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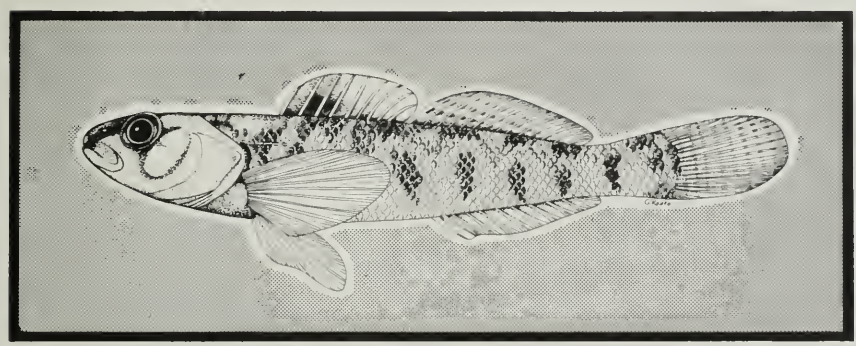
Lawrence M. Page - Brooks M. Burr



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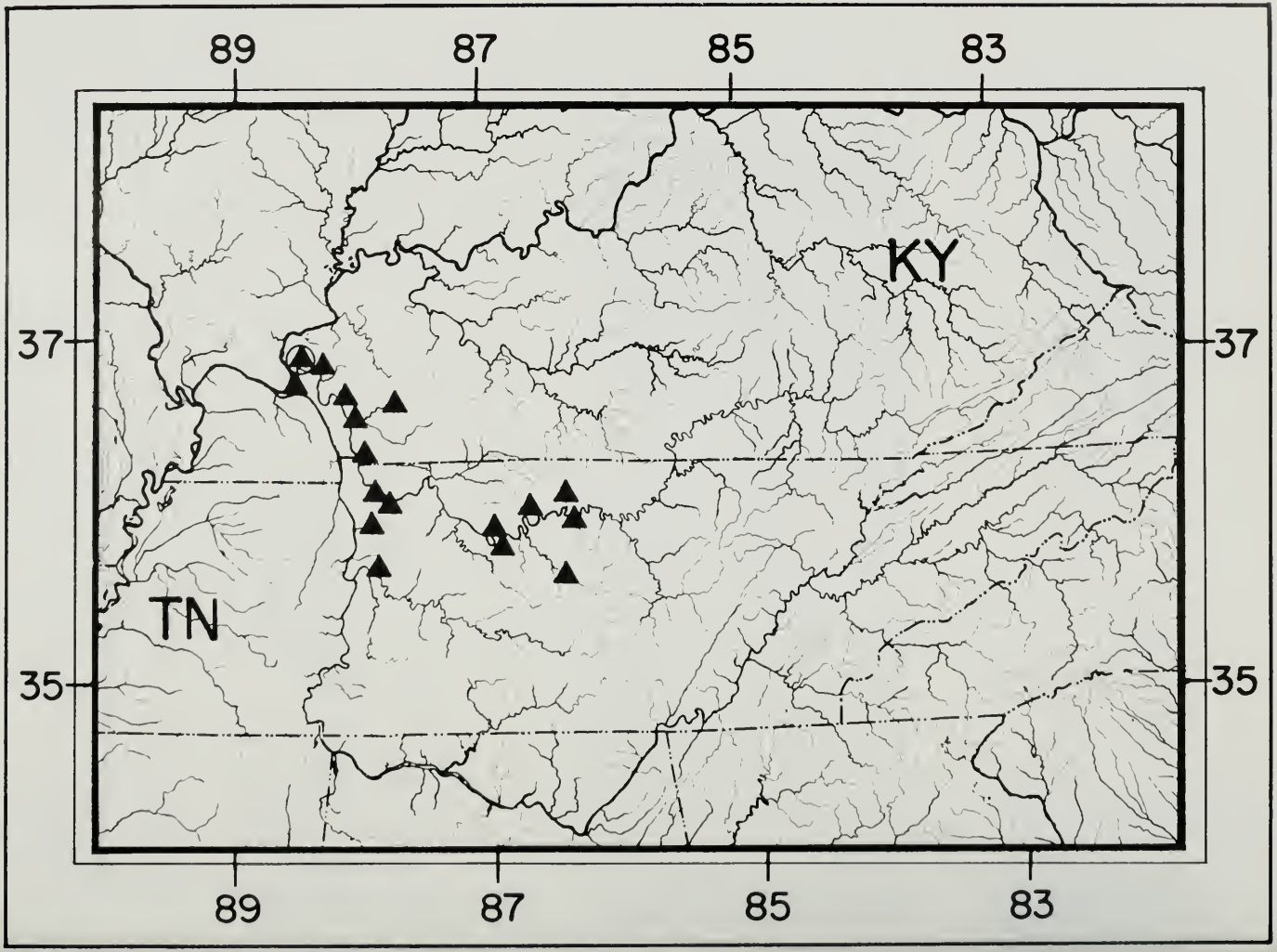
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THE LIFE HISTORY OF THE SLABROCK DARTER, *ETHEOSTOMA SMITHI*, IN FERGUSON CREEK, KENTUCKY

Lawrence M. Page and Brooks M. Burr

This is the third of three life-history reports on species of the subgenus *Catonotus* studied in southeastern Illinois and the adjacent area of Kentucky between October 1970 and April 1974. The first two reports were on *Etheostoma squamiceps* (Page 1974) and *E. kennicotti* (Page 1975*a*).

Etheostoma smithi was recently described by Page & Braasch (1976) from specimens collected in Ferguson Creek, Livingston County, Kentucky. *E. smithi* is distributed in the lower Cumberland and Tennessee river systems (Fig. 1). The closely related *E. obeyense* is distributed in the middle Cumberland River system, and until the description of *E. smithi*, the two forms were considered conspecific. This misinterpretation is reflected in the recent discussion by Page (1975*b*) of spawning observations made on "*E. obeyense*"; the population on which these observations were made is the one studied for this report and is actually *E. smithi*.

We are indebted to Douglas W. Schemske, Philip W. Smith, and Lewis J. Stannard for aid in collecting specimens, and to Dr. Smith for counsel on various matters. The illustrations were prepared by Craig W. Ronto and Illinois Natural History Survey Illustrator Lloyd LeMere and Survey Photographer Larry Farlow. The manuscript was typed by Bernice P. Sweeney and Alice Adams and edited for publication by Robert M. Zewadski, Technical Editor of the Survey. Dr. Chu-Fa Tsai, University of Maryland, served as guest reviewer.

STUDY AREA AND METHODS

The study area, Ferguson Creek in Livingston County, Kentucky (Fig. 1), is the same area described in the report on *E. squamiceps* (Page 1974: 3–4). Ferguson Creek is a small tributary of the lower Cumberland River and consists mainly of shallow slab-rock pools (Fig. 2) and slab riffles and a few deeper sand-bottomed pools.

The methods of study were the same as those used in the study of *E. squamiceps* (Page 1974: 4–5) except that aging to month was done by using May, the month of the greatest breeding activity in the study area, as month zero. The study of *E. smithi* began on 22 April 1971 and terminated on 19 June 1973. A total of 886 specimens was preserved and

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Fig. 2.—Slab pool in Ferguson Creek, Livingston County, Kentucky.

Cover Illustration.—*Etheostoma smithi* collected in Ferguson Creek in Livingston County, Kentucky. From a drawing by Craig W. Ronto.

examined. All specimens were collected during daylight. Unless stated otherwise, measurements in the text are standard lengths. For certain comparisons darters were divided into young (through 12 months) and adult (over 12 months) age groups.

HABITAT

Beginning on 9 September 1971, approximately the same seining effort was expended on each of the three major types of habitat in Ferguson Creek (slab riffles, slab pools, and non-slab pools). In each month in which they were collected, adults showed a distinct preference for pool habitats (Table 1). Adults were rarely found in riffles, and slab pools were preferred to non-slab pools. Young *E. smithi* were less rigid than adults in their habitat preferences; most were found in slab pools, but many were found in non-slab pools and some in slab riffles (Table 1).

TABLE 1.—Habitat distribution by percentages of *Etheostoma smithi* collected in Ferguson Creek between 9 September 1971 and 19 June 1973.

Month	Number Collected	Percentage of *E. smithi* in		
		Slab Pools	Slab Riffles	Non-Slab Pools
		Adults		
January	21	76	24	0
February	8	63	0	37
March	10	40	20	40
May	1	100	0	0
June	8	50	0	50
July	11	82	0	18
September	31	74	7	19
October	6	100	0	0
November	27	78	0	22
December	7	57	14	29
		Young		
January	119	60	6	34
February	27	59	4	37
March	28	54	7	39
April	18	83	0	17
May	46	65	33	2
July	128	2	1	97
September	65	54	11	35
October	32	75	0	25
November	78	68	3	29
December	21	43	5	52

The preferred habitat of *E. smithi* is best described as shallow, slab-rock pools in the headwaters and upper reaches of streams. The slab rocks on the bottoms of the pools are used as cover. This habitat preference is essentially the same as that of *E. kennicotti* (Page 1975*a*: 3) although *E. smithi* is more often found in non-slab pools.

REPRODUCTION

Reproductive Cycle of the Male

The genital papilla (Fig. 3) and the testes enlarged as the spawning season approached. Testes of

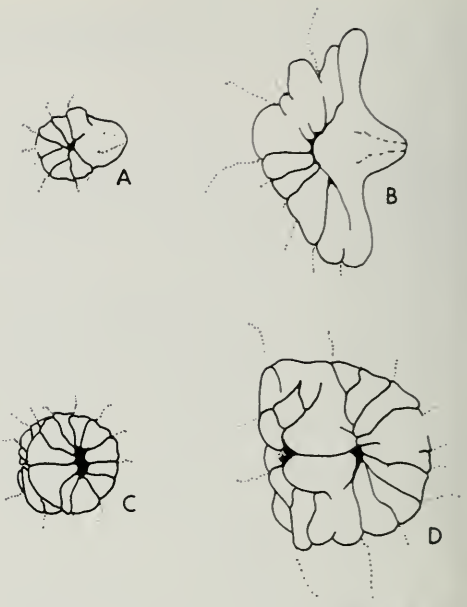

Fig. 3.—Genital papillae of *Etheostoma smithi*. *A*, nonbreeding male; *B*, breeding male; *C*, nonbreeding female; and *D*, breeding female. The breeding specimens were 1 year old, collected on 28 May 1972; the nonbreeding specimens were 1+ years old, collected on 12 September 1972.

nonbreeding males were small and translucent; those of breeding males were large, white, and spongy. Breeding tubercles did not develop. The tissue along the fin spines and rays swelled, but in contrast to *E. flabellare*, *E. kennicotti*, and *E. squamiceps*, knobs did not develop on the dorsal fins. As in other *Catonotus* species (Page 1975*a*: 5), the flesh on the head and nape became swollen.

At the height of spawning activity males were brightly colored and had developed predominantly red dorsal, caudal, and anal fins. The pectoral fins were reddish medially and had wide black margins ventrally. The anal and lower caudal fins developed blue-black margins, and the black blotch in the first dorsal fin became blacker and larger than in nonbreeding males and in females and was surrounded by red. The entire dorsum was dusky. The breast and pelvic fins were black, and the head was dark and swollen. The black on the head was concentrated in small blotches and interspersed with gold specks, creating a mottling of black and gold. The cheek bar was boldly outlined in gold, and the upper half was bright red. The dark pigment on the sides was concentrated into a series of 10–12 vertical bars.

Beginning in April, males selected cavities under slab rocks in slab pools as future nesting sites and

defended them as breeding territories. The cavities were cleaned in the same manner as that described for *E. squamiceps* (Page 1974: 7). All nesting sites found were in slab pools also occupied by breeding and nesting *E. squamiceps*. The pools were in areas where the stream was 1–3 m wide and the current was slow.

One-year-old males that had reached a standard length of about 35 mm were sexually mature and successfully spawned. Males 35.0 mm and longer constituted 33.3 percent of the males collected in April, May, and June. This group presumably represented about the proportion of the male population that spawns each year. Most nests observed were guarded by large males, and as in other *Catonotus* species, the largest males probably did most of the spawning.

Reproductive Cycle of the Female

Females reaching a standard length of at least 28 mm by the end of the spawning season (mid-June) developed mature ova and were potential spawners. As in other darters, the largest females developed mature ova earliest in the breeding season and probably contributed most of the spawning effort.

Small white ova began appearing between September and November, appearing earliest in the largest females. A minimum length of about 20 mm was reached by a female before white ova were discernible. Larger yellow ova were found as early as March in females that measured 30 mm or more, and such ova appeared later in slower growing females. Large, maturing orange ova were present from April to June. Prior to spawning the mature ova became translucent.

The female did not undergo color changes as the breeding season approached and was much less brilliantly colored than the breeding male. The genital papilla enlarged (Fig. 3), beginning about March, and the belly became greatly distended a few days or weeks before spawning.

The largest females produced the largest numbers of mature ova. In 19 females collected in April, May, and June, the number of ova varied from 17 to 69 (Table 2). For these females the relationship between the number of mature ova (F) and the adjusted body weight (W) was $F = 18.00 + 37.39W$, with $r = 0.488$, and between the number of mature ova and the standard length (L) was $\log F = -1.456 + 1.982 \log L$, with $r = 0.483$. Estimates of the number of eggs laid in aquaria by three females (approximately 30–45 mm) were 10 (interrupted spawning?), 80, and 84. Two of these females were larger than those represented in Table 2. Eggs averaged 2.2 mm in diameter, were translucent, and contained a single oil droplet.

Ovaries of postspawning females collected from July through August were very small. A relative increase in ovary size was evident by September, and ovaries continued to enlarge until the spawning

TABLE 2.—Relationship between size, age, and ovary weight of *Etheostoma smithi* females and the number of mature ova produced. An age of 1 year = 11–13 months, 2 years = 23–25 months.

Standard Length in mm	Adjusted Body Weight in Grams[a]	Age in Years	Ovary Weight in Grams	Number of Mature (Orange or Translucent) Ova
28	0.31	1	0.05	17
28	0.32	1	0.05	27
28	0.32	1	0.06	33
29	0.34	1	0.03	20
30	0.32	1	0.06	31
30	0.34	1	0.04	27
31	0.37	1	0.09	34
31	0.41	1	0.06	19
31	0.41	1	0.08	44
33	0.50	1	0.08	54
33	0.55	1	0.13	53
34	0.51	1	0.07	36
34	0.55	1	0.07	45
35	0.54	1	0.13	49
37	0.70	1	0.05	41
40	0.83	1	0.10	43
41	0.99	1	0.10	37
38	0.85	2	0.12	50
43	1.12	2	0.13	69

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

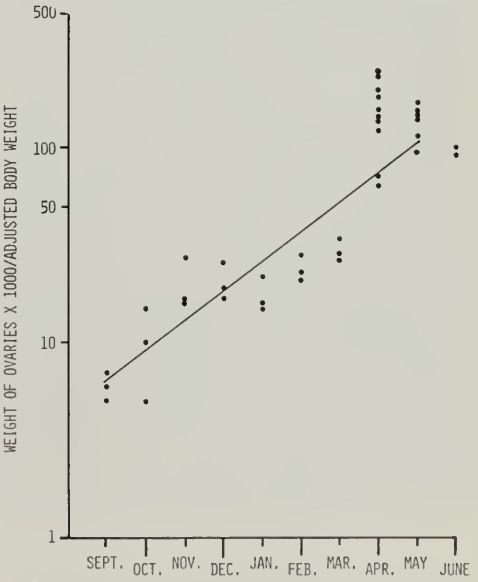

Fig. 4.—Monthly variations in ovarian weight relative to adjusted body weight of 4- to 13-month-old *Etheostoma smithi*. The vertical axis is a logarithmic scale.

period of the following spring (Fig. 4). For the females examined, the relationship between the mean of the weight of the ovaries divided by the adjusted body weight (Y) and the month (X), with September = 1 and May = 9, was log Y = 0.643 + 0.158X, with $r = 0.865$ (Fig. 4). The proportionally largest ovaries (equalling 24.3 percent of the adjusted body weight) were found in a 1-year-old, 31-mm female collected on 22 April 1971. In the 19 females represented in Table 2, ovary-weight-to-adjusted-body-weight ratios ranged from 0.065 to 0.243 and averaged 0.152.

Spawning

At the study area *E. smithi* spawned from late April to mid-June on the undersides of the slab rocks (Fig. 5) previously selected and guarded as nesting territories by the males. Spawning activity was greatest during May, when water temperatures ranged from 15° to 20°C.

Five spawnings of *E. smithi* occurred in our laboratory aquaria; three occurred in the morning and two during the night or very early morning. Aquarium temperatures varied from 18° to 19°C. We observed three of the five spawnings.

The brightly colored breeding males left their nest stones only to feed or to court a nearby female.

Fig. 5.—*Etheostoma smithi* male and his nest of eggs on the underside of a stone removed from a slab pool in Ferguson Creek on 3 May 1971. The male was guarding the eggs prior to their removal from the pool.

Courting by the male consisted of lateral displays, with the median fins held erect, and tail wagging. When a female joined a male under his nest stone, the male became extremely active, continuously courting the female and occasionally nudging her with his snout.

The spawning behavior of *E smithi* was the same as that of *E. kennicotti*. Underneath the nest stone guarded by the male (Fig. 6*A*), the female inverted by rolling to one side and remained inverted throughout the spawning period (Fig. 6*B*). She periodically darted about the nest stone, appearing to examine it and select sites for egg deposition. When not examining the stone or laying eggs, she rested by lowering her back onto the substrate beneath the stone. The male was usually intolerant of a female's remaining right side up under his nest stone.

When laying eggs, the female pressed her genital papilla against the nest stone; she was then joined by the male, who inverted by rolling to one side and positioned himself alongside the female in a head-to-tail (Fig. 6*C*) or head-to-head position. Both trembled as eggs and sperm were released, and then the male returned to an upright position.

The female deposited only one or two eggs during the brief trembling action, which lasted less than 5 seconds, and moved forward slightly as she did so. The eggs were laid in a concentrated area on the stone but never on top of one another. Periods between egg laying varied from about 15 seconds to several minutes.

Four females spawned with the same aquarium-held male. Two of the four began new egg clusters and two added eggs to a cluster begun by another female. As in both *E. squamiceps* (Page 1974: 9) and *E. kennicotti* (Page 1975*a*: 7), all *E. smithi* females after the first to spawn added eggs only to the nest of the male that had already spawned even though at least one other male held a territory in the same aquarium.

Counts and estimates of the numbers of eggs in nine nests of *E. smithi* found in Ferguson Creek were 175, 200, 225, 225, 325, 350, 400, 450, and 600 (mean = 328). Eggs in nests averaged 2.2 mm in diameter.

As in other species of *Catonotus*, males vigorously guarded the nests against potential egg predators and constantly examined the eggs visually, occasionally nipping at the eggs, presumably to remove invading organisms or dead or diseased eggs. The males were very active during this period, darting back and forth and brushing the eggs with their dorsal fins, and retained their bright breeding coloration. Females did not guard the nests.

The spawning behavior of *E. smithi* (referred to as *E. obeyense*) has been compared with that of other species of *Catonotus* by Page (1975*b*).

The same slab pools in Ferguson Creek used as spawning grounds by *E. smithi* were also used by

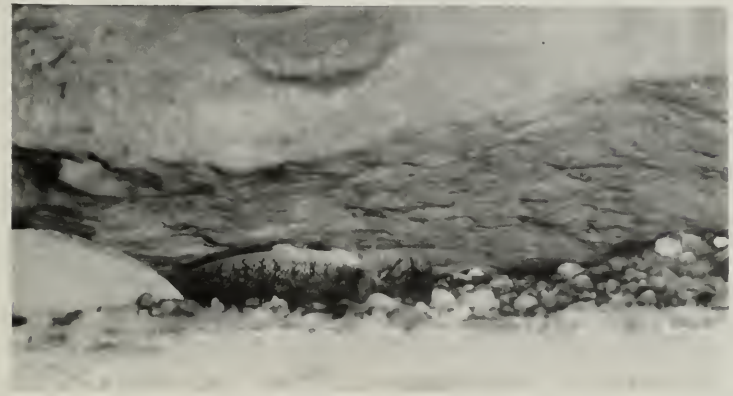

Fig. 6.—*Etheostoma smithi* in aquaria. Top: A breeding male is guarding the cavity beneath a slab stone. Middle: A female has entered the cavity, inverted beneath the stone, and begun laying eggs (the male has momentarily left the cavity). Bottom: Both male and female are inverted as eggs and sperm are released.

E. squamiceps; however, the spawning periods overlapped only in late April and in May. *E. squamiceps* spawned from late March through May with most spawning occurring in April. *E. smithi* spawned from late April to mid-June with most spawning occurring in May. The staggering of spawning periods by species known to spawn on the undersides of stones in the study area has been discussed by Page (1974: 18).

Sexual Dimorphism

Sexual dimorphism in *E. smithi* in territorial behavior, coloration, and size are discussed elsewhere in this paper. In addition, 26 meristic and morphometric characteristics were tested for sexual dimorphism in 25 specimens, each more than 33 mm long, from Ferguson Creek. Of these 26 characteristics, four were found to be sexually dimorphic: males have proportionally longer second dorsal, anal, and caudal fins ($P < 0.005$), and proportionally deeper caudal peduncles ($P < 0.025$).

DEVELOPMENT AND GROWTH

Eggs incubated in aquaria at 13° C (55° F) hatched in 708–732 hours (29.5–30.5 days), and at 21° C (70° F) they hatched in 300–324 hours (12.5–13.5 days). Eggs incubated at 6° C (43° F) and at 27° C (81° F) died before hatching.

Hatchlings of *E. smithi* averaged 6.7 mm in total length and were mostly translucent. As in other *Catonotus* species, the lower jaw and pectoral fins were well developed (Fig. 7*A*). Melanophores were mostly restricted to the yolk sac. Three-day-old larvae (Fig. 7*B*) averaged 7.2 mm in total length and were quite similar morphologically to 3-day-old *E. kennicotti* larvae. Median and pectoral fin rays were evident. At 8 days an aquarium-raised juvenile was 7.5 mm in total length, had partially lost its transparency, and had small pelvic fins (Fig. 7*C*).

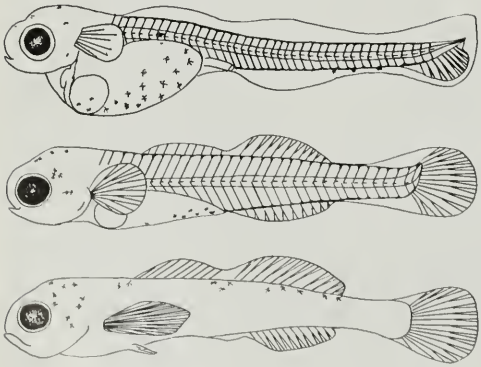

Fig. 7.—Top: *Etheostoma smithi* hatchling (6.7 mm total length). Middle: 3-day-old larva (7.3 mm total length). Bottom: 8-day-old juvenile (7.5 mm total length).

A series of 43 young *E. smithi* from 9 to 19 mm was collected in the study area on 21 July 1971. In those up to 10 mm long the color pattern was restricted to large dark spots on the dorsum and sides. At 15 mm the pattern was similar to that of adults but was more subdued. Larger individuals were darker.

At 9 mm scales were absent. At 10 mm scales were present only on the posterior half of the body. At 12 mm scales also were present on the anterior sides, and at 15 mm squamation was complete. The lateral line did not begin forming until an individual was about 18 mm, and the lateral line developed slowly after that; at 30 mm most individuals had only 4–6 pores.

E. smithi grew at a decreasing rate (Fig. 8). The relationship between standard length (Y) and age in months (X) expressed for males is $Y = 0.80 + 31.14 \log X$, with $r = 0.886$, and for females is $Y = 4.32 + 25.10 \log X$, with $r = 0.947$.

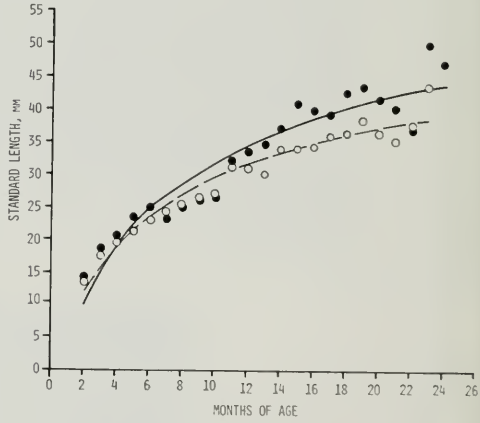

Fig. 8.—Size distribution by age of *Etheostoma smithi* collected in Ferguson Creek between 22 April 1971 and 19 June 1973. Black dots represent sample means for males; circles represent sample means for females. A total of 886 specimens is represented.

Males grew more rapidly than females (Fig. 8) and in their second year were significantly larger than females. At 13–18 months males averaged 39.3 mm and females averaged 34.3 mm ($t = 6.99$, df = 110). At 19–24 months males averaged 40.9 mm and females averaged 37.4 mm ($t = 3.16$, df = 49).

At 1 year (12 months) males (N = 29) averaged

33.3 mm and females (N = 39) averaged 30.9 mm. *E. smithi* reached one-half of the first year's mean length in approximately 13 weeks; this is about the same period as that estimated for *E. squamiceps* (12 weeks, Page 1974: 12) and *E. kennicotti* (16 weeks, Page 1975*a*: 9). The only 2-year-old (24 months) male was 47.1 mm; no 2-year-old females were found. The largest specimen examined from Ferguson Creek was a 50.1-mm, 23-month-old male collected on 22 April 1971.

DEMOGRAPHY

Density

On four separate dates at approximately 3-month intervals, quantitative samples of *E. smithi* were taken in Ferguson Creek by repeatedly seining an area until no more individuals were collected. The number collected was transposed into the number per square meter (Table 3).

TABLE 3.—Number of *Etheostoma smithi* per square meter collected in Ferguson Creek at approximately 3-month intervals, by habitat. Young were up to 1 year of age, adults over 1 year.

Collection Date	Number Collected	Number of *E. smithi* per Square Meter in		
		Slab Pools	Slab Riffles	Non-Slab Pools
		Adults		
8 July 1972	11	0.32	0	0.22
20 October 1972	6	1.61	0	0
17 January 1973	7	1.32	0	0
30 April 1973	0	0	0	0
MEAN		0.81	0	0.06
SD		0.77	...	0.11
		Young		
8 July 1972	128	0.11	0.19	13.33
20 October 1972	32	6.45	0	1.08
17 January 1973	43	1.36	0	0.62
30 April 1973	18	1.24	0	0.27
MEAN		2.29	0.05	3.83
SD		2.83	0.10	6.35

The highest densities of adults were in slab pools, the preferred habitat (Table 1). High densities of young were found in both slab pools and non-slab pools. The greatest density of *E. smithi* in Ferguson Creek, combining young and adults, was in the non-slab pools in July (13.6 per m^2).

Composition

Of the 886 *E. smithi* specimens collected in Ferguson Creek, 81.8 percent were up to 1 year of age, and the remaining 18.2 percent were over 1 year and up to 2 years of age (Table 4).

Females predominated in the young-of-the-year (−1) age class [1.2 females to 1.0 male ($\chi^2 = 4.80$; $P < 0.05$)] and in the 1+ year class [1.5 to 1.0 ($\chi^2 = 6.76$; $P < 0.01$)]. In the total sample (N = 886) the ratio was 1.2 females to 1.0 male ($\chi^2 = 9.55$; $P < 0.005$). Although significantly skewed in favor of females, the sex ratio in *E. smithi* was less skewed than in other *Catonotus* species studied (Page 1974: 13; 1975*a*: 10). It may be that the smaller size of *E. smithi* has resulted in less successful dominance by a small proportion of the male population, a larger proportion of successfully spawning males each year, and less pressure for selection toward a smaller ratio of males to females.

TABLE 4.—Distribution of sexes and year classes in samples of *Etheostoma smithi* collected in Ferguson Creek between 22 April 1971 and 19 June 1973.

Sex	Number by Year Class		Total
	−1	1+	
Male	333	64	397
Female	392	97	489
Total	*725*	*161*	*886*

Survival

Of the 397 males collected, 83.9 percent were in the −1 year class and 16.1 percent were in the 1+ year class. Assuming that each year class was collected in proportion to its relative number in the population, only 19.2 percent of the −1 year males survived to the second year. Of the 489 females, 80.2 percent were in the −1 year class and 19.8 percent were in the 1+ year class; 24.7 percent of the −1 year females survived to the second year. The survival of both sexes of −1 year *E. smithi* to a second year was 22.2 percent. These survival values were much lower than those of *E. kennicotti* in Big Creek (Page 1975*a*: 10) and *E. squamiceps* in Big Creek and somewhat lower than those of *E. squamiceps* in Ferguson Creek (Page 1974: 13–14). The oldest *E. smithi* from Ferguson Creek examined (assuming a May hatching) was a 24-month-old male collected in May 1973.

Migration

No migration was observed in the Ferguson Creek population of *E. smithi* during the study period. However, most spawning occurred in slab pools in the upper part of the stream system, and some upstream movements prior to spawning must have succeeded the downstream dispersal of the young.

Territoriality

Observations at Ferguson Creek and on aquarium-held *E. smithi* revealed much of the same type of territorial behavior observed for other *Catonotus* species. Males were strongly territorial, especially during the breeding season, and their territories were centered about depressions under slab stones. Terri-

torial males were dark and had brightly colored fins, large-appearing eyes, prominent black vertical bars, and a bold black humeral spot. Territorial defense and combat were the same as those described for *E. kennicotti* (Page 1975a: 11).

Females became territorial, at least within the confines of an aquarium, but did not establish a territory centered about a stone. The female, defending only the immediate area around her, became boldly vertically banded, appeared to have enlarged eyes, and threatened invaders with lateral displays and nipping.

DIET

The stomach contents of 187 *E. smithi* were mostly immature insects and small crustaceans (Table 5). The food items most prevalent in all size classes were chironomids and ephemeropterans. Small darters also fed heavily on copepods, trichopterans, cladocerans, ostracods, and amphipods. Large darters fed more heavily than small darters on isopods and plecopterans.

A total of 13 taxa were found in the stomachs of *E. smithi*. This number represents fewer taxa than were found in *E. squamiceps* (16 taxa) collected in the same study area (Page 1974: 14–18) even though more specimens of *E. smithi* (187 versus 67) were examined. *E. squamiceps* attains a much larger maximum size (72 mm standard length in Ferguson Creek) than *E. smithi* (50 mm) and therefore presumably can ingest a greater variety of organisms.

Some seasonal variation in diet was evident among the 131 specimens of *E. smithi* ranging in length from 21 to 40 mm (Table 6). Trichopterans and ostracods were eaten mainly from September through December, plecopterans from December through February. Food consumption was heaviest from March through June.

INTERACTIONS WITH OTHER ORGANISMS

Competition

The life histories of the species of *Catonotus* studied have included a number of similar habits, including the occupation of slab-rock habitats and spawning on the undersides of slab stones, and it seems probable that competition among species of *Catonotus* occurs even to the point of competitive exclusion, as discussed by Page & Smith (1976). Potential competition between *E. smithi* (referred to as *E. obeyense*) and *E. squamiceps* in Ferguson Creek was briefly discussed by Page (1974: 18). Described species of *Catonotus* in the Cumberland River, in addition to *E. smithi* and *E. squamiceps*, are *E. obeyense*, *E. flabellare*, *E. virgatum*, and in the extreme upper region, *E. kennicotti*.

Predation

As potential predators three *Lepomis cyanellus* (178–187 mm) and four *Esox americanus* (62–78 mm) collected in Ferguson Creek were preserved and later examined. No *E. smithi* were found in the stomachs. No other information on predation on *E. smithi* has been published.

Parasitism

Except for one parasitic copepod *(Lernaea)* on a 19-mm female collected on 12 September 1972, no ecto- or endoparasites were found on *E. smithi* col-

TABLE 5.—Stomach contents of *Etheostoma smithi* from Ferguson Creek, by size class of darter. Figures in parentheses are numbers of stomachs examined.

Food Organism	Percent of Stomachs in Which Food Organism Occurred				Mean Number of Food Organisms per Stomach			
	<21 mm (34)	21–30 mm (69)	31–40 mm (62)	>40 mm (22)	<21 mm (34)	21–30 mm (69)	31–40 mm (62)	>40 mm (22)
Arachnida								
Acarina	2.9	...	...	...	0.03	...	...	...
Crustacea								
Cladocera	11.8	1.4	...	...	0.26	0.06	...	...
Ostracoda	8.8	2.9	3.2	...	0.18	0.04	0.03	...
Copepoda	44.1	5.8	4.8	4.5	1.53	0.19	0.08	0.05
Isopoda								
Asellidae	...	1.4	9.7	9.1	...	0.01	0.10	0.09
Amphipoda	8.8	5.8	8.1	4.5	0.09	0.06	0.10	0.14
Decapoda								
Cambaridae	...	...	1.6	...	...	...	0.02	...
Insecta								
Plecoptera	...	1.4	6.5	4.5	..	0.01	0.06	0.05
Ephemeroptera	38.2	47.8	50.0	40.9	0.50	0.59	0.58	0.73
Trichoptera	20.6	2.9	8.1	4.5	0.24	0.03	0.13	0.05
Coleoptera								
Dytiscidae	...	1.4	...	...	...	0.01	...	...
Diptera								
Chaoboridae	...	...	1.6	4.5	..	...	0.06	0.05
Chironomidae	76.5	72.5	66.1	54.5	3.53	3.72	4.45	1.86

TABLE 6.—Stomach contents of *Etheostoma smithi*, ranging in standard length from 21 to 40 mm, from Ferguson Creek, by month of collection. Figures in parentheses are numbers of stomachs examined.

Food Organism	Percent of Stomachs in Which Food Organism Occurred												Mean Number of Food Organisms Per Stomach											
	Jan. (18)	Feb. (14)	Mar. (15)	Apr. (12)	May (11)	June (13)	July (4)	Aug. (4)	Sept. (9)	Oct. (9)	Nov. (10)	Dec. (12)	Jan. (18)	Feb. (14)	Mar. (15)	Apr. (12)	May (11)	June (13)	July (4)	Aug. (4)	Sept. (9)	Oct. (9)	Nov. (10)	Dec. (12)
Crustacea																								
Cladocera	...	...	...	...	...	...	...	...	...	...	...	8.3	...	...	...	...	...	...	...	...	...	...	...	0.17
Ostracoda	...	...	...	...	...	...	...	...	11.1	11.1	...	16.7	...	...	...	...	...	...	...	...	0.22	0.11	...	0.17
Copepoda	...	...	...	16.7	9.1	...	25.0	...	...	...	10.0	25.0	...	...	...	0.58	0.09	...	0.25	...	...	...	0.50	0.42
Isopoda																								
Asellidae	...	...	13.3	8.3	9.1	7.7	...	...	11.1	...	10.0	...	...	...	0.13	0.08	0.09	0.08	...	...	0.11	...	0.10	...
Amphipoda	...	7.1	26.7	...	9.1	7.7	...	...	...	11.1	...	...	...	0.07	0.27	...	0.18	0.08	...	...	...	0.11	...	...
Decapoda																								
Cambaridae	...	...	...	...	9.1	...	...	...	...	...	...	...	...	...	...	...	0.09	...	...	...	...	...	...	...
Insecta																								
Plecoptera	22.2	7.1	...	...	...	...	...	...	...	...	...	8.3	0.22	0.07	...	...	...	...	...	...	...	...	...	0.08
Ephemeroptera	50.0	28.6	53.3	8.3	36.4	53.8	75.0	50.0	33.3	77.8	90.0	58.3	0.72	0.29	0.67	0.08	0.73	0.69	0.75	0.50	0.44	0.78	1.00	0.67
Trichoptera	...	...	6.7	...	9.1	...	...	...	11.1	22.2	20.0	8.3	...	...	0.07	...	0.27	...	...	...	0.11	0.33	0.30	0.08
Coleoptera																								
Dytiscidae	...	...	...	...	...	7.7	...	...	...	...	...	...	...	...	...	...	...	0.08	...	...	...	...	...	...
Diptera																								
Chaoboridae	...	...	...	...	9.1	...	...	...	...	...	...	...	...	...	...	...	0.36	...	...	...	...	...	...	...
Chironomidae	77.8	92.9	86.7	83.3	81.8	61.5	50.0	75.0	55.6	55.6	40.0	41.7	2.67	4.79	6.13	6.00	10.09	5.54	0.75	1.75	1.22	2.11	1.40	1.67

TABLE 7.—Summary of life-history information on Ferguson Creek *Etheostoma smithi*.

Characteristic	Life-History Data
Principal habitat of adult	Slab pools
Principal habitat of young	Slab pools
Age at reaching sexual maturity	1 year
Age at first spawning	1 year
Size at reaching sexual maturity	Females about 30 mm; males about 35 mm
Sexual dimorphism	Adult males average larger, are more colorful, and have longer fins and a deeper caudal peduncle
Breeding tubercles	Absent
Number of mature ova counted	17–69
Description of egg in nest	2.2 mm in diameter, translucent, adhesive
Spawning period	From late April to mid-June
Spawning habitat	Slab pools
Spawning position	Both male and female inverted, usually head to tail
Nesting site	Underside of a slab stone
Number of eggs counted in nests	175–600
Egg guarding	Only by the male
Incubation periods	708–732 hours at 13°C, 300–324 hours at 21°C
Influence of sex on growth rate	By the second year males are significantly larger than females
Density	Up to 13.6 darters/m^2 in non-slab pools
Sex ratio among young	1.2 females : 1 male
Longevity	2 years
Maximum size	50 mm standard length
Migrations	No obvious patterns
Territoriality	Extreme in breeding males; strong in nonbreeding males; occasional in females
Principal diet	Aquatic insect immatures and crustaceans

lected in Ferguson Creek. No ectoparasites were found on *E. squamiceps* studied in the same area (Page 1974: 19–20), but a high infestation of spiny-headed worms *(Acanthocephalus)* was found. These worms were not found in *E. smithi*.

Hybridization

The only published account of hybridization involving *E. smithi* is the description by Page (1975*a*: 12) of successful matings between *E. kennicotti* and *E. smithi* (referred to as *E. obeyense*) in aquaria.

SUMMARY

The life-history information on *E. smithi* collected in Ferguson Creek between 22 April 1971 and 19 June 1973 is summarized in Table 7.

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