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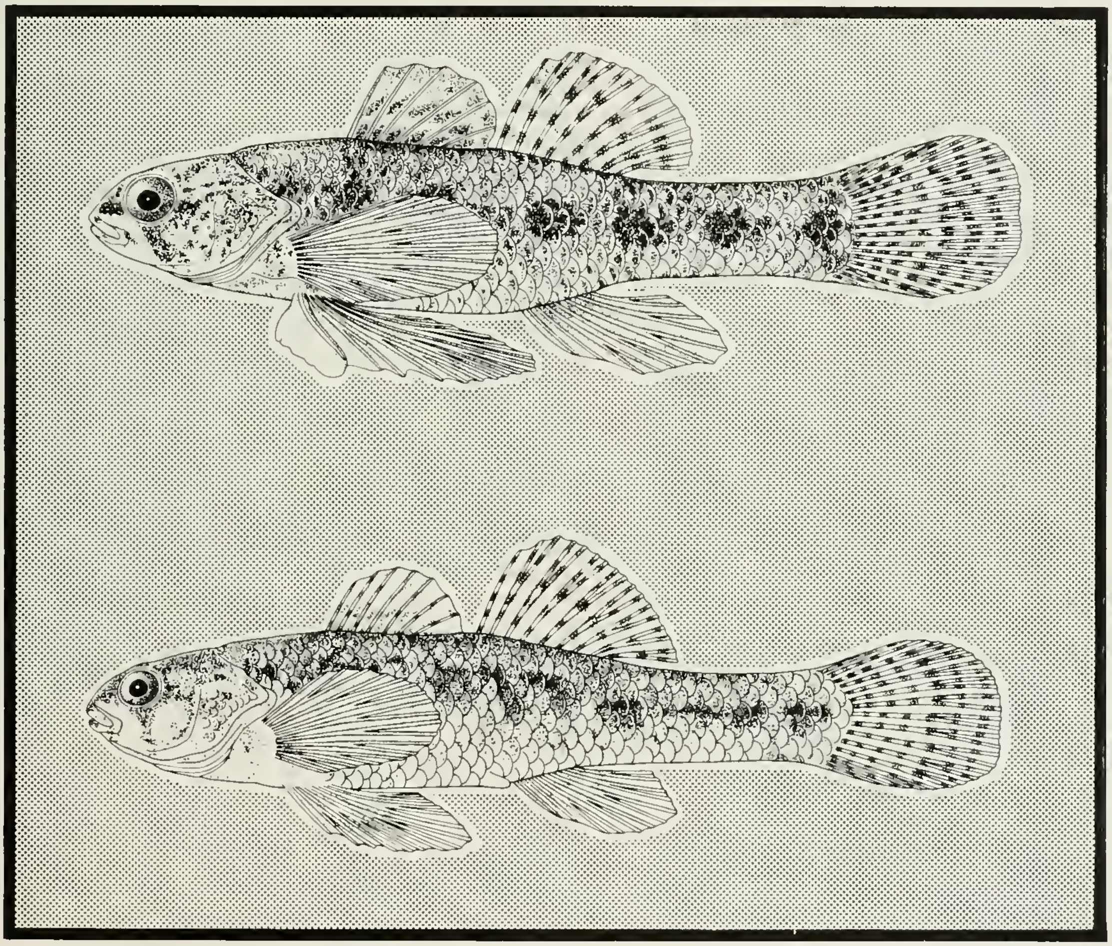
BROOKS M. BURR and LAWRENCE M. PAGE



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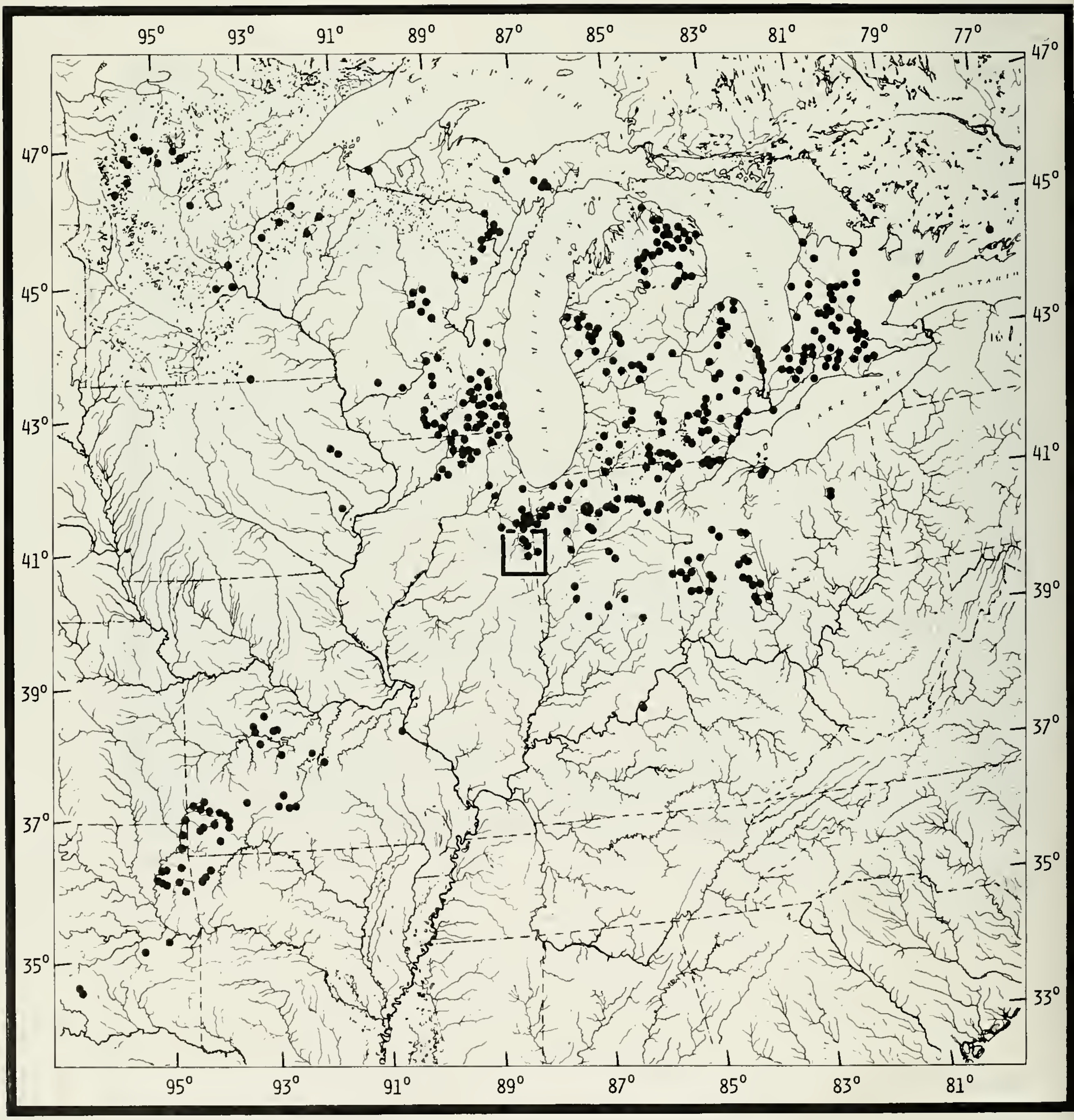

Fig. 1.—The distribution of *Etheostoma microperca*. Questionable records were not plotted. The study area is enclosed within the square.

THE LIFE HISTORY OF THE LEAST DARTER, *ETHEOSTOMA MICROPERCA*, IN THE IROQUOIS RIVER, ILLINOIS

Brooks M. Burr and Lawrence M. Page

This report on *Etheostoma microperca* in a small tributary of the Iroquois River is the second life history report on the subgenus *Microperca* in Illinois. The first was on *E. proeliare* (Burr & Page 1978). Included here are comparisons of the two Illinois species and *E. fonticola*, a third member of the subgenus recently studied by Schenck & Whiteside (1976, 1977*a*, 1977*b*).

Etheostoma microperca was described by Putnam in 1863 (as *Microperca punctulata*) from specimens collected from localities in Michigan, Wisconsin, Illinois, and Alabama. Those from Alabama presumably represented the closely related but then unnamed *E. proeliare*. The range of *E. microperca* (Fig. 1) extends from Moira River in northeast Ontario, through much of the Great Lakes drainage, northwest to the Red River of the North in Minnesota, and south through the middle Ohio River Valley. Disjunct populations occur in the Ozark Uplands and in the Blue River, Oklahoma. A detailed morphological description and comparisons with related species are found in Burr (1978).

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STUDY AREA

Etheostoma microperca occurs sporadically in northern Illinois and is common at certain localities in the Rock, Fox, and Kankakee river systems. A small, unnamed tributary of Iroquois River (Kankakee system) northeast of Watseka in Iroquois County was selected for the life history study. The Iroquois River lies within the area of Wisconsinan Drift, and the watershed was originally sandy marsh (especially in Indiana) and tall-grass prairie (Forbes & Richardson 1920:xxxviii) but is now mostly farmland.

The tributary in which *E. microperca* was studied is a short (6 km long) direct tributary of the Iroquois River, meandering through cultivated fields upstream and forested land downstream. The study area (Fig. 2), at a bridge 6 km northeast of Watseka, is surrounded by cultivated fields. One small, rock riffle and a few mud-bottom pools are present, but the rest of the study area is a sinuous channel of nearly uniform width (0.5–1.0 m), depth ($<$ 0.5 m), and substrate (mixed sand and silt). The water current is slow. Stream banks are grassy and devoid of trees. Water temperatures varied during the study period from 4°C in February to 24°C in July. In summer and fall some rooted vegetation was present, and filamentous algae dominated large stretches of the stream. At this site and for a moderate distance upstream and downstream *E. microperca* was the most common fish.

Seventy-three species of fishes occur in the Illinois portion of the Kankakee River system. At the study area the most common, in addition to *E. microperca*, are *Pimephales notatus*, *Semotilus atromaculatus*, *No-*

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Fig. 2.—The *Etheostoma microperca* life history study site, an unnamed tributary of the Iroquois River, 6 km northeast of Watseka, Iroquois County, Illinois. Photo taken 3 July 1978.

tropis stramineus, Campostoma anomalum, Lepomis cyanellus, Fundulus notatus, and *Etheostoma nigrum.*

METHODS

Methods of study were those employed by Page (1974:4–5) except as noted below. Observations and minnow-seine collections were made at approximately monthly intervals from 5 August 1975 to 27 September 1976. Additional data on reproduction were acquired on 26 March 1977 and 19 May 1977. Aging to month was done, using May, the month of the greatest breeding activity in the study area, as month zero. A total of 700 specimens was preserved and stored in 10-percent formalin.

Because the study site was physically uniform and *E. microperca* was found to be rather evenly distributed throughout, no attempts were made to sample by habitat. However, quantitative samples were made to monitor variations in the population density of *E. microperca.*

Nearly all *E. microperca* from museum collections were examined to determine probable spawning periods in other localities and other years. Indicators of spawning preparedness were the same as those listed by Burr & Page (1978:5). Specimens in a collection were considered to be in spawning condition if any of the specimens was in peak reproductive condition.

HABITAT

Adults of *E. microperca* were consistently found in submerged vegetation along overhanging grassy banks and among filamentous algae. Rarely were they found in midstream away from any vegetation. During high water they avoided strong current and were found almost exclusively in quieter water under overhanging banks. Juveniles were found in thick growths of algae at the edge of the stream.

Comparative collections made by the authors in Oklahoma, Missouri, Indiana, and Michigan indicate that the species prefers quiet waters rich in vegetation (most often filamentous algae, *Elodea, Myriophyllum,* or *Ceratophyllum)* with sand or muck bottoms. *E. microperca* is abundant in some Ozark springs, spring runs, and spring-fed creeks. In Ohio it is present in clear pothole lakes and prairie streams of low gradient with bottoms consisting of soft muck, sand, or gravel (Trautman 1957:604). The preferred habitats of *E. microperca* are heavily vegetated, low-gradient water bodies, including small to large streams and margins of lakes and vegetated springs.

REPRODUCTION

Reproductive Cycle of the Male

By early January the genital papilla of the male begins to swell noticeably, and by late March or early April it is thick and stout (Fig. 3). Testes of breeding

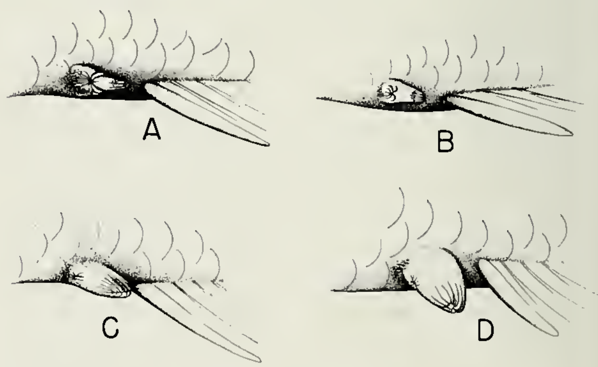

Fig. 3.—Genital papillae of *Etheostoma microperca.* A, nonbreeding male; B, breeding male; C, nonbreeding female; D, breeding female. The breeding specimens were 1 year old, collected on 23 May 1976. The nonbreeding specimens were 1+ years old, collected on 30 August 1976.

males are greatly enlarged, opaque white, and spongy; those of nonbreeding males are small and translucent.

All spring-collected males—including the smallest, a 22.0-mm male collected in April—were sexually mature and thus were potential spawners. In all three species of the subgenus *Microperca* males were found to be sexually mature at 1 year.

Males began to develop lateral flaps of skin on the pelvic fins as early as late January, but it was not until mid-March that breeding colors were evident and not until April that breeding tubercles appeared. By mid-March the pelvic-fin flaps were developed nearly to their maximum, and the color of the first dorsal, anal, and pelvic fins had intensified.

From about the second week of April to the end of June, male breeding colors and structures were at their peak development (Fig. 4). The body was dark

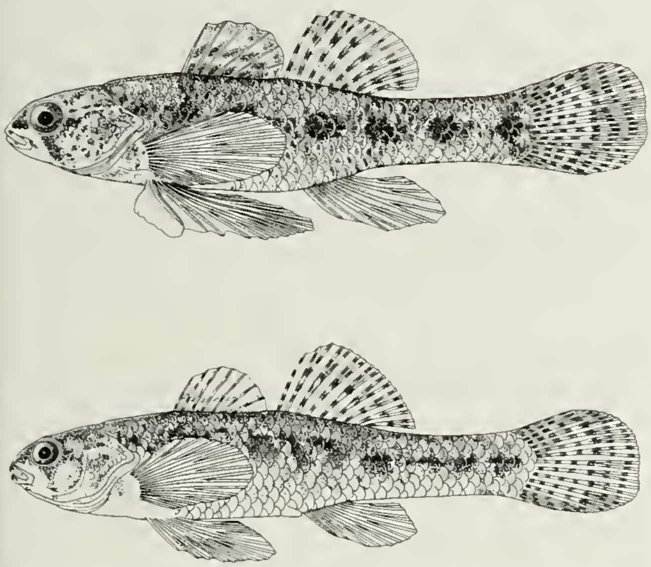

Fig. 4.—Breeding male (upper) and breeding female (lower) *Etheostoma microperca* collected in the Iroquois River on 23 May 1976. Both the male and female were 30 mm. Nuptial tuberculation is not shown. Drawings by Alice A. Prickett.

green with 8–10 intense mid-lateral black blotches interspersed with spots of metallic green. The pre-, post-, and suborbital bars were intense black. The opercle, belly, and pectoral fin bases were metallic green. The flesh overlying the top of the head and the second dorsal and caudal fins was thick and milky white. The iris of the eye was red. Distally and basally the first dorsal fin was charcoal gray; medially in each membrane was an intense red-orange spot surrounded by flecks of metallic green. The second dorsal fin had four or five charcoal gray bands; the caudal fin had six or seven charcoal gray bands. The pectoral rays were sharply outlined by melanophores. The throat, breast, and belly had large black blotches of pigment. The pelvic and anal fins were a deep red-orange.

Tubercles developed on all the pelvic fin rays, and were most heavily concentrated on the distal portions of the rays. Pelvic fin flaps were developed to their maximum, with the skin greatly expanded on both sides of the pelvic spine and between pelvic rays one through three.

Winn (1958*a*, 1958*b*) indicated that during the breeding season small stationary areas about 30 cm in diameter are defended as territories by *E. microperca*. Plants are apparently used in the delimitation of territories. At the study site on 19 May 1977 agonistic encounters were observed between males, and in aquaria certain males appeared to establish territories. Pugnacious behavior was observed on numerous occasions between rival males. Evidence for the establishment of territories was not found in *E. proeliare* (Burr & Page 1978:11) or *E. fonticola* (Strawn 1956).

Reproductive Cycle of the Female

The genital papilla of the female enlarged over several months and by the spawning period was a swollen conical structure (Fig. 3) much larger than the papilla of the male. The conical shape of the female papilla of *E. microperca* is different from the bulbous and bilobed shape of the papilla of *E. proeliare* and *E. fonticola* (Burr 1978:7).

The female color and pattern (Fig. 4) changed little prior to and during the breeding period. The pelvic and anal fins became amber in color and sometimes developed a light yellow or orange cast. In a few females there was some orange in the medial portions of the first dorsal fin membranes and in the iris of the eye. The second dorsal and caudal fin bands were charcoal gray, and the pectoral fins were sharply outlined by melanophores.

Ovaries in July and August were small. From September through February ovaries were small and pink, and ova were small and white. By March, some yellow ova were discernible, and from April to June large dark-yellow ova were present. Prior to spawning the large, dark-yellow ova transformed into translucent, prominently indented eggs 0.8–1.1 mm across and with one or two large oil droplets (see Burr & Page 1978:6 for an illustration of indented eggs). Prominently indented eggs are characteristic of the three species of *Microperca*. The indentation, involving both the chorion and egg plasma membrane, disappears soon after fertilization and does not facilitate attaching eggs to the substrate nor packing eggs in the ovaries (Burr & Ellinger 1980).

All females collected from April to June had large, maturing or translucent ova and apparently would have spawned. The smallest spring-collected female was 23.2 mm and was collected 27 April 1976. In 16 females collected in April–June 1976 the number of mature ova ranged from 31 to 240 (Table 1). For these females there was no significant correlation between the number of mature ova and the standard length, nor between the number of mature ova and the adjusted body weight; for both relationships the

TABLE 1.—Relationship between size, age, and ovary weight of *Etheostoma microperca* females and the number of mature ova. All females were 1 year (11–13 months) old.

Standard Length in mm	Adjusted Body Weight in Grams[a]	Month of Collection	Ovary Weight in Grams	Number of Mature (Dark Yellow or Translucent) Ova
28	0.20	April	0.04	54
28	0.27	April	0.04	62
23	0.21	May	0.05	102
24	0.18	May	0.04	92
24	0.20	May	0.06	104
25	0.19	May	0.05	84
25	0.23	May	0.09	180
26	0.24	May	0.06	112
27	0.24	May	0.07	154
28	0.24	May	0.06	101
30	0.32	May	0.08	240
30	0.32	May	0.09	174
29	0.18	June	0.04	31
29	0.33	June	0.03	78
30	0.28	June	0.03	36
30	0.29	June	0.04	106

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

correlation coefficient *(r)* was less than 0.12. The same lack of correlation was found in *E. proeliare* and is discussed by Burr & Page (1978:6-7). Because eggs are laid over a relatively large area, spawning in *E. proeliare* and *E. microperca* is likely to be interrupted; thus an accurate estimate of the number of eggs produced during the spawning season is difficult. Egg counts presented on these species and on *E. fonticola,* which lays eggs throughout the year (Schenck & Whiteside 1977*a*:367), may not be of the total numbers produced. Petravicz (1936:81) reported that a female *E. microperca* lays about 30 eggs during 1 day of spawning. Winn (1958*b*:182) who counted all ova (believing that all are normally laid in a season), reported 455–1,102 eggs laid by *E. microperca.*

From August until the spawning period, ovaries increased in size relative to the body of the female (Fig. 5). For the females examined, the relationship between the mean weight of the ovaries divided by the adjusted body weight (Y) and the month (X), with August = 1 and May (the month of the greatest spawning activity) = 10, was log Y = 0.799 + 0.158 X, with $r = 0.779$ (Fig. 5). The proportionally largest ovaries (equalling 38.9 percent of the adjusted body weight) were found in a 25-mm female collected on 23 May 1976. In the 16 females represented in Table 1, ovary-weight-to-adjusted-body-weight ratios ranged from 0.092 to 0.389 and averaged 0.230.

Spawning

At the study area *E. microperca* in breeding condition were found from April to June. Individuals transferred from the Iroquois River on 27 April 1975, 23 May 1976, 31 May 1976, and 19 May 1977 spawned in aquaria on those days and/or for a few days thereafter. Stream temperatures at the time of the capture of ripe *E. microperca* individuals ranged from 16° to 20°C; aquaria temperatures ranged from 20° to 23°C. Petravicz (1936:78) gave stream temperatures of 12°–15.5°C for ripe *E. microperca;* Winn (1958*b*: 158) listed spawning temperatures as 16°–18°C. Spawning was observed in the Iroquois River on 19 May 1977 along the shallow margins of the stream in dense beds of filamentous algae; this spawning habitat agrees with the observations of Petravicz (1936) and Winn (1958*a*, 1958*b*).

Examinations of preserved museum specimens from throughout the range of the species indicated that spawning occurs early (February–May) in the Blue River, Oklahoma, and certain Ozark streams and later (May–July) in more northern areas (Table 2). Populations of *E. microperca* that occur in or near constant-temperature springs in the Ozarks (see Niangua River, Missouri, Table 2) possibly spawn through much of the year, as does the related *E. fonticola* (Schenck & Whiteside 1977*a*:367–368) which occurs in a large constant-temperature spring in Texas. Geographic variation in spawning periods is almost certainly related to warmer water on earlier dates at more southern latitudes. In addition to the probable spawning dates listed in Table 2, the following are from published literature: May (Mich-

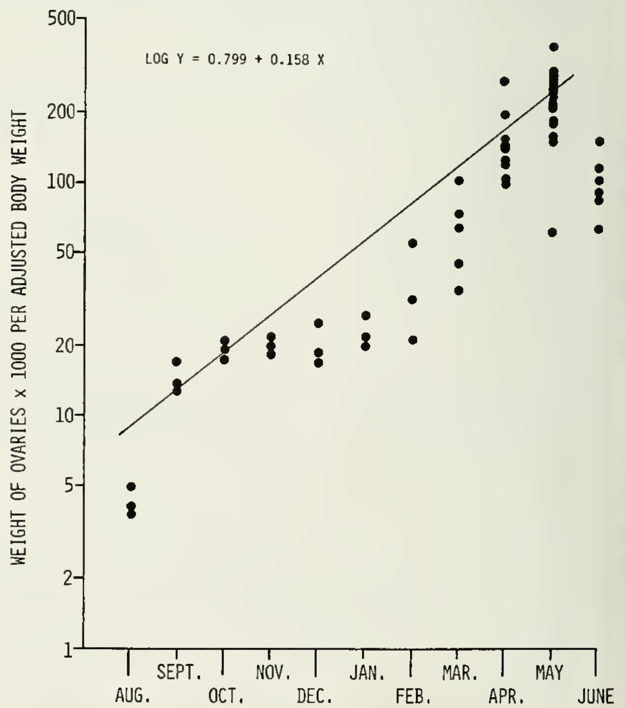

Fig. 5.—Monthly variations in ovarian weight relative to adjusted body weight of 3- to 13-month-old *Etheostoma microperca* females. The vertical axis is a logarithmic scale.

TABLE 2.—Frequency distribution by month of the collection of *Etheostoma microperca* in breeding condition from throughout the range of the species. Drainages are arranged primarily by latitude and geographic propinquity where possible. Numbers in parentheses are numbers with specimens in reproductive condition as explained under Methods. Museum collection abbreviations are given in the introduction.

Drainages	Feb.	Mar.	Apr.	May	June	July	Aug.	Collection Dates
Blue R., OK (7—EKU 614; INHS 75678; KU 12924; OAM 1597, 7157, 9158, 10015)	2		5					1 February–27 April
Illinois-Neosho R., OK, AR, MO (8—APB uncat; KU 10735, 10749; NLU 25892; UTULSAC 1171, 2571, 2522; WCS AK/NS1-1)	1	3	2	1	1			6 February–9 June
Gasconade R., MO (3—INHS 75828; KU 8029, 10989)		1	1	1				18 March–1 May
Sac R., MO (1—INHS 75822)		1						18 March
Niangua R., MO (3—INHS 75817; UMMZ 108728, 150283)		1				1	1	20 March–19 August
Great Miami R., OH (1—OSM 14249)		1						27 March
Scioto R., OH (2—OSM 22980; UMMZ 159856)			1	1				18 April–6 May
Kankakee-Fox R., IL, IN (10—INHS 4168, 5402, 5491, 73838; Iroquois River collections)			2	3	4	1		27 April–12 July
Rock R., IL, WI (4—INHS 206, 3201, 3248; MPM 7932)				2	2			8 May–11 June
Upper Mississippi R., MN (2—UF 21046; UMMZ 95001)				1		1		14 May–4 July
L. Michigan, MI, WI (10—MPM 9886; UMMZ 82012, 84222, 90033, 90123, 90380, 97950, 97994, 139002, 164398)			1	4	4	1		26 April–16 July
L. Huron, MI, ONT (9—UMMZ 61723, 66702, 67927, 67986, 68991, 69114, 73187, 85530; ROM 30505)				3	2	4		2 May–10 July
Thames R., ONT (4—ROM 30135, 30138, 30996; UMMZ 85567)				1	3			26 May–19 June
Maumee R., south L. Erie, OH, MI, ONT (10—OSM 9957; ROM 30636, 30843; UMMZ 56858, 66516, 87504, 89872, 89961, 118501, 162222)				5	4	1		2 May–21 July

igan)—Hankinson 1908:216; 26 April and 5 May (Michigan)—Petravicz 1936:78; mid-April to mid-June (Michigan)—Winn 1958*b*:165; 27 May (Michigan)—Winn 1958*a*:201; 30 June (Oklahoma)—Branson 1970: 460; May to early June (Missouri)—Pflieger 1975:323.

The first reference to spawning in *E. microperca* is that by Hankinson (1908:216) who observed breeding pairs in Walnut Lake, Michigan, with a female below and a male above in "what may have been the spawning act." Petravicz (1936) later gave a more detailed account of breeding habits of the species based on field and laboratory observations on a population in Bell Branch, Detroit, Michigan. Winn (1958*a*, 1958*b*) gave the most complete account of reproduction in *E. microperca* based on field and laboratory observations on individuals from two lakes in Washtenaw County, Michigan. Our observations of spawning in *E. microperca* agree closely with those of the above authors.

Spawning was observed at the study site at 1030 hours on 19 May 1977. Spawning in aquaria occurred at various times throughout the day and was observed on numerous occasions. Field observations agreed with those made on aquaria-held specimens. The description that follows is from laboratory observations. Males were much more active in aquaria than males of the related *E. proeliare* or *E. fonticola* (Strawn 1955:412) and constantly pursued females. They courted females by hanging vertically in mid-water for several seconds while vibrating their fins vigorously. Occasionally a male mounted a female, clasped her with his pelvic fins, and bore down on her nose, head, or nape with his chin and throat as if to stimulate her. No actual "chin rubbing" was observed as in *E. proeliare* (Burr & Page 1978:8) and *E. gracile* (Braasch & Smith 1967:7).

The female selected the site of egg deposition and, with the male close behind, elevated to the site (Fig. 6). At the egg site the male mounted the back of the female, the two quivered intensely for a few seconds while curved in a loose S-shaped fashion such that the female genital papilla was on the selected spot, and 1–3 adhesive eggs were laid. The S-shaped position presumably facilitated the release of milt close to the eggs. At the instant of egg laying both the male and female always had their mouths wide open; in *E. proeliare* only the female had her mouth open at the instant of egg laying. Eggs ranged from 0.8 to 1.1 mm across and were attached to twigs, leaves, algae and the sides of the aquarium. On several occasions spawning pairs swam the depth of the water (30 cm) in the aquarium, stuck their snouts just above the water surface, and deposited eggs on the side of the aquarium.

Usually several eggs were laid at one site (e.g., a clump of twigs). In contrast to *E. proeliare, E. microperca* would perform three or four spawning acts in succession with only a brief period of rest in between. Spawning pairs of *E. proeliare* usually separated and rested up to a minute before they resumed spawning. Typically a pair would lay several eggs at one site and then move 5–15 cm from the first site and lay several more eggs. On a few occasions eggs were not laid during mounting and quivering. In an aquarium in which were placed four females and three males, 96 eggs were laid on a plastic substrate

Fig. 6.—*Etheostoma microperca* spawning in aquaria. Top: Male bearing down on nape of female illustrating a typical part of courtship behavior. Middle and lower: Male and female in vertical position as egg and sperm are released on twigs. Note intensity of pigmentation in male and gaping mouths of both sexes.

and 29 eggs were found on a piece of leaf after 5 hours.

Laying eggs on the sides of aquaria and on leaves and twigs required the spawning pair to assume vertical positions. These positions were maintained by rapid vibrations of the caudal and pectoral fins. The expanded pelvic fins of the male enabled him to grip tightly the middorsum of the female. Fin positions for the two sexes were virtually identical to those described for *E. proeliare* (Burr & Page 1978:10). While the spawning position of *E. microperca* was almost always vertical, horizontal positioning during successful egg-laying was observed occasionally.

Some spawning males did not have pelvic or anal fin tubercles. The lack of tubercles on those individuals indicates that the structures are not necessary for maintenance of body contact but probably aid in the stimulation of the female.

In aquaria, males spawned with several females and often attempted to mount other males. All the males held in aquaria during the spawning season spawned. Neither sex gave any attention to the eggs after spawning. Parental care is absent in all three species of *Microperca*.

Winn (1958*b*:163–164) reported that *E. microperca* moved from the deeper portions of lakes and streams to shallow areas to spawn, and that males often arrived 1–2 weeks earlier than females. Petravicz (1936:79) stated that samples of *E. microperca* taken from mid-stream generally yielded many more females than males, but that hauls made near shore resulted in a more evenly distributed sex ratio. He concluded that females remained in deeper water until ready to spawn, at which time they entered the inshore spawning territory occupied by males. Spawning migrations were not observed at the study site because the small size and vegetated nature of the stream probably negated the need for the invasion of a new habitat.

The spawning behavior of the three species of *Microperca* is similar. Spawning position is usually vertical or inverted and male-female positioning is nearly identical. Only 1–3 eggs are laid at each spawning act (Burr & Page 1978:8, Strawn 1956:14), and egg deposition sites are much the same.

Sexual Dimorphism

Sexual dimorphism in tuberculation, pelvic fin structure, coloration, and genital papillae are discussed elsewhere in this paper and by Burr (1978:25–32). A taxonomic study of *E. microperca* from throughout its range revealed that 8 of 16 morphometric characters measured on breeding specimens showed highly significant ($P < 0.005$) sexual dimorphism (Burr 1978:51). Males had significantly longer heads, wider interorbital widths, longer postdorsal lengths, deeper caudal peduncles, and longer pelvic, pectoral, anal, and second dorsal fins. *E. proeliare* was sexually dimorphic ($P < 0.005$) for 7 out of the 16 morphometric characters measured and *E. fonticola* 5 out of the 16 (Burr 1978:48, 50).

DEVELOPMENT AND GROWTH

Eggs incubated in aquaria at 15.5°C (60°F) hatched in 264 ± 13 hours (11 days), at 20°C (67°–68°F) hatched in 181 ± 7 hours (7.5 days), and at 22–23°C (71°–74°F) hatched in 144 ± 12 hours (6 days). Eggs incubated at 27°C (80°F) spoiled after a few days. Petravicz (1936:82) and Winn (1958*b*:182) reported hatching time at 18°–20°C (64°–67°F) to be 6.0–6.2 days.

A hatchling 3.5 mm in total length was mostly translucent but had individual melanophores on the head, yolk sac, and some of the myomeres (Fig. 7: top). The pectoral fins were larger than in other

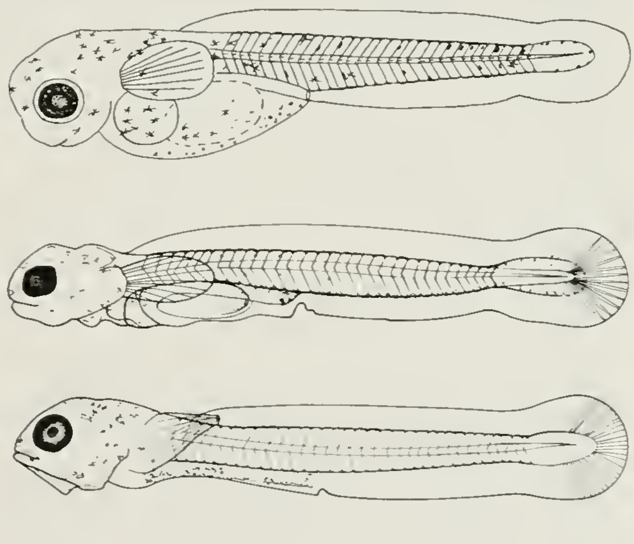

Fig. 7.—Top: *Etheostoma microperca* hatchling (3.5 mm total length). Middle: 3-day-old larva (4.0 mm total length). Bottom: 7-day-old juvenile (4.7 mm total length).

species of *Etheostoma* studied (e.g., *E. gracile*—Braasch & Smith 1967:9; species of *Catonotus*—Page 1974:11, 1975:8–9; Page & Burr 1976:8) and the tail had an unusual shape. Petravicz (1936:82) reported a hatchling 3 mm in total length. Three-day old larvae (Fig. 7:middle) averaged 4.0 mm in total length and had 10 pectoral fin rays, several caudal fin rays, and melanophores concentrated on the yolk sac remnant, head, and myomeres. At 7 days a juvenile was 4.7 mm in total length: the yolk sac had nearly disappeared, the caudal fin had many rays developed, and the pectoral fins were large (Fig. 7:bottom). The pelvic, dorsal, and anal fins had not differentiated at 7 days.

A series of 20 young *E. microperca* ranging from

7 to 13 mm was collected at the study site on 27 June 1976. At 7 mm all fins, fin rays, and branchiostegal rays were well developed; scales and the lateralis system were nonexistent; pigment was limited to discrete melanophores scattered over the head and body, and outlining fin rays and myomeres. At 8–9 mm 10 vague lateral blotches and 6–7 dorsal saddles were present, and more pigment was visible on the head, gill covers, and snout. At 10–11 mm the lateral blotches and dorsal saddles were well defined; pigment outlined the anal fin rays; scales were visible on the top and sides of the body; melanophores were beginning to outline the scales; the undersides, nape, and head were still devoid of scales; and the cephalic lateralis system was developed to its maximum. At 12–13 mm body squamation was complete, but no scales were present on the opercles; pigmentation on the head was like that of the adult, and the opercular spine was well developed.

Males and females grew at nearly the same decreasing rate (Fig. 8). The relationship between

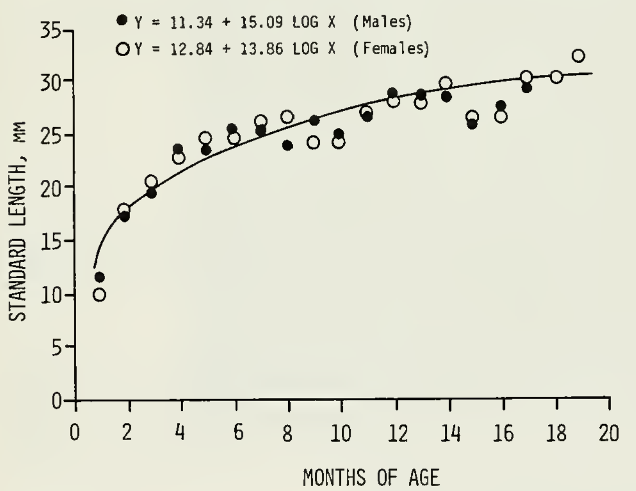

Fig. 8.—Size distribution by age of *Etheostoma microperca* collected in the Iroquois River between 5 August 1975 and 27 September 1976. Black dots represent sample means for males; circles represent sample means for females. Regression line is for both sexes. A total of 700 specimens is represented.

standard length (Y) and age in months (X) for males is $Y = 11.3 + 15.09 \log X$, with $r = 0.857$, and for females is $Y = 12.84 + 13.86 \log X$, with $r = 0.899$.

The largest specimen examined from the study area was a 32.4-mm female collected on 11 December 1975; the largest male was 31.5 mm collected on 27 September 1976. The largest specimen known is a 36.9-mm female from Spring Creek, Mayes County, Oklahoma. In general females reach a greater maximum size than do males, probably because females live longer.

At 1 year (12 months) males (N = 11) averaged 28.4 mm and females (N = 24) averaged 28.1 mm. *E. microperca* reached one-half of the first year's mean growth in about 6 or 7 weeks. *E. proeliare* required about 8 weeks to reach one-half of the first year's mean growth (Burr & Page 1978:11).

DEMOGRAPHY

Density

Quantitative samples of *E. microperca* were taken at the study area every month by repeatedly seining an area until no more individuals were present in some seine hauls. The number collected was transposed into the number per square meter (Table 3). The greatest density was 33.09 darters/m² collected on 14 October 1975.

The considerable variation in density (Table 3) seems to follow a seasonal trend and also emphasizes

Table 3.—Number of *Etheostoma microperca* per square meter in the Iroquois River by month of collection.

Collection Date	Number Collected	Number per Square Meter
14 October 1975	92	33.09
13 November 1975	70	11.78
11 December 1975	58	4.00
20 January 1976	26	2.33
12 February 1976	13	0.93
27 March 1976	13	0.84
27 April 1976	17	2.44
23 May 1976	12	0.83
27 June 1976	15	2.12
27 July 1976	29	3.81
30 August 1976	31	13.90
27 September 1976	40	26.85

certain life history phenomena. From late summer through fall the species reached its greatest density at the study area. This is presumably due to a concentration of individuals by the extremely low water levels and the presence of both −1 and 1+ year classes. During winter months the density decreased; few individuals in the 1+ year class survived, and there was a rise in the water level due to fall rains and winter snows. In spring the density remained low. In late summer the numbers in the population began to build to the maximum attained in the fall.

E. microperca was the most common species of fish at the study area and it reached greater densities than those reported for other darters studied. The highest density found for *E. proeliare* was 5.5 individuals/m² (Burr & Page 1978:11). Schenck & Whiteside (1976:702) reported that the highest density found for *E. fonticola* at San Marcos River, Hays County, Texas, was 4.7 individuals/m².

Composition

Of the 700 *E. microperca* collected in the Iroquois River between 5 August 1975 and 27 September 1976, 82.0 percent were up to 1 year of age and 18.0 percent were between 1 and 2 years of age (Table 4).

There was no significant deviation from a 1 to 1 sex ratio in the first year (−1) age class but because of greater longevity females predominated [1.7 females to 1 male ($\chi^2 = 8.12$; $P < 0.005$)] in the 1+ year class.

Survival

Of the 314 males collected, 85.0 percent were up to 1 year of age and 15.0 percent were over 1 year of age. Of the 386 females collected 79.5 percent were up to 1 year of age and 20.5 percent were over 1 year of age. Assuming that each year class was collected in proportion to its relative number in the population, 17.6 percent of the first-year males and 25.7 percent of the first-year females survived to a second year. For males and females combined, the survival to a second year was 21.9 percent. These survival values and those of *E. proeliare* (Burr & Page 1978:11) are lower than those for other darters studied, and the short life span of the species of *Microperca* is a distinctive feature among percids. *E. smithi* is also a short-lived species: the oldest individual recorded was a 24-month old male (Page & Burr 1976:9).

The oldest *E. microperca* examined from the Iroquois River (assuming a May hatching) was a 20-month old female collected in December 1975. The oldest males examined were five 18-month old individuals collected in October 1975. Winn (1958*b*:182) reported seven 2-year-old specimens of *E. microperca* collected from his study sites in Michigan. His method for determining the age of specimens was not given.

Although *E. microperca* is short-lived, it can survive extreme environmental conditions. In a study of stream desiccation in Tenmile Creek, Lucas County, Ohio, Tramer (1977:475) found that *E. microperca* survived periods of drought by burrowing into the substrate. When rain refilled the dry pools in the creek, *E. microperca* reappeared.

Migration

E. microperca was common in the study area during most months of the study period and there was no indication of any mass movements up or down stream. Reference to breeding migrations observed in other populations was made under Spawning.

Territoriality

Territorial behavior, as discussed briefly under Reproductive Cycle of the Male, was observed in the field and laboratory. The aquaria used in this study could have been overcrowded, which, according to Winn (1958*a*:202), results in abnormal behavior and possibly inhibits full expression of territoriality. Petravicz (1936) did not observe territorial behavior and it was not observed in the related *E. proeliare* (Burr & Page 1978:11) and *E. fonticola* (Strawn 1956).

TABLE 4.—Distribution of sexes and year classes in samples of *Etheostoma microperca* collected in the Iroquois River between 5 August 1975 and 27 September 1976.

Sex	Number by Year Class		Total
	−1	1+	
Males	267	47	314
Females	307	79	386
Total	574	126	700

According to Winn (1958*b*:168) *E. microperca* defended a small (ca. 25–30 cm) "stationary" territory which had three dimensions. The three dimensional territory of *E. microperca* included the vertical height of the plant as the third dimension. According to Winn territorial defense was not maintained at night.

DIET

Stomachs of 120 *E. microperca* contained mostly chironomid larvae and small crustaceans (Table 5). Gastropods, annelids, and insects other than chironomids made only small contributions to the diet. Compared to other darters studied, e.g., *Percina sciera* (Page & Smith 1970), *P. phoxocephala* (Page & Smith 1971), *P. nigrofasciata* (Mathur 1973), *Etheostoma squamiceps* (Page 1974), *E. kennicotti* (Page 1975), and *E. smithi* (Page & Burr 1976), the three species of the subgenus *Microperca* fed more on small crustaceans and less on insects other than chironomids (Burr & Page 1978:11; Schenck & Whiteside 1977*b*). Reasons for this were discussed by Burr & Page (1978: 11–12) and Schenck & Whiteside (1977*b*:490).

Isopods, cladocerans, copepods, and chironomids were major components of the diet of *E. microperca* of all sizes. Gastropods, plecopterans, and several kinds of dipterans were important to large (22–30 mm) *E. microperca*. In darters which attain a larger maximum size than do species of *Microperca*, small crustaceans are important to smaller individuals but decreasingly so with an increase in the size of the darter.

Chironomids and copepods were important diet items every month of the year (Table 6). Isopods and cladocerans were important diet items several months of the year. Fish eggs were consumed during spring months. Strawn (1956:17) and Schenck & Whiteside (1977*b*) reported that *E. fonticola* cannibalized newly hatched larvae and eggs. Petravicz (1936:81) indicated that supernumerary males of *E. microperca* may devour eggs fertilized by rival males.

Forbes (1880:26) and Forbes & Richardson (1920: 318) concluded that in Illinois small crustaceans made up 64 percent of the diet of *E. microperca*, *Chironomus* 34 percent, and ephemerids (Neuroptera) 2 percent. Forbes (1888: 516, 517, 524, 527, 529, 531) gave some indication of seasonal feeding habits with the groups mentioned above being eaten during May and June. Cahn (1927:56) reported that *E. microperca*

TABLE 5.—Stomach contents of *Etheostoma microperca* from the Iroquois River, 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			
	<16 mm (10)	16–21 mm (20)	22–27 mm (45)	>27 mm (45)	<16 mm (10)	16–21 mm (20)	22–27 mm (45)	>27 mm (45)
Gastropoda	......	5.0	13.3	4.0	......	0.10	0.22	0.04
Annelida								
Lumbricidae	......	......	......	8.0	......	......	......	0.24
Crustacea								
Cladocera	10.0	45.0	37.8	24.0	0.80	2.10	2.80	1.14
Ostracoda	......	......	......	4.0	......	......	......	0.04
Copepoda	90.0	100.0	73.3	60.0	27.20	14.35	10.22	8.96
Isopoda								
Asellidae								
Asellus	40.0	15.0	17.8	38.0	0.70	0.55	0.56	1.30
Insecta								
Plecoptera	......	10.0	6.7	4.0	......	0.10	0.07	0.04
Odonata	......	5.0	......	......	......	0.05	......	......
Collembola								
Entomobryidae	......	......	......	2.0	......	......	......	0.02
Diptera								
Chironomidae	60.0	75.0	73.3	68.0	3.30	3.25	4.91	5.98
Tabanidae	......	......	4.4	4.0	......	......	0.04	0.04
Ephydridae	......	......	......	6.0	......	......	......	0.10
Simulidae	......	......	2.2	......	......	......	0.38	......
Lepidoptera								
Pyralididae	......	......	......	2.0	......	......	......	0.02
Fish eggs	......	......	4.4	6.0	......	......	0.07	0.14
Empty	......	......	2.2	4.0	......	......	0.02	0.04

in southern Wisconsin (Waukesha County) ate insect larvae, nymphs, and entomostraca.

INTERACTIONS WITH OTHER ORGANISMS

Competition

Pflieger (1971:280–281) suggested that the complementary distribution of *E. microperca* and *E. proeliare* in Missouri was a result of competition. The two species have been collected together in a stream in Oklahoma in years past but recent collections have produced only specimens of *E. proeliare*. Similarly, *E. microperca* was known by an old collection from a creek in southwestern Arkansas. Numerous recent collections in the creek have again produced only specimens of *E. proeliare*. Because the habitat requirements of the two species are similar, their complementary distributions may be due at least in part to competition.

Other than *E. microperca* the only darter captured in the study area was *E. nigrum*. *E. nigrum* usually inhabited the central portion of the stream in sandy stretches and was never common. No evidence of competition involving *E. microperca* was found at the study area.

Predation

As potential predators of *E. microperca*, eight *Semotilus atromaculatus* (73–90 mm) and three *Lepomis cyanellus* (49–82 mm) were preserved and later examined. No fish remains were found in their stomachs.

Hankinson (1911:204) found remains of *E. microperca* in the stomachs of young "black bass" 2.5 inches long from Walnut Lake, Michigan. Cahn (1927:56) reported that the species was eaten by *Pomoxis annularis* and *Micropterus salmoides*. In an analysis of the feeding habits of two species of trouts from Birch Lake, Cass County, Michigan, Leonard & Leonard (1949:304) found that *E. microperca* was not eaten although it was present in the lake.

Parasitism

Of the 120 *E. microperca* in which stomach contents were examined, two each contained one spiny-headed worm (*Acanthocephalus* sp.). Parasitic nematodes were found in the stomachs from every month of the year except August and February. A total of 32 nematodes was found in the stomachs examined and up to 4 nematodes were found in an individual stomach. The only external infestation was a parasitic copepod (*Lernaea* sp.) found on a specimen collected in August.

In specimens examined from throughout the range of *E. microperca* external fluke infestations were found in four collections: OSM 16617 (Scioto River, Ohio); ROM 26803 (AuSable River, Ontario); UMMZ 136999 (Bad River, Michigan); UMMZ 139765 (Saline River, Michigan).

In a study of parasites in Lake Erie fishes Bangham & Hunter (1939:406) examined four specimens of *E. microperca* and found no infestations. The only published report of parasitism in this species is by

Table 6.—Stomach contents of *Etheostoma microperca* from the Iroquois River, by month of collection. Figures in parentheses are numbers of stomachs examined.

Percent of Stomachs in Which Food Organism Occurred

Food Organism	Jan. (10)	Feb. (10)	Mar. (10)	Apr. (10)	May (10)	June (10)	July (10)	Aug. (10)	Sept. (10)	Oct. (10)	Nov. (10)	Dec. (10)
Gastropoda	......	......	......	10.0	10.0	10.0	......	......	......		20.0	40.0
Annelida												
Lumbricidae	......	......	40.0	......	......	......	......					......
Crustacea												
Cladocera	70.0	50.0	......	......	......	......	10.0	20.0	60.0	50.0	50.0	90.0
Ostracoda	......	10.0	10.0	......	......	......	......	......	......	......	......	......
Copepoda	90.0	100.0	40.0	40.0	50.0	50.0	60.0	80.0	100.0	100.0	80.0	90.0
Isopoda												
Asellidae												
Asellus	......	10.0	20.0	70.0	30.0	40.0	30.0	40.0	40.0	10.0	20.0	20.0
Insecta												
Plecoptera	10.0	20.0	......	......	......	......	30.0	10.0	......	......	......	......
Odonata	......	......	......	......	......	......	10.0	......	......	......	......	......
Collembola												
Entomobryidae	......	......	10.0	......	......	......	......	......	......	......	......	......
Diptera												
Chironomidae	40.0	100.0	100.0	60.0	100.0	90.0	90.0	40.0	60.0	80.0	80.0	30.0
Tabanidae	......	10.0	30.0	......	......	......	......	......	......	......	......	......
Ephydridae	......	......	......	30.0	......	......	......	......	......	......	......	......
Simulidae	......	......	......	......	......	10.0	......	......	......	......	......	......
Lepidoptera												
Pyralididae	......	......	......	......	......	......	......	......	......	......	......	10.0
Fish Eggs	......	......	......	30.0	......	20.0	......	......	......	......	......	......
Empty	......	......	......	20.0	......	......	......	......	......	......	......	10.0

Mean Number of Food Organisms per Stomach

Food Organism	Jan. (10)	Feb. (10)	Mar. (10)	Apr. (10)	May (10)	June (10)	July (10)	Aug. (10)	Sept. (10)	Oct. (10)	Nov. (10)	Dec. (10)
Gastropoda	......	......	......	0.10	0.10	0.20	......	......	......		0.30	0.70
Annelida												
Lumbricidae	......	......	1.20	......	......	......	......	......	......	......	......	......
Crustacea												
Cladocera	1.50	1.20	......	......	......	......	0.40	0.90	2.30	2.00	3.30	12.50
Ostracoda	......	0.10	0.10	......	......	......	......	......	......	......	......	......
Copepoda	3.40	51.40	1.30	0.90	1.20	1.30	4.60	27.90	18.30	16.60	4.30	13.70
Isopoda												
Asellidae												
Asellus	......	0.20	0.30	4.50	0.30	0.70	0.90	1.80	0.60	0.20	0.20	0.30
Insecta												
Plecoptera	0.10	0.20	......	......	......	......	0.30	0.10	......	......	......	......
Odonata	......	......	......	......	......	......	0.10	......	......	......	......	......
Collembola												
Entomobryidae	......	......	0.10	......	......	......	......	......	......	......	......	......
Diptera												
Chironomidae	1.10	10.20	7.70	3.50	15.20	9.60	7.10	1.00	1.10	1.90	1.90	0.50
Tabanidae	......	0.10	0.30	......	......	......	......	......	......	......	......	......
Ephydridae	......	......	......	0.50	......	......	......	......	......	......	......	......
Simulidae	......	......	......	......	......	1.70	......	......	......	......	......	......
Lepidoptera												
Pyralididae	......	......	......	......	......	......	......	......	......	......	......	0.10
Fish Eggs	......	......	......	0.40	......	0.60	......	......	......	......	......	......
Empty	......	......	......	0.20	......	......	......	......	......	......	......	0.10

Evermann & Clark (1920:450–457) who found that some individuals from Lake Maxinkuckee, Indiana, were infected with trematodes.

SUMMARY

The life-history information on *E. microperca* in Iroquois River is summarized in Table 7.

TABLE 7.—Summary of life-history information on the Iroquois River *Etheostoma microperca*.

Characteristic	Life-History Data
Principal habitat	Vegetated, sluggish water bodies with a bottom of sand or muck
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 potential spawners
Sexual dimorphism	Adult males average smaller, have red-orange in their first dorsal, anal, and pelvic fins, develop cuplike appendages on their pelvic fins, and have longer heads, wider inter-orbital widths, longer postdorsal lengths, deeper caudal peduncles, and longer pelvic, pectoral, anal, and second dorsal fins
Breeding tubercles	Present on undersides of pelvic fins in males only (none found on anal fin in this population)
Description of genital papillae	Females have a swollen, conical papilla; males have a pointed, tubular papilla
Number of mature ova in preserved females	31–240
Description of egg	0.9 mm across, translucent (1–2 oil droplets) and prominently indented on one side
Spawning period	From April to June
Spawning habitat	Shallow, sluggish edges of stream in dense beds of filamentous algae
Egg deposition sites	Dead leaves, twigs, debris, filamentous algae
Number of eggs laid per spawning act	1–3
Spawning position	Both male and female in vertical position (rarely horizontal), male mounted on back of female
Egg guarding	None observed
Incubation period	264 ± 13 hours at 15.5°C, 181 ± 7 hours at 20°C, 144 ± 12 hours at 22°–23°C
Influence of sex on growth rate	Both sexes grew at approximately same rate
Density	Up to 33.09 darters/m^2 during fall along vegetated stream edges
Sex ratio among first year (–I) age class	1 male: 1 female
Sex ratio among 1+ year age class	1 male: 1.7 females
Longevity	20 months for females; 18 months for males
Maximum size	32.4 mm standard length for females; 31.5 mm standard length for males
Migrations	None observed
Territoriality	Males establish territories about plants at least during breeding season
Principal diet	Chironomid larvae and small crustaceans

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