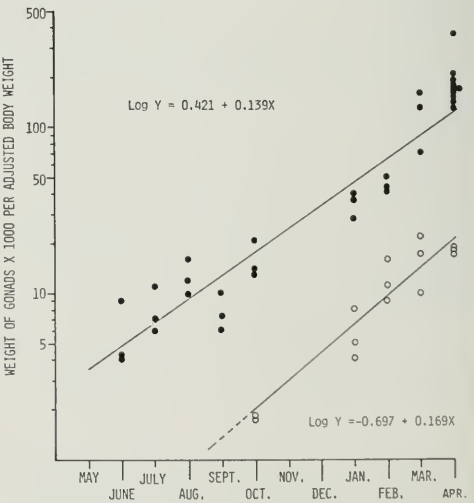

Fig. 4.—Monthly variations in ovarian (dots) and testicular (open circles) weights relative to adjusted body weights in *Etheostoma simoterum*.

Reproductive Cycle of the Female

The genital papilla of the nonbreeding female is a short thick tube. During spring the tube elongates into a structure (Fig. 3) used to attach the adhesive eggs to a suitable substrate (Fig. 5). The breeding female is slightly brighter but nearly identical in color to the nonbreeding female.

Ovaries of June-collected 1-year-old females were in a state of reabsorption and had no mature ova. From July to September the ovaries contained only undifferentiated (clear) ova and were small and translucent. In October the largest females (1 + age class) contained a few differentiated (white) ova. By February yellow ova were present, and in March large, dark yellow, nearly mature ova were present (only -1 age class females were collected after October).

All April-collected females (N = 48) were 1 year old, contained mature ova, and presumably would have spawned within a few weeks. They ranged from 38.5 to 50.8 and averaged 44.1 mm in length. Fully mature ova averaged 1.2 mm in diameter and were transparent with one to several oil droplets and deeply indented on one side. Indented eggs have been described for darters of the subgenera *Microperca* (= *Boleichthyes* — see Page 1981) and *Catonotus* (Burr & Page 1978:6, 1979:5; Page 1980:7) but are not known in other freshwater fishes (Burr & Ellinger 1980).

In 10 females collected on 16 April 1978 the number of mature ova ranged from 110 to 240 (Table 1). As in other darters living through only one breeding season (Burr & Page 1978:6–7, 1979:5–6; Page 1980:7), no significant correlation exists between the number of mature ova produced by a female and the standard length, nor between the number of mature ova and the body weight or adjusted body weight; for all relationships the correlation coefficients (r) were less than 0.32.

Table 1.—Relationship between female size, weight of ovaries, and number of mature ova in *Etheostoma simoterum*. All females were collected in April 1978 and estimated to be 12 months old.

Standard Length in mm	Body Weight in Grams	Adjusted Body Weight in Grams[a]	Weight of Ovaries in Grams	Number of Mature (Orange or Translucent) Ova
42	1.44	1.07	0.18	122
43	1.46	1.15	0.15	110
43	1.41	1.05	0.17	144
43	1.53	1.11	0.20	170
43	1.88	1.27	0.45	240
45	1.60	1.25	0.20	128
47	1.75	1.34	0.28	112
48	2.07	1.57	0.22	188
49	1.93	1.49	0.24	128
51	2.52	2.03	0.38	182

[a] Adjusted body weight is the specimen's weight after removal of the ovaries, stomach, intestine, and liver

The relationship between the mean weight of the ovaries divided by the total body (including the ovaries) weight (Y) and the month of collection (X), with May = 1 and April = 12, was log Y = 0.402 + 0.133X, with r = 0.963. The relationship between the mean weight of the ovaries divided by the adjusted body weight (Y) and the month of collection (X) was log Y = 0.421 + 0.139X, with r = 0.963 (Fig. 4). The proportionally largest ovaries, equalling 24.0 percent of the body weight or 35.5 percent of the adjusted body weight, were found in a 43.2-mm female collected on 16 April 1978. In the 10 females represented in Table 1, ovary-weight-to-adjusted-body-weight ratios ranged from 0.128 to 0.355 and averaged 0.185.

Spawning

In Brush Creek in 1978, *E. simoterum* spawned in April and probably in early May. Ripe individuals transferred from Brush Creek (19°C) on 16 April 1978 to a laboratory aquarium were observed spawning the next 2 days (at 25°–27°C).

Three males and five females were held in an aquarium on 17–18 April 1978; the two largest males and at least three of the females were observed spawning. Aquarium-held breeding males did not defend stationary territories, but were combative toward one another when in close proximity (within 10 cm). A male courted a nearby female by laterally displaying his erect median fins. During displays the blue-green and red-orange on the side of the body and in the fins were at their greatest intensity. When receptive to the courting of a male, a female led the male to a site selected for egg deposition. The male followed closely behind the female and at the selected site mounted the female (Fig. 5). The pair vibrated and one or two eggs were released and fertilized. Characteristically the pair then moved to another site and repeated the spawning act. However, males and females were promiscuous and repeatedly switched from one spawning partner to another.

Usually eggs were attached to the side of a large stone; less often they were laid on top of a stone. On a few occasions eggs were buried in gravel (Fig. 5); however, the female did not bury her body as deeply into the gravel as do more typical egg-burying species (e.g., *E. caeruleum* — Winn 1958:177). Eggs were not guarded by the parents. Often after laying the eggs in gravel the female immediately turned and ingested them. The related *E. coosae* and two undescribed species of *Nanostoma* also deposit eggs on the surfaces of large stones (Winn 1985:160, O'Neil & Buschung 1980); *E. zonale* lays eggs among filamentous algae in riffles (Pflieger 1975:312).

DEVELOPMENT AND GROWTH

A series of 40 young *E. simoterum* ranging in length from 14 to 32 mm was collected at the study area on 18 June 1977. At 14 mm, the pigmentation was essentially the same as that of the adult and squamation was complete except on the nape and anterior half of the belly. Head canals were complete but the lateral line had not yet

Fig. 5.—*Etheostoma simoterum* spawning in an aquarium. Usually eggs were deposited on the sides of boulders (right and left photos), although some were buried in gravel (bottom photo).

begun to form. On specimens 17–18 mm, the lateral line extended to near the junction of the first and second dorsal fins. At 20 mm the lateral line was complete but the nape and anterior portion of the belly were still unscaled. At 25 mm squamation was complete.

For males, the relationship between mean standard length (Y) and age in months (X) is Y = 18.4 + 27.66 log X, with r = 0.924, and for females is Y = 19.2 + 22.48 log X, with r = 0.933 (Fig. 6). At 1 year (12

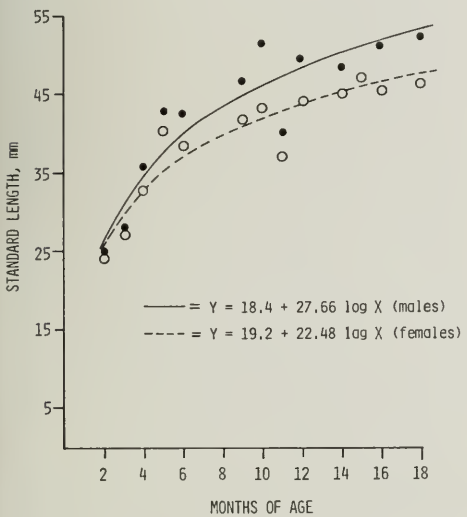

Fig. 6.—Size distribution by age of *Etheostoma simoterum* collected in Brush Creek between 3 March 1977 and 30 January 1979. Black dots represent sample means for males; circles represent sample means for females. A total of 425 specimens is represented.

months) males ($\bar{N}$ = 19) were significantly (t_{cal} = 5.66, df = 65) longer ($\bar{X}$ = 49.1 mm) than females (N = 48, $\bar{X}$ = 44.1 mm). *E. simoterum* reached one-half of the first year's mean growth in about 8 weeks.

The largest specimen examined from Brush Creek was a 55.7-mm male collected on 16 April 1978; the largest female was 50.6 mm and collected on the same date. The largest specimen known for the species is 64 mm.

For males (N = 45) the functional regression (Ricker 1973) of total weight (W) on standard length (L) was log W = -5.116 + 3.196 log L, with r = 0.995; for females (N = 52) was log W = -5.209 + 3.255 log L, with r = 0.983; and for both sexes (N = 97) was log W = -5.149 + 3.216 log L, with r = 0.990. A slope above 3 means that the fish grows proportionally heavier as it grows longer (Ricker 1968). Among darters, the largest slopes are found in deep-bodied riffle-inhabiting species such as *E. tippecanoe* (slope = 3.9 — Page & Burr 1979) and *E. caeruleum* (3.4 — Lutterbie 1979:7); the smallest values are found in slender, quiet-water species such as *E. exile* (2.6 — Copes 1976:9) and *E. striatulum* (2.7 — Page 1980:9). The value of 3.2 for *E. simoterum* corresponds to its typical occupation of habitats having moderate but not swift current.

DEMOGRAPHY

Density

Density estimates were made on two dates by repeatedly seining an area of Brush Creek until no *E. simoterum* were present in two consecutive seine hauls. On 10 August 1977, the density of *E. simoterum* in bedrock pool, the preferred habitat, was 5.38 individuals per m². On 30 January 1979, densities per m² were: in slab pools, 0.0; in riffles, 0.0; and in bedrock pools, 2.61.

Density values given for *E. olivaceum* in Brush Creek (Page 1980:10) were incorrect. Those values should have been, for 10 August 1977: in slab pools, 4.04 individuals per m²; for 30 January 1979: in slab pools, 8.07; in riffles, 1.79; and in bedrock pools, 1.47. For *E. striatulum* the value should have been 1.34 per m².

Composition

Of the 425 specimens collected in Brush Creek between 3 March 1977 and 30 January 1979, 90.1 percent were up to 1 year of age and 9.9 percent were between 1 and 2 years of age (Table 2).

Table 2.—Distribution of sexes and year classes in samples of *Etheostoma simoterum* collected in Brush Creek between 3 March 1977 and 30 January 1979.

Sex	Number by Year Class		Total
	-1	+1	
Males	139	12	151
Females	244	30	274
Total	*383*	*42*	*425*

Females significantly outnumbered males in the first year (-1) age class [1.75 to 1 (X^2 = 28.79; $P < 0.001$)] and in the second year (1 +) age class [2.5 to 1 (X^2 = 35.59; $P < 0.001$)]. Among all specimens collected, females were 1.81 times as abundant as males (X^2 = 35.59; $P < 0.001$). Although females often predominate in the highly territorial species of the subgenus *Catonotus* (Lake 1936:829; Schwartz 1965:100; Page 1974:13, 1975:10; Page & Burr 1976:9), most sex ratios among darters have not deviated significantly from 1:1. More data are needed on *E. simoterum* and on other species of the subgenus *Nanostoma* to determine if the Brush Creek ratio is typical.

Survival

Of the 151 males collected, 92.1 percent were up to 1 year of age and 7.9 percent were between 13 and 18 months of age. Of the 274 females, 89.1 percent were up to 1 year old, and 10.9 percent were between 13 and 18 months of age. Assuming that each year class was collected in proportion to its relative number in the population, only 8.6 percent of the first-year males and 12.3 per-

cent of the first-year females survived to a second year. For males and females combined, survival to a second year was 11.0 percent.

From this 2-year study, it appears that in Brush Creek, *E. simoterum* does not live beyond 18 months and experiences only one spawning season. A maximum longevity of 18 months and a survival rate to a second year of only 11 percent are smaller than the values found for other darters, including *E. proeliare* and *E. microperca* for which short life spans were thought to be a distinctive feature among darters (Burr & Page 1978:11, 1979:11). The largest *E. simoterum* in the fish collection of the Illinois Natural History Survey is a 63-mm male collected in East Fork Stones River, Rutherford County, Tennessee, on 14 March 1976. Scale readings suggest that this specimen, which is only 1 mm less than the length of the largest specimen known for the species, was 2 years (23–24 months) old when captured. The consubgeneric species, *E. coosae* and *E. zonale*, live to 3 and 3 + years, respectively (O'Neil & Boschung 1980; Lachner et al. 1950:101).

DIET AND PARASITISM

Stomach contents of 45 *E. simoterum* were identified and tabulated by size class of darter (Table 3) and month of collection (Table 4). Midge larvae (Chironomidae) formed the bulk of the diet of all size classes. Other major items were mayfly naiads, caddisfly larvae, copepods, and cladocerans. The smallest darters fed mainly on midges, copepods, and cladocerans. With an increase in size, the darters shifted to larger food items, eating fewer crustaceans and more mayflies and caddisflies (Table 3).

Food consumption was high in spring and fall, and highest in April (Table 4), the month of peak spawning activity. Consumption was lowest in January, February, and July, months of temperature extremes and probably of reduced activity by the darters.

In the 45 stomachs examined, 6 contained a total of 12 flukes and 2 contained a total of 3 parasitic nematodes. Flukes were present in individuals collected in February, March, and April; nematodes were present in January and February. All flukes and nematodes were found in large darters (42 mm and longer).

External parasites found on *E. simoterum* from Brush Creek were fluke metacercariae (black-spot disease) and piscicolid leeches. The leeches were found only on darters collected in April 1977, and were present on 7 of 19 darters collected. The metacercariae were present in most months but only on darters 35 mm and longer.

CONTRASTS WITH *ETHEOSTOMA OLIVACEUM*

E. simoterum and *E. olivaceum* are rivaled in abundance in Brush Creek only by midwater minnows (*Pimephales notatus* and an undescribed species of *Notropis*) which do not compete with the darters for space and probably not for food. The only species of darter other than *E. simoterum* and *E. olivaceum* encountered at the Brush Creek study site was *E. flabellare* and it was extremely uncommon. *Cottus carolinae,* the banded sculpin, is a benthic species which might compete with the darters but also was uncommon. In Brush Creek, the most likely competitors for *E. simoterum* and *E. olivaceum* are each other. However, their life-history characteristics suggest a low probability of competition between the two species for resources likely to be in limited supply.

Although sharing the same small stream the two darters occupy different habitats and are not in direct competition for space or food. *E. olivaceum* lives and breeds in the slab-rock pools along the margins of Brush Creek and only rarely is found in bedrock pools. *E.*

Table 3.—Stomach contents of *Etheostoma simoterum* from Brush Creek, by size class of darter. Figures in parentheses are numbers of stomachs examined.

Food Organism	Percent of Stomachs in Which Food Organisms Occurred				Mean Number of Food Organisms per Stomach			
	17–25 mm (6)	26–35 mm (7)	36–45 mm (20)	46–55 mm (12)	17–25 mm (6)	26–35 mm (7)	36–45 mm (20)	46–55 mm (12)
Gastropoda	....	14.3	....	....	....	0.14	....	....
Arachnida								
Acarina	....	....	....	8.3	....	....	....	0.16
Crustacea								
Cladocera	16.7	28.6	15.0	8.3	0.17	7.71	0.35	0.08
Copepoda	33.3	42.9	10.0	8.3	0.50	4.00	0.15	0.08
Insecta								
Ephemeroptera	...	42.9	25.0	33.3	....	0.71	0.70	0.42
Trichoptera	...	14.3	5.0	16.7	....	0.14	1.45	0.50
Diptera								
Chironomidae	100.0	85.7	80.0	91.7	7.50	2.14	24.15	12.17

Table 4.—Stomach contents of *Etheostoma simoterum* from Brush Creek, by month of collection. Figures in parentheses are numbers of stomachs examined.

Food Organism	Percent of Stomachs in Which Food Organisms Occurred									Mean Number of Food Organisms per Stomach								
	Jan. (5)	Feb. (5)	Mar. (5)	Apr. (5)	June (5)	July (5)	Aug. (5)	Sept. (5)	Oct. (5)	Jan. (5)	Feb. (5)	Mar. (5)	Apr. (5)	June (5)	July (5)	Aug. (5)	Sept. (5)	Oct. (5)
Gastropoda	....	....	....	....	....	20.0	....	....	....	....	....	....	....	....	0.20	....	....	....
Arachnida																		
Acarina	....	....	....	20.0	....	....	....	....	....	....	....	....	0.40	....	....	....	....	....
Crustacea																		
Cladocera	....	....	....	....	20.0	....	60.0	40.0	20.0	....	....	....	....	0.20	....	11.80	0.40	0.20
Copepoda	....	....	....	20.0	20.0	40.0	60.0	....	20.0	....	....	....	0.20	0.20	0.60	5.60	0.60	0.40
Insecta																		
Ephemeroptera	20.0	20.0	20.0	40.0	....	....	80.0	40.0	40.0	0.20	0.40	0.20	0.60	....	....	2.20	....	0.40
Trichoptera	....	20.0	....	40.0	....	....	20.0	....	....	....	0.80	....	6.20	....	....	0.20	....	....
Diptera																		
Chironomidae	80.0	40.0	100.0	100.0	100.0	100.0	80.0	80.0	100.0	5.20	4.20	13.40	66.20	8.00	3.20	4.00	14.40	19.20

simoterum lives and breeds in bedrock pools and crevices and seldom invades the smaller, more shallow slab-rock pools.

The most striking ecological difference, other than habitat, between the two darters is their reproductive behavior. *E. olivaceum* males establish territories beneath slab stones and guard their nests of eggs until hatching. *E. simoterum* does not establish stationary territories, lays eggs over a relatively large area, and immediately abandons them. As would be predicted by the reproductive effort expended (Hoar 1957), *E. olivaceum* produces fewer (60–112) and larger (2.0 mm in diameter) eggs per female than does *E. simoterum* (110–240 eggs averaging 1.2 mm).

E. olivaceum lives longer (to 27 months) than does *E. simoterum* (18 months) and gets larger (to 14 percent longer). Presumably as a result of its larger size, *E. olivaceum* eats a more varied diet, including some organisms generally too large for *E. simoterum* to ingest (e.g., stonefly naiads, beetle larvae, amphipods, and isopods).

SUMMARY

The life history information on *E. simoterum* collected in Brush Creek between 3 March 1977 and 30 January 1979 is summarized in Table 5.

Table 5.—Summary of life-history information on *Etheostoma simoterum* in Brush Creek.

Characteristic	Life-history Data
Principal habitat	Rock and gravel-bottomed pools with current
Age at reaching sexual maturity	1 year
Age at first spawning	1 year
Size at reaching sexual maturity	All spring-collected individuals regardless of size were sexually mature.
Sexual dimorphism	Males are larger and more colorful.
Number of mature ova counted	110–240
Description of egg	1.2 mm in diameter, translucent, and deeply indented on one side
Spawning period	April and probably early May
Spawning position	Male mounted on back of female
Egg deposition site	Usually the sides and tops of large stones
Egg guarding	None
Influence of sex on growth rate	At 1 year males are significantly larger than females.
Sex ratio	1.8 females: 1 male
Longevity	18 months
Maximum size	55.7 mm standard length for males; 50.6 mm for females
Territoriality	Stationary territories not observed; moving territories may be established by males.
Principal diet	Crustaceans and immature aquatic insects

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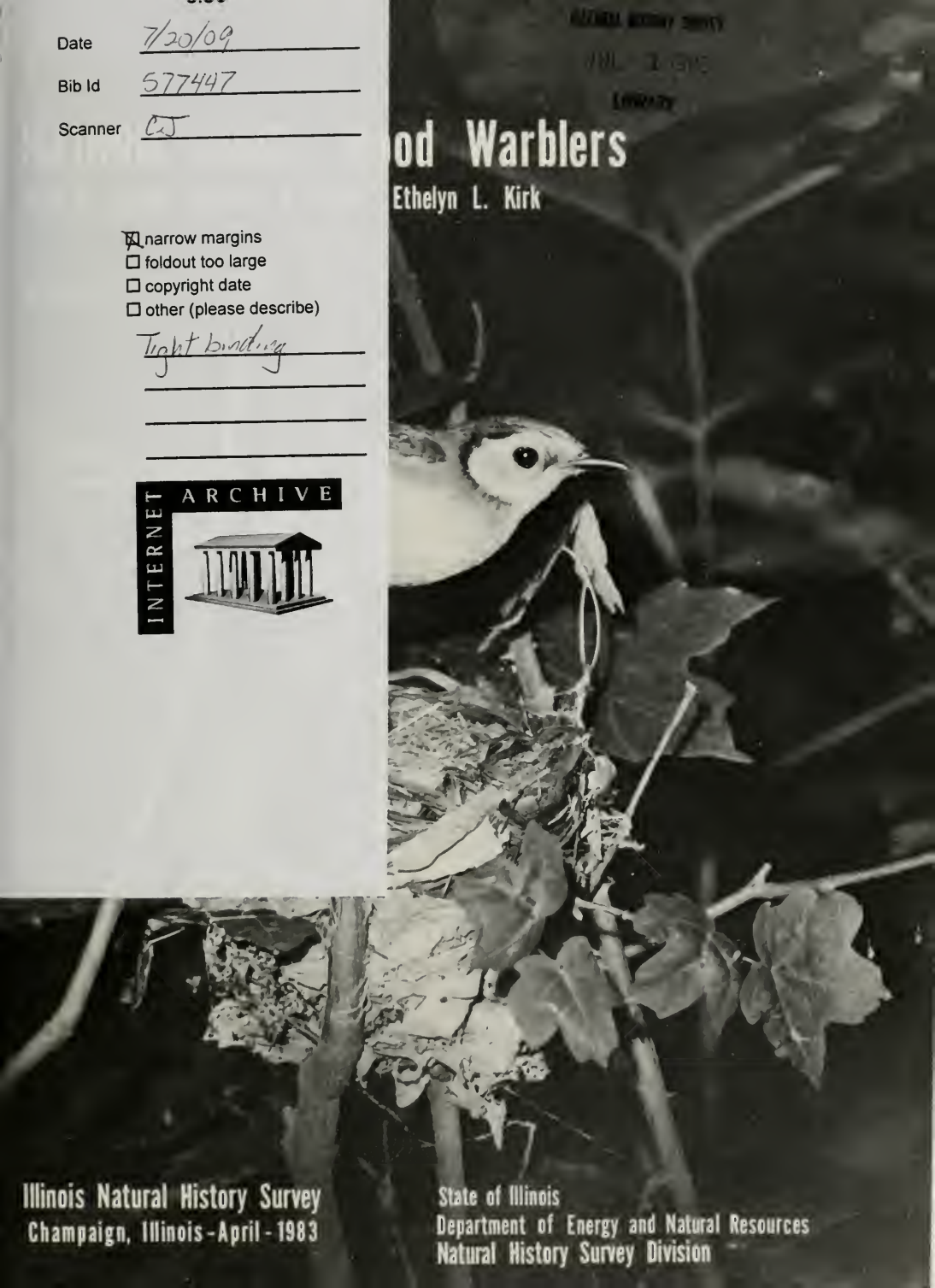

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