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Recommended Citation  
Todd, C. Stan and Stewart, Kenneth W. (1985) "Food habits and dietary overlap of nongame insectivorous fishes in Flint Creek, Oklahoma, a western Ozark foothills stream," Great Basin Naturalist: Vol. 45 : No. 4 , Article 9. Available at: https://scholarsarchive.byu.edu/gbn/vol45/iss4/9

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FOOD HABITS AND DIETARY OVERLAP OF NONGAME INSECTIVOROUS FISHES IN FLINT CREEK, OKLAHOMA, A WESTERN OZARK FOOTHILLS STREAM

C. Stan Todd and Kenneth W. Stewart

ABSTRACT.—Insectivorous fishes were sampled from March, 1983 to February 1984, in Flint Creek, Delaware Co., Oklahoma. There was insignificant habitat segregation between *Etheostoma spectabile* and *E. punctulatum* and seasonal habitat partitioning between *Cottus carolinus* and both darters. Mature *E. spectabile* ate primarily chironomids and mayflies, whereas juveniles fed primarily on microcrustaceans. Mature *E. punctulatum* consumed fewer *Ephemera* and *Leptophlebia* than *E. spectabile*, feeding on *Stenonema* and other crustaceans. Juvenile *E. punctulatum* fed mainly on amphipods and mayflies, and juvenile *E. spectabile* ate primarily microcrustaceans. *Cottus carolinus* elected primarily mayflies in spring-summer and chironomids in January-February. Coefficients of dietary overlap were highest between larger *E. spectabile* and juvenile *E. punctulatum* and lowest between immature *E. spectabile* and mature *E. punctulatum*. Overlap between the two darters was significantly correlated with differences in mean prey size (p<0.0005). Overlap between sizes of *E. spectabile* was also significantly correlated to differences in mean prey sizes. *Etheostoma spectabile* generally preferred smaller prey than *E. punctulatum*. All three species avoided *Stenonema*. *Cottus carolinus* avoided microcrustaceans. The study showed that resource partitioning among these three insectivorous fishes is affected by complex interactions of habitat and prey electivity, and prey size selectivity.


Several factors may influence competition for food between cohabiting fishes. These include primarily: (1) the utilization of different habitats, (2) prey size selectivity, and (3) the selection of specific prey species.

Spatial segregation by stream fishes is difficult to assess, and studies based on seine hauls may be deceptive, since the method of capture potentially disturbs them to the point where their distribution may no longer represent natural activities, or the sampling area is so large that important differences in microhabitat usage are obscured.

The food habits of some darters and sculpins change as they mature (Koster 1937, Bailey 1952, Daiber 1956, Braasch and Smith 1967, Page and Smith 1970, 1971, Scalet 1972, Page 1974, Flynn and Robert 1977, Schenec and Whiteside 1977, Layzer and Reed 1978). This suggests an age-related change in the strategies of food partitioning. Different size classes of a species are often found in different habitats. This potentially reduces both interspecific and intraspecific competition. The selection of different prey or different prey sizes may be influenced by many factors such as morphological, physiological, and behavioral characteristics of both the predator and prey.

Preliminary studies of darter food habits in Flint Creek, Oklahoma, suggested a difference in the magnitude of dietary overlap, depending on the size classes of fishes compared. Although Smart and Gee (1979) separated fish into age groups, most studies have reported indices of overlap without sub-

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1. Study supported in part by National Science Foundation Grants # DEB 78–12565 and # BSR 8309422 and the Faculty Research Fund of NTSU.
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dividing the population into size classes, possibly overlooking some very important aspects of darter ecology.

At times during the life histories of game fishes there may be competition with noneconomic fishes for the available food resources. To better comprehend these relationships, it is necessary to understand the resource requirements of the noneconomic species. In Flint Creek, Delaware County, Oklahoma, insectivorous fishes that are in potential competition with the primary game fish, the smallmouth bass (*Micropterus dolomieu* Lacépede), are the orangethroat darter (*Etheostoma spectabile* Agassiz), the stippled darter (*Etheostoma punctulatum* Agassiz), the banded darter (*Etheostoma zonale* Cope), the fantail darter (*Etheostoma flabellare* Rafinesque), the greensided darter (*Etheostoma blemmioide* Rafinesque), and the banded sculpin (*Cottus caroliniae* Gill).

The food habits and life histories of many darters and sculpins have been studied (Koster 1937, Dineen 1951, Bailey 1952, Braasch and Smith 1967, Page and Smith 1970, 1971, Scalet 1972, Novak and Estes 1974, Page 1974, Flynn and Hoyt 1979, Cordes and Page 1980). Neither the food habits of the orangethroat darter, the stippled darter, or the banded sculpin nor the relationships between these species have been reported. Therefore, the objectives of this study were: (1) to describe the food habits of the three most abundant insectivorous fishes in Flint Creek, Oklahoma, *E. spectabile*, *E. punctulatum*, and *C. caroliniae*; (2) to determine the magnitude of dietary overlap between various sizes of the two darter species and the banded sculpin; (3) to conduct field and laboratory studies to determine if the darters and sculpins of each size class are selecting prey items.

**Materials and Methods**

**Study Area.**—Flint Creek is a third order stream running southeasterly through Delaware County, Oklahoma, to its confluence with the Illinois River. The study area was a 1-km section approximately 4-km upstream from Oklahoma Highway 33. At this point the stream passes through an open valley with occasional riparian trees. The stream consists of many pools separated by as many riffles. The substrate ranges from detritus and silt to gravel and rubble, with gravel being most common. During summer months, a large portion of the stream becomes covered with water willow (*Justicia americana*) and water primrose (*Ludwigia spp.*).

**Habitat Usage.**—Fish were captured monthly from March 1983 to February 1984 using a kick-net placed downstream of habitats to be sampled, with the substrate disturbed to dislodge fish. A total of 50 kick-sets were made monthly in each of four general habitats: (1) open pools, (2) open riffles, (3) pools with submerged and/or emergent cover, and (4) riffles with submerged and/or emergent cover. The standard length in mm was measured for each fish. An analysis of co-dispersion was made incorporating a log-likelihood ratio test. Although sampling efficiencies may have differed in each habitat, an ANOVA was run to test for differences in the average length of each species between the four habitats followed by a Student-Newman-Keuls multiple comparison.

**Stomach Analysis.**—In habitats where two or more species were captured, five fish in as many 10-mm size classes as possible were preserved in 10% formalin for stomach analysis. Roberts and Winn (1962) and Daughtery et al. (1976) found that visual stimuli were necessary for normal feeding responses of darters. Several researchers have found darters to exhibit diurnal feeding patterns, with peak feeding occurring in midday or afternoon, with maximum gut content later in the day (Matthur 1973, Schenec and Whiteside 1977, Layzer and Reed 1978, Cordes and Page 1980, Matthews et al. 1982). Preliminary studies indicated the two darter species under study both fit this pattern; therefore, all fish were captured between 12:00 noon and 5:00 p.m.

Stomach contents of the preserved darters were identified to the lowest possible taxon (genera for most insects). The head capsule width (HCW) of insects or the maximum diameter of other taxa was measured with an ocular micrometer.

**Food Availability.**—Within the same habitats where darters were collected for stomach analyses, three 0.05 m² Hess samples were taken at the same monthly sampling times and preserved in 70% isopropanol for
determination of prey availability. Additional benthic organisms were collected, and their HCW or maximum diameter measured. These organisms were then killed in 4% formalin, immediately dried for 24 hours at 105°C, and their dry weight was measured to the nearest 0.1 mg. Regression lines were developed from these data and were used to estimate the live dry weight of the prey consumed.

Dietary overlap. — Dietary overlap was determined with an index of association CA (Horn 1966) which is calculated:

\[
CA = \frac{2\sum_{i=1}^{s} x_i y_i}{\sum_{i=1}^{s} x_i + \sum_{i=1}^{s} y_i}
\]

where:
- \( s \) = total number of food taxa
- \( x_i \) = proportion of the total diet of species \( x \) taken from taxa \( i \)
- \( y_i \) = proportion of the total diet of species \( y \) taken from taxa \( i \)

This index ranges from 0.0 to 1.0, with a value of 0.0 indicating no overlap, and 1.0 indicating complete overlap. An index of overlap was calculated for both numbers and biomass of each prey taxa.

Prey selection. — A linear index of food selection \( L \) (Strauss 1979) was used. It is calculated:

\[
L_i = r_i - p_i
\]

where:
- \( r_i \) = the relative abundance of item \( i \) in the gut
- \( p_i \) = the relative abundance of item \( i \) in the environment

This index ranges from -1.0 to 1.0, with positive values indicating preference and negative values indicating avoidance and/or inaccessibility. A Students t-test was used to test the null hypothesis of no difference in \( L \) from zero.

An index of selectivity assesses differences in the proportions of a specific prey item in the diet relative to proportions available in the environment. These indices may or may not express actual election or avoidance of a prey item. The real availability of prey items is usually not known; therefore, unavailability may be mistaken as avoidance.

The following experiment was conducted in June 1984 to gain some further insight into selectivity by darters in a situation where no prey had protective cover. Five 18.9-L aquariums were placed in the stream to minimize stress on the darters during the experiment. A selected group of prey, representative of the stream population and in sufficient numbers (\( n = 70 \)) to allow feeding without greatly affecting the proportions of the prey, were counted into the aquariums. Fish were placed in the aquarium after dark as follows: (1) two mature \( E. spectabile \) in each of three aquariums and (2) two mature \( E. punctulatum \) in each of two aquariums. This allowed adjustment to confinement prior to dawn, when normal feeding should begin. The darters were allowed to feed until noon, when they were preserved for stomach analysis.

Size selectivity. — Size selectivity was assessed by comparing mean widths of prey consumed by each species in each size class. A one-way ANOVA followed by a Student-Newman-Keuls multiple range test was used to test for differences in mean widths of prey consumed between different size classes of fishes.

Results and Discussion

Seasonal abundance. — A total of 992 darters and sculpins were captured over the 12-month study period. \( E. spectabile \) was most abundant (\( n = 543 \)), followed by \( C. carolinae \) (\( n = 275 \)), \( E. punctulatum \) (\( n = 157 \)), and \( E. zonale \) (\( n = 17 \)). Their seasonal abundance from March 1983 to February 1984 is illustrated in Figure 1, and numbers of \( E. spectabile \) and \( C. carolinae \) generally followed expected survivorship, except in August when dense macrophytic vegetation may have impaired sampling efficiency. These two species are spring and summer spawners, and their numbers were greatest, as expected, during these periods of recruitment. \( E. zonale \) was low in abundance over the entire year, with the greatest number captured (\( n = 6 \)) occurring in August. The efficiency of seining as a method of sam-
pling darters and sculpins is questionable, because of their ability to avoid capture by hiding under rocks and in crevices. The use of kicknets in this study probably gave a more discrete sample.

Habitat Usage.—An analysis of co-dispersion for *E. spectabile* and *E. punctulatum* revealed no significant habitat segregation. Significant (p<0.05) positive co-dispersion (overlap) was observed in June and September 1983. All values for co-dispersion were positive except in November 1983 and January 1984, when numbers collected were low (19 and 13, respectively).

Areas sampled can greatly affect the results of an analysis of co-dispersion. Small sampling areas tend to give negative values, whereas large sampling areas tend to result in positive values. Kick-netting resulted in a large percentage of kick-sets capturing no fish. The positive values for co-dispersion and a low capture rate suggests that the two darters did not separate themselves on the basis of habitat selection alone.

Similar analyses with *C. carolinae* and both darters showed relatively more habitat segregation between mature banded sculpins and both darters during spring (March, April), with significant negative co-dispersion between *C. carolinae* and *E. punctulatum* in April. Significant (p<0.05) overlap was shown between *C. carolinae* and *E. spectabile* in May, coinciding with the hatching and recruitment of both species. Mature *C. carolinae* were absent from the four habitats sampled from May to September, when juvenile fish were abundant, probably reducing intraspecific and interspecific competition.

On a yearly basis, an ANOVA revealed a significant difference in the average body lengths of both *E. spectabile* and *E. punctulatum* between habitats (p<0.0001), whereas no significant difference in the mean lengths of *C. carolinae* were found. A Student-Newman-Keuls multiple comparison showed *E. punctulatum* with a significantly larger mean length in riffles with submerged and/or emergent cover than in open pools, 62.3 and 43.5 mm, respectively (p<0.05). *Etheostoma spectabile* had a significantly higher mean length in riffles with and without submerged and/or emergent cover (51.6 and 50.3 mm,
respectively) than in pools with and without submerged and/or emergent cover (42.3 and 40.8 mm, respectively) (p<0.05). Although not significant, both species were larger in riffles with submerged and/or emergent cover and pools with submerged and/or emergent cover than in open riffles and open pools, respectively. The presence of different sizes of fishes in different habitats may be important in the reduction of intraspecific competition. Since roughly similar size classes of the two darters were found in similar habitats, the segregation of habitat alone by different size classes probably had little effect on interspecific competition; however, the combination of habitat selection, temporal segregation of spawning times, prey selection, and differences in prey size probably resulted in lowered competition between *E. spectabile* and *E. punctulatum*.

**FOOD HABITS.**—In both darters a major dietary shift could be related to maturation, and therefore separation of fish sizes for discussion of food habits was made on this basis. *Etheostoma spectabile* and *E. punctulatum* were therefore respectively separated into <41 and >40, and <51 and >50 mm sizes (Figs. 2–5).

The stomachs of 244 *E. spectabile* contained 35 different prey taxa. Both juveniles and adults fed heavily on chironomids during winter and early spring (January–March, Figs. 2, 3). Chironomids continued to constitute 16.1%–59.5%, by dry weight, of juvenile fish diets in April to July, as they increased feeding on microcrustaceans and small mayflies (Fig. 2). This shift to planktonic prey items coincided with recruitment of darter fry. In August, diets of these smaller fish were exclusively composed of microcrustaceans, particularly Cladocera and Copepoda, and for the rest of the year microcrustaceans and amphipods continued to make up the major percentages by number and dry weight, into December (Fig. 2). Mayfly nymphs (*Baetis, Stenonema, Ephemerella, Leptophlebia*, and *Caenis*) made up 49.1%–77.3%, by dry weight, of mature *E. spectabile* diets in spring.
Fig. 3. Food habits of *Etheostoma spectabile* >40 mm February 1983 to February 1984.

Fig. 4. Food habits of *Etheostoma punctulatum* <51 mm February 1983 to February 1984.
and early summer until June (Fig. 3), corresponding with the emergence and recruitment of these insects. They were ingested at lower levels for the rest of the summer, and none were eaten by 12 fish in October (Fig. 3). Unlike juveniles, mature fish fed on chironomids at levels less than 11% by dry weight from April to July, and microcrustacea were not present in mature fish guts in late spring and summer in amounts above 3.1% by dry weight (June, August). Amphipods appeared in diets of mature orangethroat darters at levels of 42.5% and 91.0% (dry weight), respectively, in September and October, when ingestion of amphipods generally decreased and chironomid feeding increased in November and December until winter, when chironomids again predominated in guts. Mature fish relied more heavily on larger items such as Baetis, Ephemera, Leptophlebia, Stenonema, and amphipods as these items were available.

Stomachs of 205 E. punctulatum contained 30 different prey taxa. Both classes of E. punctulatum utilized chironomids in the coldest months, January and February (Figs. 4, 5), but relied much less on them in those months, and generally throughout the year, than did E. spectabile (Figs. 2, 3). Feeding by E. punctulatum during these months was less concentrated on chironomids than in E. spectabile, in favor of diverse feeding on mayflies, Asellus, and amphipods (Figs. 4, 5).

Few juvenile E. punctulatum were captured in spring (March-May). The five fed fish taken in March fed almost exclusively on the mayfly Leptophlebia (94.6% by dry wt.), apparently segregating themselves from small E. spectabile that spread their feeding predominately over chironomids (24.3% by dry wt.), Ephemera (18.1%), and Leptophlebia (21.2%). During summer months (June-September) and into November, juvenile stippled darters fed mainly on amphipods and the mayflies Stenonema, Baetis, and Leptophlebia, further suggesting segregation of themselves from smaller E. spectabile that were feeding more on microcrustacea during that time. The single fed immature fish captured in December had only Asellus in the gut (Fig. 4). Mature E. punctulatum showed little pattern in feeding, except in January to March, when chironomids, Leptophlebia, and Ephemera were ingested in high vol-

**Fig. 5.** Food habits of *Etheostoma punctulatum* >50 mm February 1983 to February 1984.
umes (Fig. 5). During these months larger E. spectabile were feeding predominately on chironomids and the mayflies Ephemerella and Leptophlebia. Ingestion of Stenoneuma and miscellaneous organisms was greater and more seasonally distributed (Fig. 5) than in larger E. spectabile (Fig. 3), indicating partitioning of available food resources by the mature fish of both species. The seemingly erratic pattern of prey ingestion (Figs. 4, 5) was generally closely related to the relative abundance of the various prey in the environment.

A few taxa which were not consumed in sufficient numbers to be important items in the annual diet of both darter species composed a large percentage of the diet in months when these items were available. In March 1983 fish eggs made up 25.6%, by dry weight, of the diet of juvenile E. spectabile. In mature fish the following prey made up an important part of the diet: February 1983, Prostoia (12.8%); April 1983, fish eggs (18.3%), Isoperla (5.1%); August 1983, Isomychia (35.4%). The diet of smaller E. punctulatum contained such important prey as: July 1983, Neoperla (16.2%), Stenacron (9.8%); August 1983, Corydalus (61.4%); September 1983, Leptophyes (5.2%). The following items were important at times in the diet of mature E. punctulatum: May 1983, Isomychia (39.1%), oligochaeta (27.3%), Psephenus (8.2%), Aceroneuria (15.2%); June 1983, decapoda (20.8%), Aceroneuria (38.6%), Corydalus (16.4%); July 1983, Neoperla (17.9%), Psephenus (27.9%), decapoda (18.8%); August 1983, Corydalus (47.9%), decapoda (34.2%), Psephenus (13.7%); September 1983, Psephenus (42.4%); October 1983, Argia (15.2%), Corydalus (78.2%); November 1983, Psephenus (86.5%); December 1983, oligochaeta (94.3%).

Two size classes of sculpins were selected with similar reasoning as with the two darter species. These size classes were <71 and >70 mm (Fig. 6).

During the initial months of the study (February–April), it was not known whether sufficient sculpins could be sampled for food habits analysis; therefore, young sculpins were returned to the stream. In the fall, fish were collected for stomach analysis, and 42 specimens were taken during the period Oc-

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Fig. 6. Food habits of *Cottus caroliniae* February 1983 to February 1984.
October 1985  TODD. STEWART: O KLAHOMA FISH  729
tober–February (Fig. 6). Mature fish were not collected in the study area of the stream during May–September, and very few were captured until February, possibly because of migration into unsampled habitats such as deep pools. Therefore, food habits were determined from a relatively small sample of nine fish during February–April 1983 and February 1984 (Fig. 6). While studying the movements of sculpins, Bailey (1952) found that, although they usually remained within a radius of 46 m, some moved up to 144 m from the point of initial capture. Deep pools were always within this range in the study area.

Stomachs of 53 C. carolinae contained 18 prey taxa. Cladocerans, copepods, and ostracods were absent in the diets of both size classes of C. carolinae, suggesting segregation of this species from juvenile E. spectabile during August–December, when the latter fed heavily on these items. Both size classes of C. carolinae fed on Ephemera (47.9% and 38.0%, by dry weight) during February 1983, as did mature E. spectabile (Figs. 3, 6). Mature C. carolinae continued to feed on Ephemera through April, when no juveniles were collected. At this time, mature E. spectabile and E. punctulatum were observed feeding on the mayfly Ephemera (Figs. 3, 5).

In May and July the three small fish collected fed on chironomids (May, 20.0% by dry weight) and small mayflies, Stenonema (May, 80.0%), and Leptophlebia (July, 53.7%) (Fig. 6); in July Hydroptila was also taken (46.3%). During October and November small mayflies such as Baetis (0.7% and 15.8%, respectively, by dry weight) were taken, with large numbers of Psephenus (2.5%), decapods (63.2%), and Corydalus (29.8%) in October. In November Corydalus (59.0%) and Psephenus (16.6%) made up a large percentage of the diet. Heavy feeding by small C. carolinae on chironomids was observed in January (56.0%), increasing to 97.5%, by dry weight, in February (Fig. 6). Although the larger size class consumed some chironomids in this month, Asellus made up 91.3% of the diet of the mature fish (Fig. 6). Only mature E. punctulatum also fed on Asellus at this time in amounts higher than 2 percent (Fig. 5).

Dietary overlap.—Monthly values for dietary overlap between different size classes of darters and sculpins were highly variable, ranging from 0.00 to 0.99 for numeric data and 0.00 to 0.97 for dry weight data (Table 1). Based on numeric data, the lowest average monthly overlap value was between immature E. spectabile and mature E. punctulatum (0.22), whereas the highest average monthly overlap value was between larger E. spectabile and juvenile E. punctulatum (0.45). Variations in monthly overlap values may be attributed to differences in prey availability, gape size differences, or differences in prey size. No significant correlation between overlap values and prey availability, or differences in gape were shown; however, a significant (p<0.0005) correlation between the difference in mean prey sizes of the groups being compared and overlap values was found. This indicates that prey size selection is important in regulating possible competition for food between these insectivorous fishes in Flint Creek.

Indices of dietary overlap between the two size classes of E. spectabile were significantly correlated (p<0.05) to the difference in the mean size of prey selected by the two groups. Although mean prey size selection may be important in reducing intraspecific competition for E. spectabile, the indices of dietary overlap between the two size classes of E. punctulatum were not correlated with the differences in the mean prey size selected by the two size classes. This suggests that the regulation of dietary overlap between the two size classes of E. punctulatum is dependent on some factor besides prey size, such as actual selection of specific prey items.

Dietary overlap was generally high (.81–.99) only between small banded sculpins and both classes of the orangemouth darters in January–February 1984, since both species fed heavily on chironomids (Table 1). Overlap values between the banded sculpin and E. punctulatum were generally low. A value of .96 by number, .93 by dry weight (Table 1), however, was found in January between juvenile C. carolinae and mature E. punctulatum, when both species were feeding on chironomids.

SIZE SELECTIVITY.—The selection of prey on the basis of size is important in the partitioning of Flint Creek food resources by orangemouth and stippled darters. During most
months there were significant differences (p<0.05) in the mean prey widths selected by *E. spectabile* and *E. punctulatum* (Table 2). Also, during many months there were significant differences in prey widths selected by the different size classes of each darter species (Table 2). Differences in morphology may be partially responsible for these differences. *Etheostoma punctulatum* has the larger gape of the two species. However, in both species the mean prey size selected was not significantly correlated with gape size (p>0.05). In months when *C. carolinae* were sampled for stomach analysis, the size of prey selected by this species was generally similar to that consumed by immature *E. punctulatum*. During January and February 1984, when both *C. carolinae* and *E. spectabile* were electing chironomids, prey size for these two groups were similar, possibly indicating a period of higher competition.

**Selectivity.**—For each class of fishes, monthly electivitiy for particular prey items were variable; however, some trends are evident (Figs. 2–6). All classes of fishes avoided *Stenelmis*. A preference for specific prey items coincided with months when those prey items were abundant. *Etheostoma spectabile* generally preferred smaller items such as cladocerans and chironomids, whereas *E. punctulatum* generally preferred larger items such as mayflies, *Corydalis*, decapods, and oligochaetes. *Cottus carolinae* showed negative selection for microcrustaceans such as *os*.
Table 2. Mean prey size (mm) of different size classes of *Etheostoma spectabile*, *E. punctulatum*, and *Cottus carolinae* from February 1983 to February 1984.

<table>
<thead>
<tr>
<th>Month</th>
<th><em>E. spectabile</em> immature</th>
<th><em>E. spectabile</em> mature</th>
<th><em>C. carolinae</em> immature</th>
<th><em>C. carolinae</em> mature</th>
<th><em>E. punctulatum</em> immature</th>
<th><em>E. punctulatum</em> mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb</td>
<td>—</td>
<td>0.74</td>
<td>—</td>
<td>1.40</td>
<td>1.14</td>
<td>1.45</td>
</tr>
<tr>
<td>Mar</td>
<td>0.54</td>
<td>0.67</td>
<td>—</td>
<td>1.29</td>
<td>1.31</td>
<td>1.35</td>
</tr>
<tr>
<td>Apr</td>
<td>0.28</td>
<td>0.92</td>
<td>—</td>
<td>1.47</td>
<td>—</td>
<td>1.38</td>
</tr>
<tr>
<td>May</td>
<td>0.11</td>
<td>0.36</td>
<td>0.98</td>
<td>—</td>
<td>—</td>
<td>2.30</td>
</tr>
<tr>
<td>Jun</td>
<td>0.13</td>
<td>0.68</td>
<td>—</td>
<td>—</td>
<td>0.84</td>
<td>1.49</td>
</tr>
<tr>
<td>Jul</td>
<td>0.23</td>
<td>0.55</td>
<td>0.55</td>
<td>—</td>
<td>0.93</td>
<td>2.14</td>
</tr>
<tr>
<td>Aug</td>
<td>0.07</td>
<td>0.65</td>
<td>—</td>
<td>—</td>
<td>0.83</td>
<td>2.73</td>
</tr>
<tr>
<td>Sep</td>
<td>0.21</td>
<td>0.35</td>
<td>—</td>
<td>—</td>
<td>0.36</td>
<td>1.66</td>
</tr>
<tr>
<td>Oct</td>
<td>0.19</td>
<td>0.58</td>
<td>1.33</td>
<td>—</td>
<td>0.80</td>
<td>1.37</td>
</tr>
<tr>
<td>Nov</td>
<td>0.08</td>
<td>0.25</td>
<td>1.41</td>
<td>—</td>
<td>0.82</td>
<td>2.63</td>
</tr>
<tr>
<td>Dec</td>
<td>0.05</td>
<td>0.19</td>
<td>—</td>
<td>—</td>
<td>1.15</td>
<td>1.47</td>
</tr>
<tr>
<td>Jan</td>
<td>0.24</td>
<td>0.39</td>
<td>0.36</td>
<td>—</td>
<td>0.81</td>
<td>0.52</td>
</tr>
<tr>
<td>Feb</td>
<td>0.32</td>
<td>0.38</td>
<td>0.30</td>
<td>1.21</td>
<td>0.54</td>
<td>0.89</td>
</tr>
</tbody>
</table>

tracods and cladocerans, preferring mayflies, oligochaetes, and decapods.

Several researchers have suggested that changes in the diets of darters occur in response to changing prey densities (Braasch and Smith 1967, Page and Smith 1971, Page and Burr 1976, Schenck and Whiteside 1977). The results of this study support this conclusion. However, changes in either morphology or behavior, or both, as darters mature may also contribute to shifts in the diet. For example, the greater and more seasonally distributed ingestion of *Stenonema* and other miscellaneous organisms by mature *E. punctulatum* (Fig. 5) than by mature *E. spectabile* (Fig. 3), and other instances of positive electivity (Figs. 2-5), cannot be totally rationalized on the basis of those food items becoming more available at certain times.

In-stream aquaria experiments.—A group of natural prey, totaling 70 individuals in each aquarium, was used for assessing darter selectivity under the condition of no protective cover. Specific potential prey and their predetermined compositions (by number) were *Chemumatopsycye* (14.3%), *Atherix* (28.6%), *Neoperla* (28.6%), *Stenelmis* larvae (7.1%), *Psephenus* (7.1%), *Isonychla* (7.1%), and *Stenonema* (7.1%). Under these conditions in June 1984, prey selection by the mature fish of each species generally corroborated selectivity indices calculated from field studies in June 1983. Positive election for mayflies and negative selection for *Psephenus* continued. Both species continued to avoid *Stenelmis*, and none were consumed. *Atherix*, which was not abundant in the stream in June 1983, was also completely avoided. *Etheostoma spectabile* had a higher selectivity index for *Chemumatopsycye* (.11) and *Neoperla* (.13) than in the field studies (.01 and -.00, respectively). *Etheostoma punctulatum* also showed a higher index for *Neoperla* (.21) than in the field (-.00). The inaccessibility of *Chemumatopsycye* and *Neoperla*, because of their cryptic nature and the fact that the experimental array of prey was not exactly the same as in the field, may have resulted in altered electivities.

Conclusions

Several factors influence the degree of overlap in the diet of cohabiting fishes. Differences in the diets of *E. spectabile*, *E. punctulatum*, and *C. carolinae* in Flint Creek, Oklahoma, are related to a complex of factors, including the utilization of different habitats, prey size selection, and the selection of specific prey items.

The absence of mature *C. carolinae* during the summer and fall suggests their movement into unsampled areas, thereby exhibiting habitat partitioning. Analyses of co-dispersion further revealed partitioning of habitat between the banded sculpin and both darters during months when mature sculpins were captured in the study area. Habitat partitioning probably reduces both intraspecific and interspecific competition.

An analysis of co-dispersion between the two darters showed no habitat segregation; however, different lengths of both darter species were found in different habitats. This not
only may reduce intraspecific competition, but, together with temporal segregation of spawning times, may reduce interspecific competition.

The selection of prey on the basis of size was found to be an important factor in explaining overlap in the diets of insectivorous fishes. Other researchers have shown prey size to be consistent with gape (Northcote 1954, Daiber 1965, Matthews et al. 1982), and the results of this study support this. However, no correlations between mean prey size and gape were found. No significant (p<0.05) correlation was found between differences in gape and dietary overlap between corresponding fish groups. This suggests that gape may be important in prey size range, but other ethological or morphological factors are involved in the determination of the degree of dietary overlap between species. The selection of prey on the basis of size may reduce both intraspecific and interspecific competition. Although difference in dietary overlap between age groups of _E. spectabile_ are correlated with differences in mean prey size, differences in dietary overlap between age groups of _E. punctulatum_ and mean prey size are not.

_Etheostoma spectabile_ generally fed upon smaller prey than _E. punctulatum_. Although the selection of prey items may be due to the election of a specific prey size, some selection of specific prey items regardless of size was noted. Both species selected prey at times when the particular item was abundant.

The management of stream game fishes is dependent on a knowledge of the species to be managed and their potential competitors. The resources available for management are dependent on the entire food web in the stream, and the resource requirements of noneconomic fishes are often overlooked, obscuring an important factor in total stream management. This study reveals food and potential habitat resource use by, and interactions between, nongame fishes in an Ozark stream. These findings not only provide new basic knowledge for these fishes, but they should be helpful reference data for future assessments of resource use, partitioning, and consequent development of management strategies for stream fishes.

**Acknowledgments**

We thank M. R. Ernst, who accompanied the authors on sampling trips and assisted in collections.

**Literature Cited**


October 1985

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