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Reviewed work(s):

Source: *The Southwestern Naturalist*, Vol. 21, No. 4 (Feb. 10, 1977), pp. 487-492

Published by: [Southwestern Association of Naturalists](#)

Stable URL: <http://www.jstor.org/stable/30054031>

Accessed: 10/01/2012 14:11

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FOOD HABITS AND FEEDING BEHAVIOR OF THE
FOUNTAIN DARTER, *ETHEOSTOMA FONTICOLA*
(OSTEICHTHYES: PERCIDAE)

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ABSTRACT. Food habits and feeding behavior of the endangered fountain darter, *Etheostoma fonticola* was studied in the San Marcos River, Texas. This species was found to be selective in how and what it eats. The food habits varied with seasons and size of fish and the species fed primarily during daylight.

The fountain darter, *Etheostoma fonticola*, is an endangered species of fish which lives only in the headwaters of the San Marcos and Comal rivers, Texas, and in the Dexter National Fish Hatchery, New Mexico, and occupies vegetated habitats (Schenck and Whiteside, submitted). Since no work has been reported concerning the food habits or feeding behavior of this species, a study to determine its feeding behavior, food habits in relation to fish size and seasons, and diel feeding periodicity was conducted.

STUDY AREA. The study area included the entire range of *E. fonticola* in the San Marcos River watershed which includes an 18 hectare lake (Spring Lake) and the upper 4.8 km of the river. The river is formed from springs of the Edwards Aquifer in south-central Texas and Spring Lake is the impounded origin of the river. Based on 12 monthly water temperature determinations made during the study period, March 1973 through April 1974, Spring Lake had a mean temperature of 21.8°C and a range of 21.0 to 22.0°C while the water 4.8 km downstream from the Spring Lake dam had a mean temperature of 22.8°C and a range of 20.6 to 24.9°C.

METHODS AND MATERIALS. Monthly collections of *E. fonticola* were made with a dip net from an area directly adjacent to the Aquarena Springs Hotel in Spring Lake and from five representative stations of the upper 4.8 km of the river. For a more detailed description of the collecting stations see Schenck (1975). Gen-

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erally, fish were collected between 0800 and 1200 hours and no regurgitation of food following fixation in 10% formalin was observed.

In the laboratory, stomachs were excised and the food items were sorted into various taxa and counted under a binocular dissecting microscope. If positive identification of a food item was not possible it was recorded as unidentified.

To determine the food habits of *E. fonticola* of different sizes, the data were divided into three groups according to size ranges of the fish. Size Group I included fish smaller than 24.0 mm total length, Size Group II included fish 24.0 to 36.9 mm total length and Size Group III included fish 37.0 mm total length or larger.

To determine seasonal patterns in food habits, the data were grouped according to seasons: winter (Dec.–Feb.), spring (March–May), summer (June–Aug.) and fall (Sept.–Nov.). Data from March of 1973 and of 1974 were combined as were data from April of 1973 and of 1974. The percentage of stomachs in which a particular taxon occurred (percent frequency of occurrence) was used to determine the seasonal patterns in food habits as well as the food habits in relation to fish size.

To determine the diel feeding periodicity, *E. fonticola* were collected from one station in the river between the hours of 1400–1500, 2000–2100 and 0200–0300 on 29 May 1973 and between the hours of 0800–0900 on 29 June 1973. The diel sample was not completed 29 May because of an equipment failure. The percentage of fish with empty stomachs collected during each of the four time periods was used as an indication of diel feeding periodicity.

RESULTS AND DISCUSSION. *Feeding behavior*—*E. fonticola* was found to be selective in its feeding behavior as exemplified by three observations. (1) *E. fonticola* held in an aquarium fed on moving aquatic invertebrates while disregarding those which remained immobile which suggested that the fish responded to visual cues. This behavior has previously been reported for *Etheostoma nigrum* by Roberts and Winn (1962) and *Etheostoma radiosum cyanorum* by Scalet (1972). The fountain darters did not chase food organisms but remained stationary until the prey moved to within approximately 3 cm. (2) Gastropods and oligochaetes were abundant in the study area but only one gastropod and no oligochaetes were found in the stomachs of *E. fonticola*. (3) Very little plant and mineral debris was found in their stomachs.

Food habits in relation to fish size. The food of most species of darters consists mainly of small aquatic invertebrates and the type and amount of food eaten changes as the fish increase in size. Young darters of most species feed almost exclusively on minute crustaceans but as the fish increase in size, larger quantities of minute crustaceans and/or larger aquatic invertebrates, primarily insect larvae, are eaten. (Turner 1921; Fahy 1954; Page and Smith 1970, 1971; Scalet 1972).

The food habits in relation to fish size of 380 *E. fonticola* collected in the river and 72 collected in Spring Lake are represented in Tables

1 and 2, respectively. The majority of Size Group I fish contained copepods. Dipteran larvae ranked second in the diet of Size Group I fish from the river while amphipods ranked second for Size Group I fish from Spring Lake. The majority of Size Group II fish collected in the river contained either dipteran larvae or ephemeropteran larvae while the majority of Size Group II fish collected in Spring Lake contained either amphipods, copepods or dipteran larvae. The majority of Size Group III fish collected in the river contained ephemeropteran larvae and no fish in this size group were collected in Spring Lake. These data showed that the food habits of fish in Spring Lake were different from the food habits of fish in the river. Casual observations indicated that the overall invertebrate community in Spring Lake was different from the community in the river which could explain the observed differences in food habits of fish in these two areas on the basis of availability of food items.

The food habits of *E. fonticola* were also different as the fish increased in size and two possible explanations for this difference seem

TABLE 1
Percent frequency of occurrence (%FO) of various food items in stomachs of *Etheostoma fonticola* of different sizes in the San Marcos River, Hays County, Texas. (Number of fish examined for each size group is given in parentheses)

Taxon	%FO		
	Size group I (109)	Size group II (266)	Size group III (5)
Cladocera	19.3	7.5	—
Copepoda	62.4	16.9	—
Ostracoda	19.3	13.5	—
Amphipoda	16.5	12.4	20.0
Hydracarina	19.3	9.8	—
Ephemeroptera	29.4	57.1	60.0
Odonata	—	0.8	—
Trichoptera	16.5	33.1	40.0
Lepidoptera	—	0.8	—
Coleoptera	1.8	—	—
Diptera	49.5	60.5	40.0
Gastropoda	—	1.1	—
Fish eggs	—	0.4	—
Vegetation	—	1.1	—
Rocks	—	0.4	—
Unidentified	10.1	13.9	20.0

TABLE 2

Percent frequency of occurrence (%FO) of various food items in stomachs of *Etheostoma fonticola* of different sizes in Spring Lake, Hays County, Texas.
(Number of fish examined for each size group is given in parentheses)

Taxon	%FO	
	Size group I (30)	Size group II (42)
Cladocera	6.7	2.4
Copepoda	60.0	52.4
Ostracoda	10.0	7.1
Amphipoda	40.0	64.3
Isopoda	—	2.4
Hydracarina	10.0	11.9
Ephemeroptera	3.3	21.4
Trichoptera	3.3	—
Diptera	33.3	52.4
Fishes	—	2.4
Fish eggs	—	2.4
Unidentified	—	4.8

most plausible. First, the fish prefer particular food organisms because of their size. Size Group I fish may have fed primarily on copepods because this size food organism could be ingested by the small fish. Larger food items such as ephemeropteran larvae, trichopteran larvae and dipteran larvae could only be ingested by the larger fish and were therefore used by them to a greater extent. Second, availability of particular food items may be important. For example, Size Group I fish ate copepods, and small fish were predominantly found in quiet water areas of the river where most copepods could be expected to live. In accordance with Scalet's (1972) observations on *E. radiosum cyanorum*, it is probable that both of these factors influenced the food habits of *E. fonticola*.

Seasonal patterns in food habits.—The seasonal changes in food habits of 380 *E. fonticola* collected in the San Marcos River and 72 collected in Spring Lake are represented in Tables 3 and 4, respectively. The majority of all fish collected during the spring contained dipteran larvae. Dipteran larvae were also found in the majority of fish collected in the river during the summer whereas copepods and ephemeropteran larvae were found in the majority of fish collected in Spring Lake during this period. Ephemeropteran larvae were found in the greatest number of fish collected in the river during the fall

whereas amphipods were found in the majority of fish collected in Spring Lake during this period. Ephemeropteran larvae were found in the majority of fish collected in the river during the winter, whereas copepods were found in the majority of fish collected in Spring Lake during this period.

Seasonal changes in food habits occurred in the Spring Lake and river populations and these changes differed for the two areas. Page and Smith (1971) and Braasch and Smith (1967) explained seasonal

TABLE 3

Percent frequency of occurrence (%FO) of various food items in stomachs of *Etheostoma fonticola* collected seasonally in the San Marcos River, Hays County, Texas. (Number of fish examined for each season is given in parentheses)

Taxon	%FO			
	Spring (97)	Summer (135)	Fall (73)	Winter (75)
Cladocera	16.5	8.9	4.1	17.3
Copepoda	35.1	28.9	19.2	37.3
Ostracoda	13.4	19.2	15.1	9.3
Amphipoda	19.6	12.6	9.6	12.0
Hydracarina	14.4	14.8	11.0	4.0
Ephemeroptera	49.5	50.0	45.2	60.0
Trichoptera	32.0	25.2	30.1	28.0
Diptera	69.1	63.0	35.6	52.0
Unidentified	19.6	13.3	13.7	1.3

TABLE 4

Percent frequency of occurrence (%FO) of various food items in stomachs of *Etheostoma fonticola* collected seasonally in the Spring Lake, Hays County, Texas. (Number of fish examined for each season is given in parentheses)

Taxon	%FO			
	Spring (16)	Summer (3)	Fall (22)	Winter (31)
Cladocera	6.2	—	4.5	3.2
Copepoda	50.0	66.6	36.4	71.0
Ostracoda	6.2	—	—	12.9
Amphipoda	50.0	—	90.0	35.5
Hydracarina	12.5	33.3	4.5	12.9
Ephemeroptera	31.2	66.6	—	9.7
Trichoptera	—	—	—	3.2
Diptera	93.8	33.3	18.2	38.7
Unidentified	—	—	4.5	3.2

variations in food habits of *Percina phoxocephala* and *Etheostoma gracile*, respectively, as a response to fluctuations in prey populations. Quantitative benthic macroinvertebrate collections were not made during this study but casual observations of invertebrate communities indicated seasonal fluctuations in prey species occur which could explain some of the seasonal changes in the food habits of *E. fonticola*.

Diel feeding. Between the hours of 1400–1500 hours, 29 fish were collected and none of the stomachs were empty; between the hours of 2000–2100, 35 fish were collected and 5.7% had empty stomachs; between the hours of 0200–0300, 31 fish were collected and 19.3% had empty stomachs; and between the hours of 0800–0900, 32 fish were collected and 6.3% had empty stomachs. The above data indicate that *E. fonticola* feeds primarily during daylight.

We gratefully acknowledge W. C. Young and D. G. Huffman for their constructive criticism of this manuscript. This research was supported by a faculty research grant from Southwest Texas State University.

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