FOOD HABITS AND FEEDING PERIODICITY OF THE RAINBOW, FANTAIL, AND BANDED DARTERS IN FOUR MILE CREEK[1]

SCOTT W. ADAMSON[2] AND THOMAS E. WISSING, Department of Zoology, Miami University, Oxford, OH 45056

Abstract. Stomach analyses were carried out on 3 darter species (*Etheostoma caeruleum, E. flabellare* and *E. zonale*) from Four Mile Creek, Ohio, May 1973–May 1974. These species are mainly insectivorous in this stream. Trichopterans were the most important food type by weight in the diets of *E. caeruleum* and *E. flabellare;* chironomid larvae and pupae and *Simulium* sp. dominated the diet of *E. zonale.* Electivity indices indicated a general selection for *Simulium* sp. and Trichoptera by *E. caeruleum* and *E. flabellare,* with *E. zonale* selecting against all trichopterans. Feeding activity of the 3 species was largely confined to the daylight hours, and 2 feeding peaks were generally observed for *E. caeruleum* and *E. flabellare:* one in the morning and the other in late afternoon or early evening. Over a 24 hr period, *E. zonale* consumed smaller quantities of food than the other species and exhibited no feeding maxima.

OHIO J. SCI. 77(4): 164, 1977

Through the years a substantial literature has developed on the biology of the darters (Pisces: Percidae), a group of small fishes that are often abundant in eastern American streams. The food habits of a number of darter species have been described (Forbes 1880; Turner 1921; Karr 1963, 1964; Scalet 1972; Mathur 1973) but little is known of the feeding periodicities of darters and the partitioning of food among cohabiting darter species. Mather (1973) reported on the feeding chronology of the black-banded darter, *Percina nigrofasciata,* in Halawakee Creek, Alabama. Studies of the food habits of cohabiting darter and non-darter species have been carried out by Daiber (1956), Braasch and Smith (1967), and Page and Smith (1970, 1971). As interest in the trophic dynamics of flowing water ecosystems increases (Cummins 1974; Small 1975), the need for a more detailed understanding of the feeding relationships of stream fishes becomes apparent since many of these forms prey on the macroinvertebrates involved in the transfer of energy and nutrients from allochthonous organic matter to other consumer species in the stream community. Our study examined the feeding relationships of the following 3 darter species found in Four Mile Creek, Ohio: the rainbow darter, *Etheostoma caeruleum* Storer; fantail darter, *E. flabellare* Rafinesque; and banded darter, *E. zonale* (Cope). The studies were designed to determine the prey organisms utilized by each species and the degree of electivity for or against particular food items.

STUDY AREA, MATERIALS AND METHODS

Four Mile Creek originates in Preble County in southwestern Ohio and flows in a southeasterly direction until its confluence with the Great Miami River at Hamilton, Ohio. The path of the stream is interrupted for 4.3 km by Acton Lake, a 253 ha impoundment located in Hueston Woods State Park. Four Mile Creek is approximately 58.0 km in length, excluding the impounded section, and is characterized by pools with sandy or silty bottoms and riffles and raceways formed by rubble of Ordovician and Silurian origin.

Darters were most abundant in the riffle areas of the stream. A riffle was typically 10–20 m in width, 10–25 cm in depth and 20–30 m in length, with current velocity ranging from 50 to 60 cm/sec. Substrate in the riffles consisted of gravel, pebbles and cobbles, which were often covered with filamentous algae (*Cladophora sp.*). Darters were also observed occasionally in the raceways and pools connecting the riffles.

[1]Manuscript received November 1, 1976 and in revised form April 15, 1977 (#76-84).

[2]Present Address: Lake Erie Junior Nature and Science Center, 28728 Wolf Road, Bay Village, OH 44140.

Field studies were carried out from May 1973 through May 1974. Two riffles above the Acton Lake dam and a third below the dam were sampled once during early summer and once in late summer. A fourth riffle was also selected below the dam for 24 hr studies of feeding periodicity. This area was sampled at 4 hr intervals on 14–15 June 1973, 9–10 November 1973 and 10–11 May 1974. Water temperature was determined with a Celsius thermometer at each collection time on those dates.

Dip nets of various sizes were utilized to capture darters, when seining proved to be ineffective. Wherever possible several representatives (males and females) of all species taken on each collection date were retained for stomach analyses. These were placed in plastic bags and stored on ice to prevent regurgitation of the stomach contents.

Macroinvertebrates available as potential food items were collected with a Surber bottom sampler. One sample was usually taken prior to the collection of the darter species present at each of the 3 stations. Additional samples (n=6) were also taken during the 24 hr study in May 1974. Organisms captured with the Surber sampler were carefully removed from the netting, and refrigerated in stream water until they could be examined.

Macroinvertebrates from each riffle were identified to genus, wherever possible, counted and dried at 105° for 48 hr, and weighed. Relative importance of the various forms at each site was expressed in terms of their dry weights. Darters used for determination of dry weight to wet weight ratios were measured, weighed and dried to constant weight at 60°. Ratios were averaged for all individuals of each species and were utilized to convert the wet weights of fish used for stomach analyses to their corresponding dry weights.

Stomach analyses were carried out on the fish collected in early and late summer and during the 3 studies of feeding periodicity. Total length (mm), wet weight (g) and sex of each fish were recorded prior to the analysis of stomach contents. The stomach was then removed, and the food organisms were separated, identified and counted. Food items were dried, weighed, and each food type was expressed as a percentage of the total dry weight of the stomach contents. Calculated dry weights of the fish taken during the 24 hr studies, along with the total dry weights of their stomach contents, were used to calculate dry wt food (g)/dry wt fish (g).

The percentage importance of each food type in the total dry weight of stomach contents of each species was calculated from the food data for the 4 stations. These percentages, along with similar values for the macroinvertebrates, were then utilized for the Electivity Index (E):

$$E = \frac{(r_i - p_i)}{(r_i + p_i)}.$$

where r_i is the relative content of any ingredient in the ration (as a percentage of the whole ration or as a ratio of the particular part of the ration to the whole), and p_i is the relative value of the same ingredient in the environment (Ivlev 1961). Values of E can range from +1, which indicates positive electivity, to −1, or negative electivity. Electivity values were determined for each food type present as 1% or more by weight of the identifiable stomach contents or of the organisms taken with the Surber sampler.

RESULTS AND DISCUSSION

DIET COMPOSITION. Stomach analyses were carried out on a total of 183 darters. Of these, 147 were taken during the three 24 hr studies. The ranges in total length for *Etheostoma caeruleum*, *E. flabellare* and *E. zonale* were 33–68, 36–64 and 40–61 mm, respectively.

The combined data of darter diets (fig. 1) illustrate the importance of aquatic

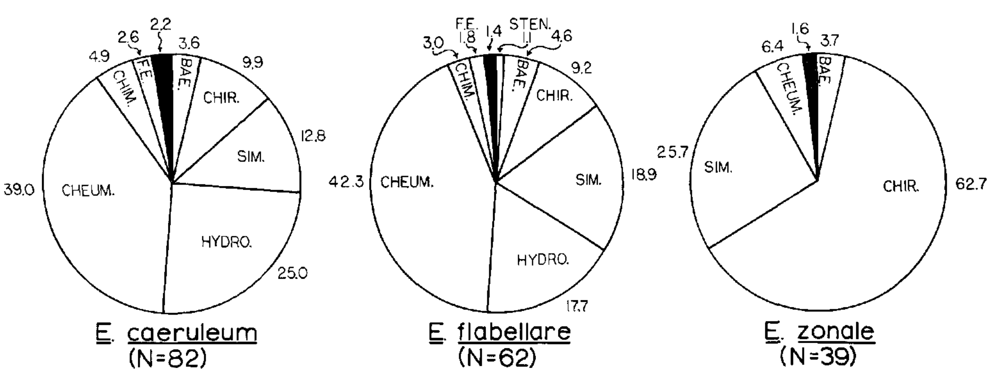

FIGURE 1. Diet composition of 3 darter species collected from Four Mile Creek, May 1973–May 1974. Values, expressed as percentages of the total dry weight of identifiable stomach contents, represent the average for all individuals of each species. BAE. = *Baetis* sp.; STEN. = *Stenonema* sp.; CHIR. = *Chironomidae*; SIM. = *Simulium* sp.; HYDRO. = *Hydropsyche* sp.; CHEUM. = *Cheumatopsyche* sp.; CHIM. = *Chimarra*. sp.; F.E. = Fish eggs; and solid area = others (plecopterans, water mites, nematodes, *Caenis* sp. and larvae and adults of *Stenelmis* sp.).

insects in the diets of all 3 species. Trichoptera such as *Cheumatopsyche* sp. and *Hydropsyche* sp. were taken in large quantities by *E. caeruleum* and *E. flabellare*. The banded darter, *E. zonale*, was more dependent on Diptera as a food source. In fact, chironomid larvae and pupae and *Simulium* sp. comprised about 88% of the total dry weight of stomach contents of *E. zonale*. Ephemeroptera were consumed by all 3 species. The most common representative of this order was *Baetis* sp., though small numbers of *Stenonema* sp. were observed in *E. flabellare*. Fish eggs were taken in small amounts by *E. caeruleum* and *E. flabellare*.

In addition to the major food items shown in figure 1, small quantities (1.1–2.2% of total dry weight of stomach contents) of plecopterans, the ephemeropteran, *Caenis* sp., water mites, larvae and adults of the coleopteran, *Stenelmis* sp. and nematodes were observed occasionally in the digestive tracts of the 3 species. The latter were probably consumed incidentally as internal parasites of the chironomid larvae.

Results of the food habit analyses for *E. zonale* generally agreed with the findings of other investigators (Forbes 1880; Turner 1921). The diets of *E. caeruleum* and *E. flabellare*, however, differed from other accounts in the literature. In an early study, mayfly and midge larvae were found to be the most important foods of rainbow darters greater than 15 mm in length (Turner 1921). Snails and crayfish were also observed in some stomachs. Other studies have shown a preponderance of dipterans (Turner 1921; Karr 1964) and mayflies (Small 1975) in the diet of the fantail darter.

ELECTIVITY INDICES. Several trends in selection for or against certain food items can be observed in table 1. The ephemeropteran, *Baetis* sp., was selected for more than *Caenis* sp. and *Stenonema* sp., the other mayfly species. *Etheostoma caeruleum* and *E. flabellare* selected for Trichoptera and the dipteran, *Simulium* sp.; however, chironomids were selected against. Interestingly, the banded darter, *E. zonale*, showed positive selection for the Diptera but selected against all caddisflies. Each species also showed high selection against *Stenelmis* sp. larvae and adults. Fish eggs were selected for by *E. caeruleum* and *E. flabellare*, but not by *E. zonale*.

Quantitative differences in selection for or against particular food organisms indicate that the factors of prey availability, vulnerability or quality may determine the proportions of various food items in the diets of the darters at any time. These factors apparently influence the foods eaten by some darter species (Fahy 1954; Scalet 1972), though the details of these interactions have not been determined. The availability and vulnerability of the prey items taken by darters

TABLE 1

Electivity indices for 3 darter species collected from Four Mile Creek, May 1973–May 1974.*

Food item	*E. caeruleum*	*E. flabellare*	*E. zonale*
Stenonema sp.	−0.68	−0.61	−1.00
Baetis sp.	0.18	0.05	−0.20
Caenis sp.	—	−0.57	−1.00
Chironomidae	−0.04	−0.35	0.28
Simulium sp.	0.56	0.64	0.36
Hydropsyche sp.	0.06	−0.34	−0.92
Cheumatopsyche sp.	0.11	0.41	−0.33
Chimarra sp.	0.48	0.50	−0.87
Stenelmis sp. (larvae)	−0.79	−0.46	−1.00
Stenelmis sp. (adult)	−0.93	−1.00	−1.00
Fish eggs	0.56	0.12	−0.68

*Values can range from +1 (positive electivity) to −1 (negative electivity).

are probably highly dependent on habitat characteristics such as current velocity, turbidity and temperature, as well as such behavioral traits as drifting, swimming, crawling or burrowing. The latter, which are often periodic in occurrence,

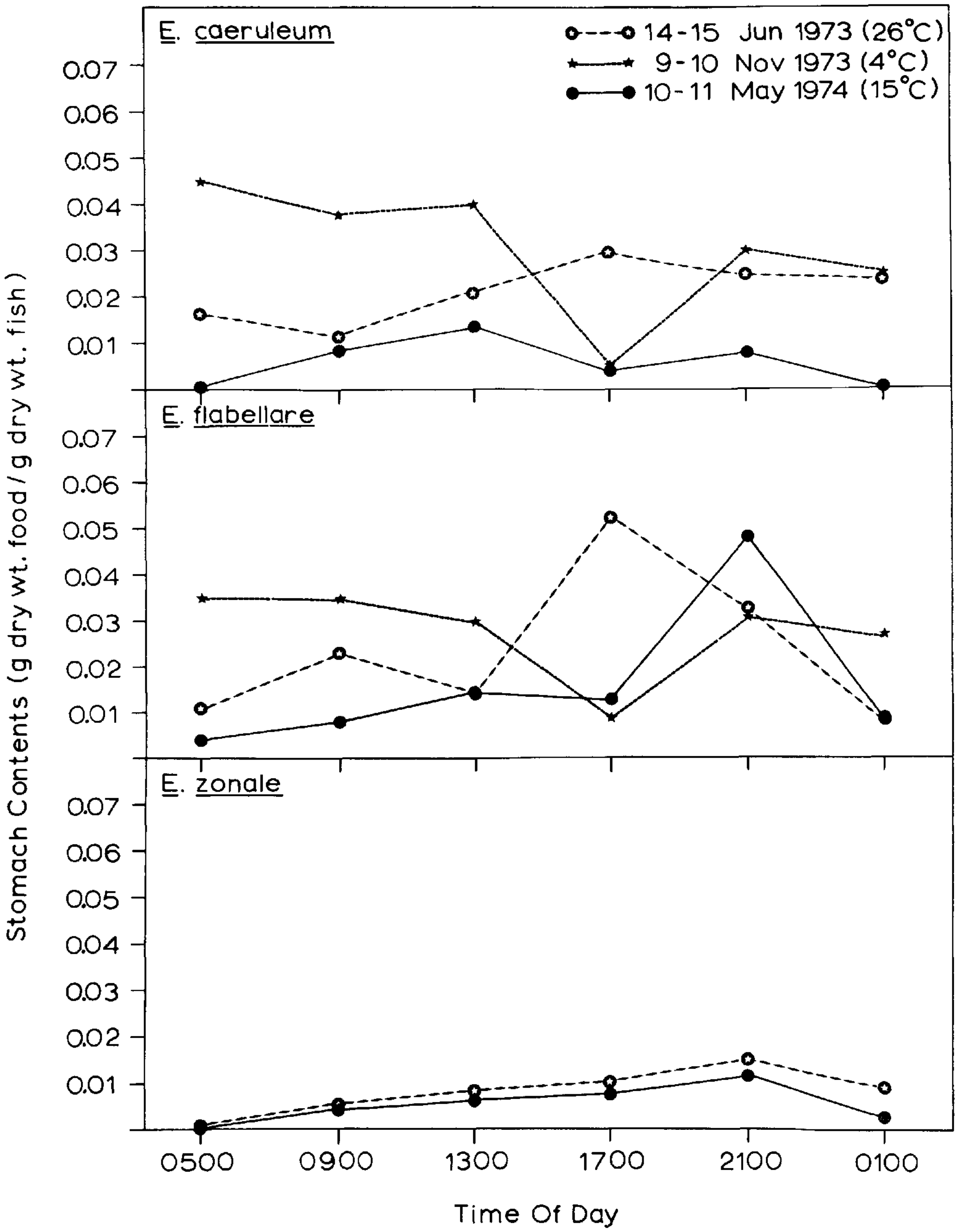

FIGURE 2. Feeding periodicities of *E. caeruleum*, *E. flabellare* and *E. zonale* in Four Mile Creek, 14–15 June 1973, 9–10 November 1973 and 10–11 May 1974. Mean values per g dry wt. food/g dry wt. fish are plotted for 6 collection times (N=3) on each date. Because of the small sample size standard errors of the mean often overlapped and hence were not included. Mean water temperatures are given in parentheses.

are important in the macroinvertebrates of standing and flowing water eocystems (Mundie 1959; Hynes 1970; Waters 1972; Mathur 1973). Food quality may also influence the diet composition of these fishes. Small (1975) has shown recently that food items lacking a hard exoskeleton are consumed more readily by benthic fishes.

FEEDING PERIODICITIES. Variability was observed in the quantities of food in the stomachs of fish taken at 4 hr intervals during the 24 hr studies. This may reflect in part the small sample sizes used to avoid depletion of the darter populations in the riffle. Some interesting trends are apparent, however, in the data (fig. 2). On 14–15 June 1973, the mean dry weight of stomach contents of *E. caeruleum* was lowest at 0900 hr. Thereafter, the quantity of food material in the gut increased steadily, reaching a maximum at 1700 hr. The stomach contents then declined in weight over the evening and early morning hours. On 9–10 November 1973, the food intake of *E. caeruleum* was highest during the morning and early evening hours, with only a small amount of food being observed in the stomachs of fish taken at 1700 hr. Subsequent collections (2100 and 0100 hr) revealed the presence of large quantities of intact food items in the stomachs. The curve for this species on 10–11 May 1974 again suggests a period of feeding in the morning, with a peak occurring at 1300 hr. However, the late afternoon maximum (1700 hr) observed in June 1973 was not apparent.

The data for *E. flabellare* on 14–15 June 1973 suggest early morning and late afternoon feeding activity, with the largest amount of food occurring in the stomachs of fish collected at 1700 hr. A similar feeding chronology has been observed in blackbanded darters, *P. nigrofasciata*, in an Alabama stream (Mathur 1973). The curve for *E. flabellare* on 9–10 November 1973 was similar to that described previously for *E. caeruleum* on the same date. On 10–11 May 1974, this species again exhibited increased feeding activity in early morning and in late afternoon, with a maximum in the dry weight of stomach contents occurring at 2100 hr. Both *E. flabellare* and *E. caeruleum* consumed smaller quantities of food during the May 1974 study than during the studies of June and November 1973.

Etheostoma zonale exhibited no feeding periodicity on 14–15 June 1973 and 10–11 May 1974, though the food material in the stomachs slowly increased during the interval of 0900 to 2100 hr. This species was captured only at 0900 (n = 1) and 1700 hr (n = 2) on 9–10 November 1973. The mean dry weight of food material in the stomachs of these fish was less than 0.01 g/g dry weight. *Etheostoma zonale* consumed much less food over the 24 hr period than did the other species.

The feeding chronology studies indicate that most feeding activity occurs during the daylight hours. Darters appear to be visual feeders, preferring moving food organisms to those that are sedentary or cryptic in their habits (Scalet 1972). The feeding maxima present during each 24 hr study were generally followed by periods in which food intake declined or was replaced by gastric evacuation. The large quantities of food present in the stomachs of *E. caeruleum* and *E. flabellare* during the morning hours of the November, 1973 study may not imply increased food intake so much as a reduced rate of gastric evacuation induced by the low water temperature (4°) recorded in the stream (fig. 2). The gut contents at that time included newly-captured food items, as well as forms in various stages of breakdown. Temperature is known to have a considerable influence on rates of food movement through the digestive tracts of fishes (Windell 1967). However, few published data are available on the effects of temperature on food intake and digestion in the darters. Mathur (1973) reported little winter feeding by *P. nigrofasciata* in Alabama. Braasch and Smith (1967), on the other hand, observed extensive feeding activity in the slough darter, *E. gracile*, during the winter months.

Acknowledgments. We would like to thank H. Adamson, J. Babiarz, S. Graumlick, J. Reitz, N. Sattler and P. Sattler for their assistance in the field. We are also grateful to Dr. R. Kuehne for critically reviewing the manuscript.

LITERATURE CITED

Braasch, M. E. and P. W. Smith 1967 The life history of the slough darter, *Etheostoma gracile* (Pisces, Percidae). Illinois Natur. Hist. Surv. Biol. Notes 74: 1–14.

Cummins, K. W. 1974 Structure and function of stream ecosystems. BioScience 24: 631–641.

Daiber, F. C. 1956 A comparative analysis of winter feeding habits of two benthic stream fishes. Copeia. 1956: 141–151.

Fahy, W. E. 1954 The life history of the northern greenside darter, *Etheostoma blennioides blennioides* Rafinesque. Proc. Elisha Mitchell Sci. Soc. 70: 139–205.

Forbes, S. A. 1880 The food of the darters. Amer. Natur. 14: 697–703.

Hynes, H. B. N. 1970 The Ecology of Running Waters. Univ. Toronto Press, Toronto. 555 p.

Ivlev, V. S. 1961 Experimental Ecology of the Feeding of Fishes. Yale Univ. Press, New Haven, CT. 302 p.

Karr, J. R. 1963 Age, growth, and food habits of the johnny, slenderhead and blackside darters of Boone County, Iowa. Proc. Iowa Acad. Sci. 70: 228–236.

——— 1964 Age, growth, fecundity, and food habits of fantail darters in Boone County, Iowa. Proc. Iowa Acad. Sci. 71: 274–280.

Mathur, D. 1973. Food habits and feeding chronology of the blackbanded darter, *Percina nigrofasciata* (Agassiz), in Halawakee Creek, Alabama. Trans. Amer. Fish Soc. 102: 48–55.

Mundie, J. H. 1959 The diurnal activity of the larger invertebrates at the surface of Lac la Ronge, Saskatchewan. Canadian J. Zool. 37: 945–956.

Page, L. M. and P. W. Smith 1970 The life history of the dusky darter, *Percina sciera*, in the Embarras River, Illinois. Illinois Natur. Hist. Surv. Biol. Notes 69: 1–15.

——— 1971 The life history of the slenderheaded darter, *Percina phoxocephala*, in the Embarras River, Illinois. Illinois Natur. Hist. Surv. Biol. Notes 74: 1–14.

Scalet, C. G. 1972 Food habits of the orangebelly darter, *Etheostoma radiosum cyanorum* (Osteichthyes: Percidae). Amer. Midl. Natur. 89: 156–165.

Small, J. W., Jr. 1975 Energy dynamics of benthic fishes in a small Kentucky stream. Ecology 56: 827–840.

Turner, C. L. 1921 Food of the common Ohio Darters. Ohio J. Sci. 22: 41–62.

Waters, T. F. 1972 The drift of stream insects. Ann. Rev. Entomol. 17: 253–272.

Windell, J. T. 1967 Rates of digestion in fishes, pp. 151–173. *In:* S. D. Gerking ed. The Biological Basis of Freshwater Fish Production. Blackwell Scientific Publ. Oxford (England). 495 p.