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Food Habits and the Utilization of Drift Organisms by Larval Fishes in the Middle Fork of Drake's Creek, Kentucky

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FOOD HABITS AND THE UTILIZATION OF DRIFT ORGANISMS BY LARVAL FISHES IN THE MIDDLE FORK OF DRAKE'S CREEK, KENTUCKY

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Master of Science

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Shirley Kaye Timbrook May, 1983 48 pages
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Food habits of larvae of the northern hog sucker, common shiner, rosyface shiner, and *Micropterus* sp. from the Middle Fork of Drake's Creek, Kentucky were identified from 18 March to 12 August 1982. Eighteen taxa of animals were observed in the stream drift and a total of seventeen taxa, including larval fish, were identified in the stomach analysis. Eggs, rotifers, hydracarina, and diptera represented the greatest component of the drift comprising 34%, 32%, 8%, and 6%, respectively. The major organisms observed in the gut analysis included eggs (fish, rotifer, and copepod species), rotifers (*Euchlanis* sp.), diptera (Chironomidae), annelida (Naididae), copepoda (cyclopoids), and cladocera (*Alona*, *Camptocercus*, and unknown spp.). The northern hog sucker had the most diverse diet ingesting 15 different taxa, whereas the rosyface shiner consumed only 8 taxa. Rosyface shiners selected for rotifers in their diet during their first four weeks of life and dipterans during the last two weeks as larvae (Ivlev's Electivity Index). Common shiners selected for a greater variety of organisms during their first week while selecting only for dipterans during their last week. Northern hog suckers selected annelids, dipterans, and copepods throughout their larval period. *Micropterus* sp. selected rotifers, annelids, cladocerans, and copepods during their first two weeks and annelids, cladocerans, and

copepods during their last four weeks as larvae. Piscivory was observed in *Micropterus* sp. during the third week of life with 12% of the meta-larvae consuming other larvae. With the exception of *Micropterus* sp., larvae ingested progressively more taxa as they developed from pro- to meta-larvae. The greatest percentage of empty stomachs in all species was observed in the pro-larvae and the fewest in the meta-larvae. Likewise, the rosyface shiner had the greatest percentage of empty stomachs of the four major species studied.

Even as larvae, the four species studied demonstrated resource sharing and positive interrelationships in their food habits.

INTRODUCTION

Feeding behavior and food habits of fishes have long been of interest to fishery investigators. Such studies provide an understanding of the complex interrelationships of cohabiting fish species in their utilization of stream resources. Relatively few reports, however, have dealt with the feeding habits of larval freshwater stream fishes.

It has been suggested that size-selection predation by larval fish occurs within the morphological limits imposed by mouth size (Northcote 1954, Wong and Ward 1972) and that as mouth size increases with larval fish development there is a selection toward increased prey size (Hartman 1958). Mendelson (1975), however, noted that diet composition may be the result of pressures from others at the same trophic level, and Werner (1979) found that there is a partitioning of food between sympatric fishes. Larkin (1956) in his review of various literature on dietary interrelationships among freshwater fishes concluded that they exercise flexibility in choosing their diets as a result of sharing many available resources, including food, with other species.

The objectives of this study were aimed at identifying the composition of the drift, determining the food habits of the northern hog sucker (*Hypentelium nigricans*), the rosyface shiner (*Notropis rubellus*), the common shiner (*Notropis cornutus*), and *Micropterus* sp., describing the role of drift organisms in the early feeding of fishes, and compiling information on how diet was affected by food availability and other species of fishes in the stream. The four species above were chosen for study because of their interaction in occupying similar habitats as larvae (Floyd 1983).

STUDY AREA

The Middle Fork of Drake's Creek is a spring-fed stream which arises in Sumner County, Tennessee and flows 33.8 km in a northwesterly direction through Simpson, Allen, and Warren County, Kentucky where it converges with the Trammel Fork and the West Fork to form Drake's Creek (Figure 1). The creek courses through mildly karstic topography characteristic of south central Kentucky. The substrate is chiefly bedrock with intermittent riffle areas of gravel and rubble separating long pools of moving water. Following heavy rains the Middle Fork of Drake's Creek, as well as other streams in the drainage, is subject to a rapid increase in flow rate and water depth but returns to a more normal seasonal flow within a few days.

In this study, two stations were designated at the ford 0.8 km south of Drake, Kentucky, 3.6 km upstream from the mouth of the Middle Fork (Figure 2). Station I was located midstream 4.3 m between the northeast bank and a shoal area and consisted of a hard clay-silt substrate. Station II was situated at the ford 230 m downstream from Station I. It was located midstream 6.5 m between the east and west banks and consisted of a bedrock-hard clay substrate.

During the study period stream flow ranged from 79 cm/sec in March to 10.5 cm/sec in July. Dissolved oxygen concentrations averaged 10.9 mg/l in March decreasing an average of 0.95 mg/l each month thereafter to a minimum of 7.1 mg/l in July. Water depths ranged from a minimum of 25.0 cm and 22.5 cm in July to a maximum of 109.0 cm and 105.0 cm in April at Stations I and II, respectively. However, on at least two occasions in April, the

Figure 1. Map of the Drake's Creek Drainage. The asterisk indicates the collection site on the Middle Fork of Drake's Creek.

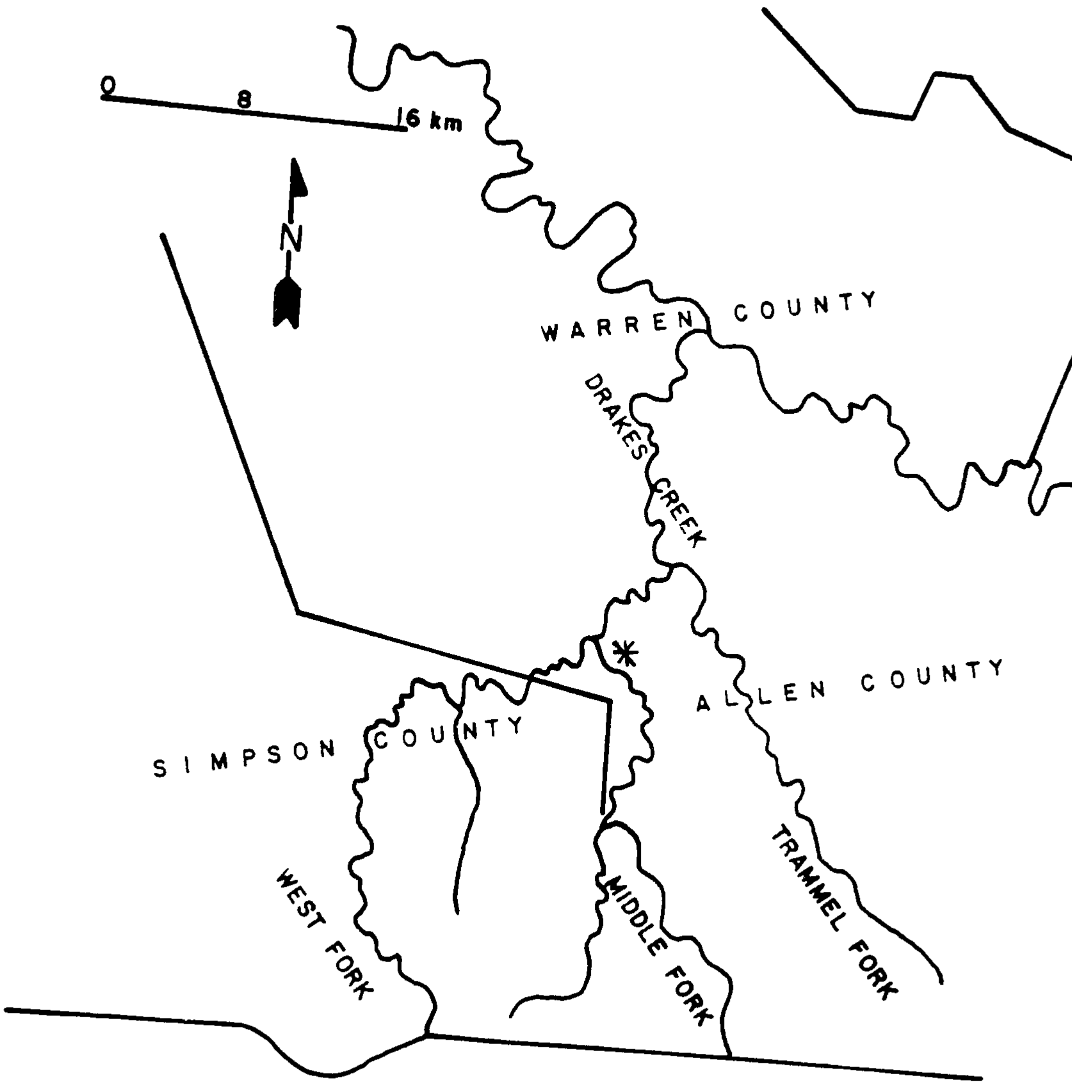
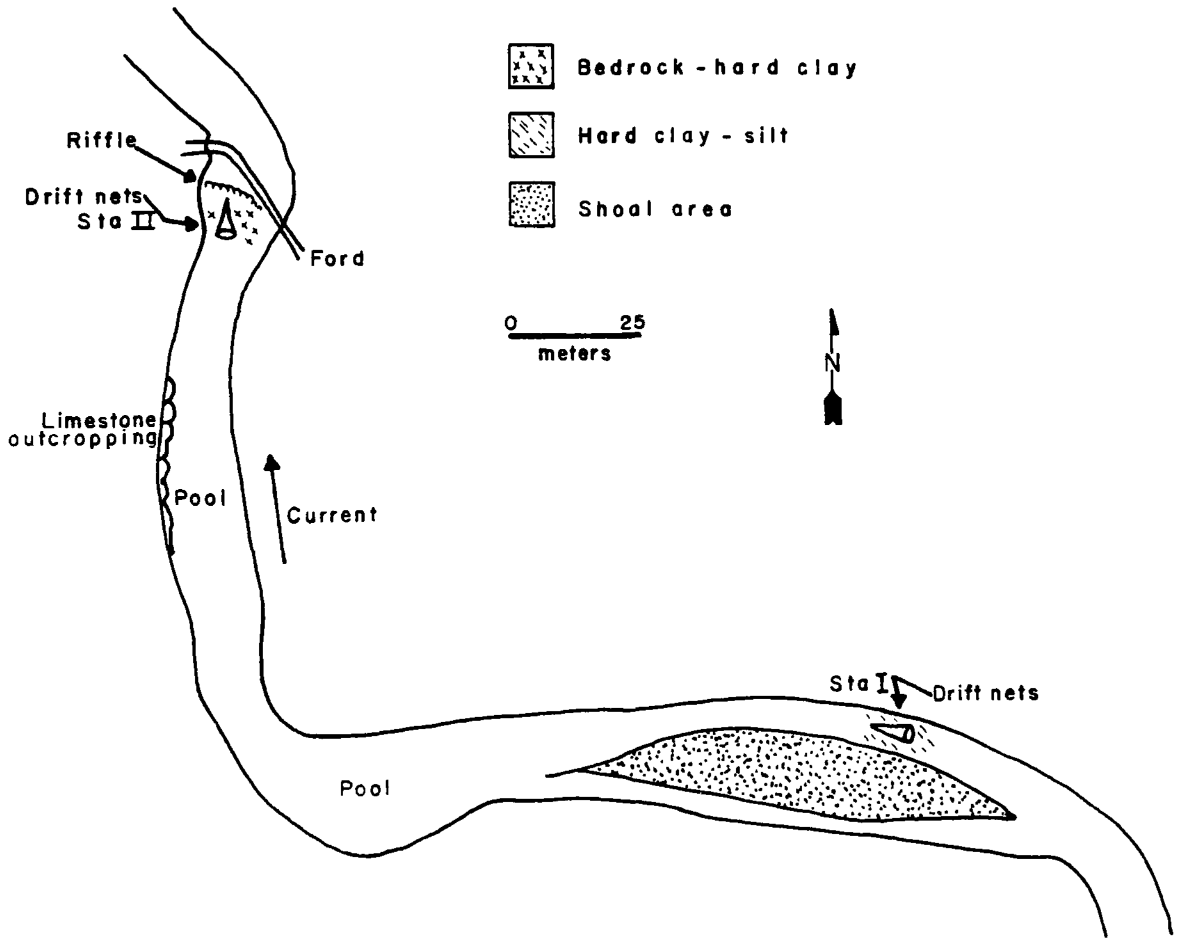

0
8
16 km
N
WARREN COUNTY
DRAKES CREEK
ALLEN COUNTY
SIMPSON COUNTY
WEST FORK
MIDDLE FORK
TRAMMEL FORK

Figure 2. Stream study area of the Middle Fork of Drake's Creek, Kentucky showing Stations I and II.


Bedrock - hard clay
Hard clay - silt
Shoal area
Riffle
Drift nets
Sta II
Ford
0 25
meters
N
Limestone
outcropping
Pool
Current
Sta I
Drift nets
Pool

stream rose substantially above the 109.0 cm mark and actual depths could not be recorded because of the extremely high water level and rapid current flow in the stream.

METHODS AND MATERIALS

Drift zooplankton and larval fish collections were made twice weekly from 18 March 1982 through 12 August 1982. Both drift collections and fish samples were taken approximately one hour after analytical sunset.

Drift samples were taken with two 1 m long, 15 cm aperature plankton nets having 0.076 mm mesh. The nets were positioned one above the other on a pair of metal rods anchored in a cement base. Drift samples were of five minute duration at each station site. Larval fish were collected with light traps and with a 3 m long, 0.5 m aperature, conical ichthyoplankton net of 0.5 mm mesh. Light traps were placed in specific habitat areas having minimum current including rooted undercut banks, rock outcroppings and drift-log obstructions while the ichthyoplankton net was placed facing into the current. The light traps were set for 40 minutes while the ichthyoplankton net was set for 5 minutes.

Upon collection, larval fish were immediately fixed in 5% formalin. Drift zooplankton was filtered through a number 20 silk bolting cloth (0.076 mm) and diluted to 40 ml with water to which was added 10 ml of Lugol's Solution. Larval fish were identified using keys of May and Gasaway (1967) and Hogue et al. (1976). Developmental phases (modified from Snyder 1976) were defined as pro-larvae - caudal fin rays not yet apparent; meso-larvae - at least one distinct caudal fin ray apparent but pelvic buds not apparent; meta-larvae - pelvic buds or fins apparent but preanal finfold not entirely absorbed. Five 1 ml samples from each of the four 50 ml drift collections taken on each trip were counted and the organisms identified using keys of Eddy and Hodson (1970), Peterson (1973), and Pennak (1978). The number of drift organisms per cubic meter of water sampled was determined by averaging the number of organisms from both sampling nets and dividing that number by the volume of water sampled. The volume of water sampled by the drift nets was determined with the aid of a digital flowmeter and the formula

$$\frac{\pi \text{ x (net diameter in meters)}^2}{4} \text{ x } \frac{\text{flowmeter revolutions x 51020}}{999,999} \text{ x time}$$

Temperature (degrees Celsius) and dissolved oxygen concentration (mg/l) were determined with a YSI oxygen meter.

Larval and juvenile fishes were randomly selected from each of four species including the northern hog sucker, *Micropterus* sp., the common shiner, and the rosyface shiner. Specimens from each of the pro-larval, meso-larval, and meta-larval developmental stages were chosen for gut analysis for each of the four species. The total length of each fish was recorded to the nearest 0.5 mm with a standard ruler and the gut excised and measured. Contents from the entire digestive tract were removed and permanently mounted in a toluene-butyl acetate-nitrocellulose resin. All food organisms were counted under 600x magnification and identified to genus where possible. Computations of mean numbers of organisms per gut were based on stomachs with and without food. Selection of available food in the environment by fish larvae was determined by use of the quantitative index of electivity, "E", described by Ivlev (1961). The electivity index followed the formula

$$E = \frac{r_i - p_i}{r_i + p_i}$$

where E = electivity (selectivity)

r_i = % composition of plankter i in the ration (gut contents)

and p_i = % composition of plankter i in the food complex (plankton)

"E" values for each major food group occurred within the limits of +1 and -1, the former value indicating complete positive selection and the latter complete rejection of a food item.

RESULTS

Stream Drift - Eighteen taxa of organisms, in addition to algae, were observed in the stream drift (Table 1). Inter- and intra-station comparisons of drift organisms (Students t, $P > 0.05$) showed no significant difference between the two drift net collections at either station or between stations (Appendix I). Drift organisms were represented primarily by seven groups: eggs (34%), rotifers (32%), hydracarina (8%), dipteran larvae (6%), annelids (2%), copepods (2%), and cladocerans (1%). During the study period, 29 April through 29 July, eggs averaged 250/m^3 and constituted 20% to 57% of the total drift component (Table 2). Rotifers exhibited two peaks of abundance, 29 April to 6 May and 21 June to 1 July, during which they averaged 1065 organisms/m^3, or 69% of the total. By 29 July, rotifers had decreased to only 3% of the total. Hydracarina increased from 1% on 29 April to 10% on 3 June, reached a maximum of 28% from 7 June to 17 June, then declined to 12% on 29 July. Diptera showed no marked change in percent composition (1%) throughout the study period. Annelids ranged from 0.5% to 5%. Copepods represented no more than 8% of the total throughout the study while cladocerans ranged from 22/m^3 (3%) on 1 June to a high of 111/m^3 (12%) from 5 July to 15 July.

Stomach Analyses - The number of stomachs examined among the four species included 226 northern hog suckers, 151 *Micropterus* sp., 103 common shiners, and 107 rosyface shiners (Table 3). Rosyface shiners and common shiners exhibited the greatest percentages of empty stomachs with 54% and 42%,

TABLE 1. Drift organisms observed in the Middle Fork of Drake's Creek, Kentucky from 18 March through 12 August 1982.

EGGS:
- Pisces
- Rotatoria
- Copepoda
- Unidentified

GASTROTRICHA

ROTATORIA:
- *Asplanchna*
- *Brachionus angularis*
- *Brachionus calyciflorus*
- *Brachionus furculatus*
- *Brachionus havanaensis*
- *Cephalodella*
- *Euchlanis*
- *Filina longiseta*
- *Kellicottia longispina*
- *Keratella cochlearis*
- *Keratella quadrata*
- *Keratella* sp.
- *Lecane*
- *Lepadella*
- *Monostyla*
- *Mytilina*
- *Notholca*
- *Philodina*
- *Platyias patulus*
- *Polyarthra*
- *Pompholyx*
- *Trichotria*
- Unidentified spp.

NEMATODA

NEMATOMORPHA

TARDIGRADA

ANNELIDA:
- Oligochaeta:
  - Naididae
  - Unidentified

ALGAE

CLADOCERA:
- *Alona*
- *Bosmina longirostris*
- *Bosmina* spp.
- *Camptocercus*
- *Ceriodaphnia*
- *Daphnia galeata*
- *Daphnia longispina*
- *Daphnia pulex*
- *Diaphanosoma*
- Unidentified spp.

NAUPLII

COPEPODA:
- Calanoida
- Cyclopoida
- Harpacticoida:
  - *Canthocamptus*
- Unidentified

HYDRACARINA
- Hydrachnidae
- Unidentified

COLLEMBOLA

PLECOPTERA:
- Chloroperlidae
  - *Allocapnia*
- Perlidae
- Unidentified

EPHEMEROPTERA

HEMIPTERA

TRICHOPTERA

COLEOPTERA:
- Hydrophilidae
- Unidentified

DIPTERA:
- Chironomidae
- Heleidae
- Simuliidae
- Tabanidae

TABLE 2. Relative prey density (organisms/m^3) of the seven major plankton groups collected in the Middle Fork of Drake's Creek, Kentucky from 29 April through 29 July 1982.

	Organisms/m^3						
T A X A	29 Apr-6 May	10 May-20 May	31 May-3 Jun	7 Jun-17 Jun	21 Jun-1 Jul	5 Jul-15 Jul	29 Jul
EGGS	308	367	376	130	331	435	138
ROTATORIA	1062	423	96	70	1068	151	14
ANNELIDA	25	33	14	6	14	5	24
CLADOCERA	57	53	22	30	68	111	52
COPEPODA	7	24	23	4	4	34	36
HYDRACARINA	17	19	68	126	32	26	53
DIPTERA	1	19	9	0	1	23	10

TABLE 3. Number of digestive tracts examined and the number of empty tracts observed in each developmental stage for *Hypentelium nigricans*, *Micropterus* sp., *Notropis cornutus*, and *Notropis rubellus*.

SPECIES	EXCISED TRACTS				EMPTY TRACTS			
	Total	Pro	Meso	Meta	Total	Pro	Meso	Meta
Hypentelium nigricans	226	36	116	74	42(19%)	25(69%)	17(15%)	0(0%)
Micropterus sp.	151	0	75	76	4(3%)	*	4(5%)	0(0%)
Notropis cornutus	103	34	35	34	43(42%)	33(97%)	8(23%)	2(6%)
Notropis rubellus	107	43	34	30	58(54%)	30(70%)	19(56%)	9(30%)
Totals	587	113	260	214	147(25%)	88(78%)	48(18%)	11(5%)

* No pro-larvae were collected for *Micropterus* sp.

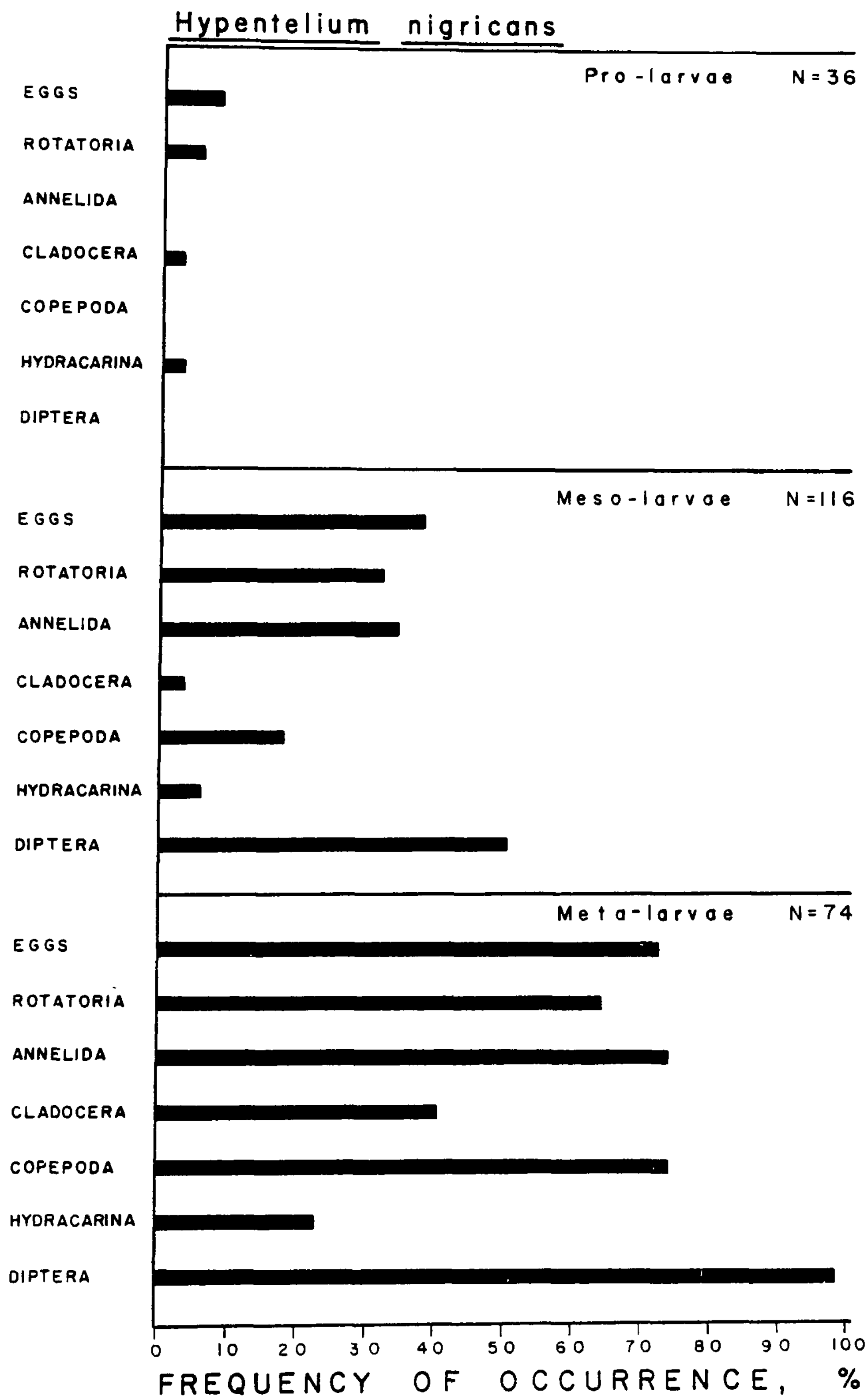
respectively, while the northern hog suckers and *Micropterus* sp. had only 19% and 3%, respectively. The greatest percentage of empty stomachs in all species was observed in the pro-larval and the fewest in the meta-larval stages. In the stomach analysis, a total of 17 taxa, including larval fish and algae, were identified among the four larval species. The major prey groups observed included eggs (fish, copepod, and rotifer species), rotifers (*Euchlanis* sp.), diptera (Chironomidae), annelids (Naididae), copepods (cyclopoids), and cladocerans (*Alona*, *Camptocercus*, and unknown species) (Table 4). The northern hog sucker had the most diverse diet ingesting 15 different taxa (Tables 1 & 4). *Micropterus* sp. (Tables 1 & 4) and the common shiner (Tables 1 & 4) consumed 13 and 11 taxa, respectively, while the rosyface shiner (Tables 1 & 4) ingested 8 taxa. However, rosyface shiners contained prominent algal masses in their stomach contents.

Pro-larvae - Most pro-larval representatives of the four species studied (78%) contained yolk material in the digestive tract with no food organisms (Table 3). However, some pro-larval specimens of each species, with the exception of *Micropterus* sp. which had no pro-larval representatives, contained food organisms in addition to yolk. The maximum total lengths of pro-larvae containing yolk were 14.75 mm, 6.50 mm, and 6.00 mm for the northern hog sucker, the rosyface shiner, and the common shiner, respectively. Thirty-one percent of pro-larval northern hog suckers ingested four groups of food organisms including eggs, rotifers, cladocerans, and hydracarina (Figure 3). Rosyface shiner pro-larvae

TABLE 4. Food items and taxa of organisms observed in the stomach contents of *Hypentelium nigricans*, *Micropterus* sp., *Notropis cornutus*, and *Notropis rubellus*.

FOOD/PREY TAXA	FISH TAXA			
	Hypentelium nigricans	*Micropterus* sp.	*Notropis cornutus*	*Notropis rubellus*
EGGS	+	+	+	-
GASTROTRICHA	-	-	+	-
ROTATORIA	+	+	+	+
NEMATODA	+	-	+	-
ANNELIDA	+	+	+	+
ALGAE	+	+	+	+
CLADOCERA	+	+	+	+
NAUPLII	+	+	+	-
COPEPODA	+	+	+	+
HYDRACARINA	+	+	+	+
COLLEMBOLA	+	-	-	-
PLECOPTERA	+	+	-	-
EPHEMEROPTERA	+	-	-	+
COLEOPTERA	+	+	-	-
DIPTERA	+	+	+	+
NEUROPTERA	+	+	-	-
PISCES	-	+	-	-

Figure 3. Percentage frequency of occurrence of various food organisms in the digestive tracts of *Hypentelium nigricans* during three developmental stages.

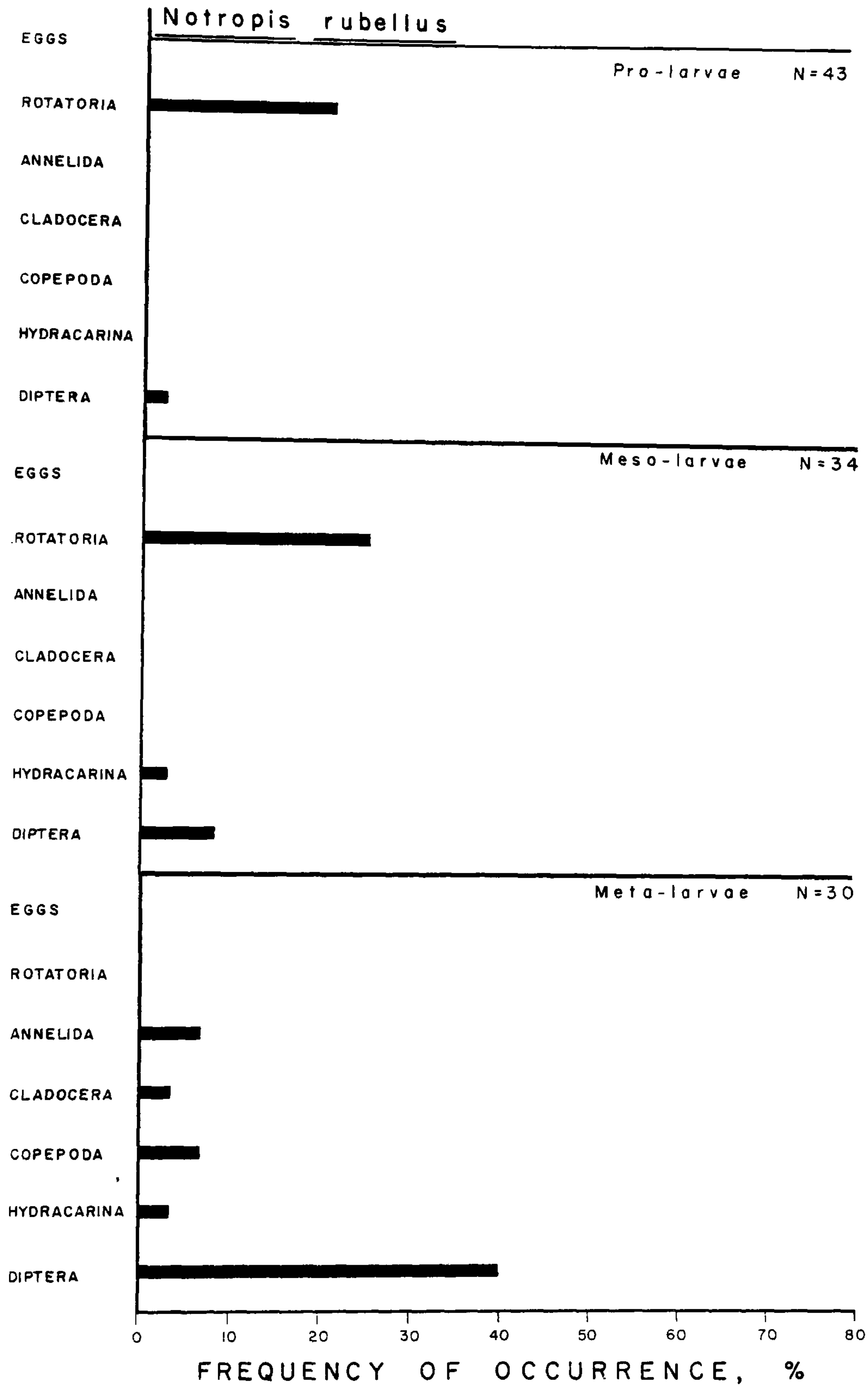

Hypentelium nigricans
Pro-larvae N=36
Meso-larvae N=116
Meta-larvae N=74
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
0 10 20 30 40 50 60 70 80 90 100
FREQUENCY OF OCCURRENCE, %

ingested rotifers (*Euchlanis* sp.) and dipteran larvae (Chironomidae) (Figure 4) while common shiner pro-larvae (Figure 5) ingested only rotifers (*Euchlanis* sp.). Most of the pro-larvae of all species containing stomach contents also included various algal forms (Table 4).

Meso-larvae - Meso-larval stages in all species had some representatives which still contained yolk material in their guts. The maximum total lengths of meso-larvae containing yolk were 14.25 mm, 8.00 mm, 7.00 mm, and 8.50 mm for the northern hog sucker, the rosyface shiner, the common shiner, and *Micropterus* sp., respectively. Meso-larvae of northern hog suckers and common shiners included representatives of all seven major prey groups in their stomach contents (Figures 3 & 5). The four most abundant groups in both species included rotifers, dipteran larvae, eggs, and annelids. *Micropterus* sp. ingested six major prey items with very high percent frequencies of occurrence for cladocerans, copepods, and dipteran larvae but with no hydracarina (Figure 6). Rosyface shiner meso-larvae contained representatives of only three taxa: rotifers, dipterans, and hydracarina (Hydrachnid) (Figure 4).

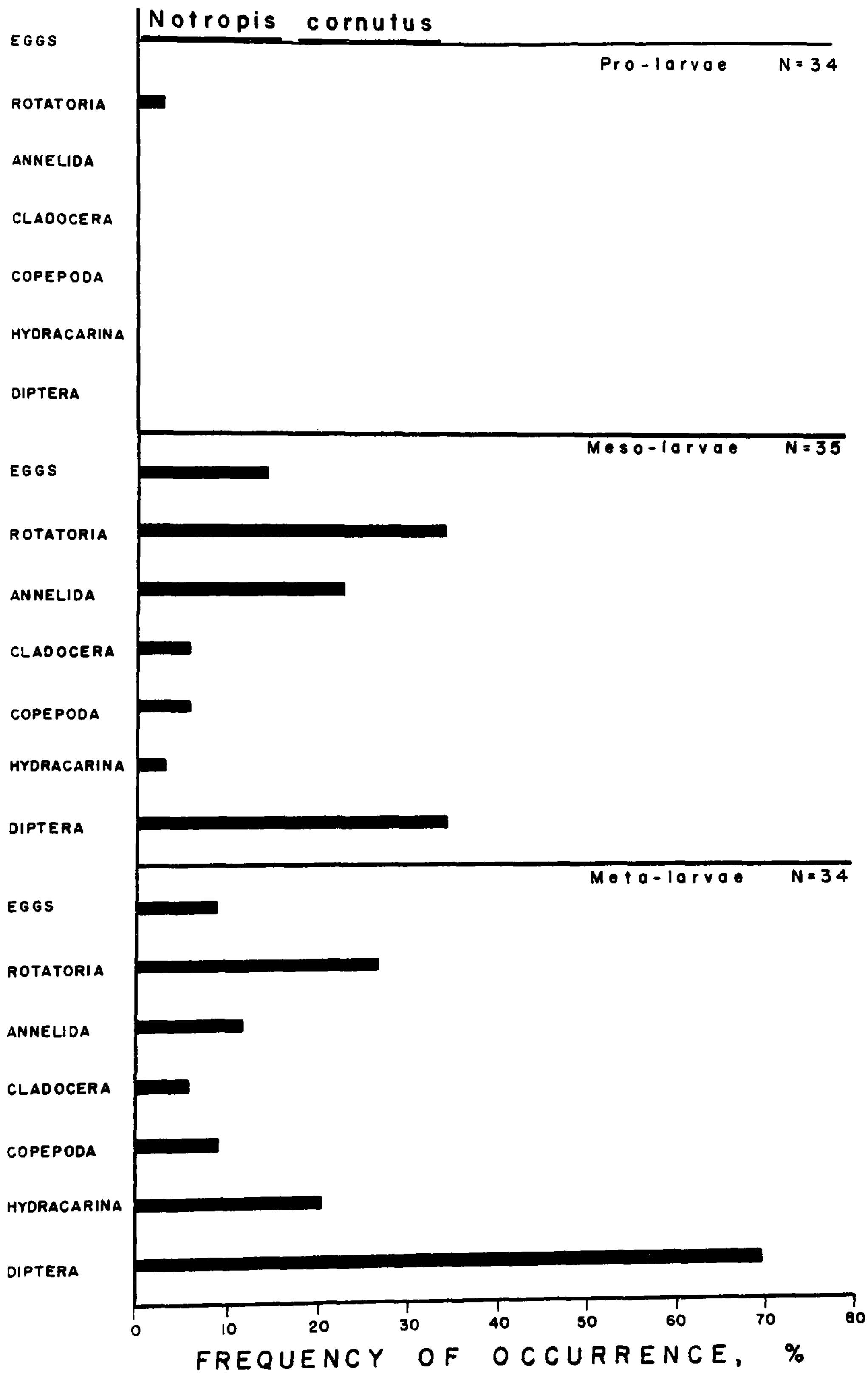
Meta-larvae - Meta-larval representatives of all four species, except the rosyface shiner, ingested specimens of all seven major food categories (Figures 3 - 6). Dipteran larvae represented the greatest frequency of occurrence in all species observed. Northern hog suckers showed the greatest balance in stomach contents with over 40% of the stomachs containing organisms of every food group except hydracarina (Figure 3). *Micropterus* sp. showed very high percentage frequencies for dipterans and copepods (Figure 6). Rosyface shiners indicated the least complete diet

Figure 4. Percentage frequency of occurrence of various food organisms in the digestive tracts of *Notropis rubellus* during three developmental stages.



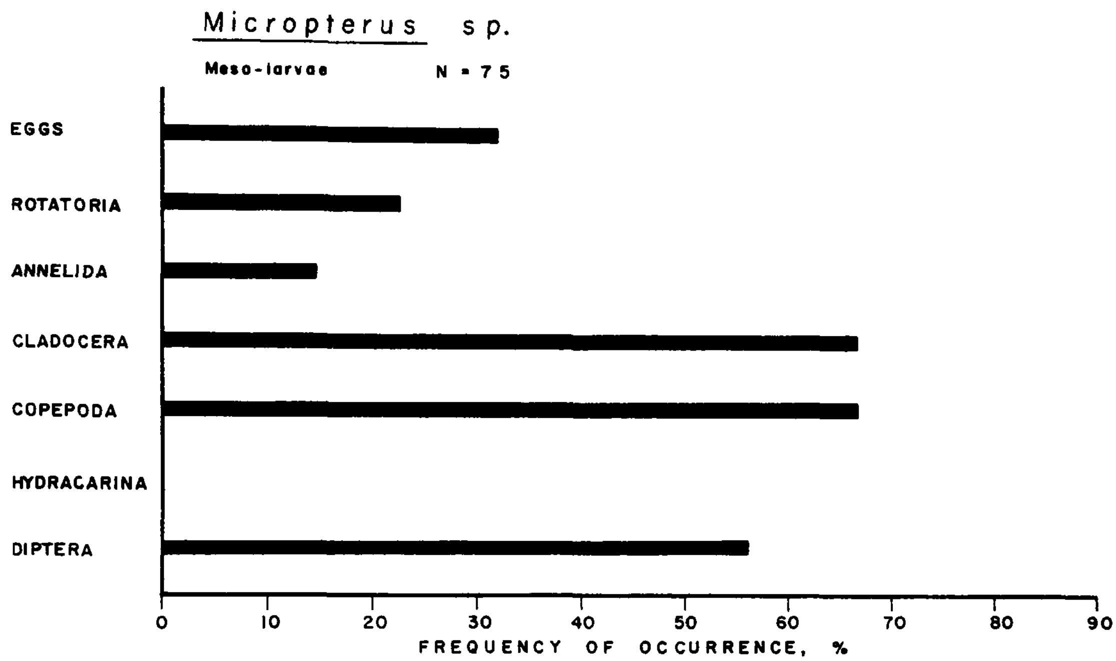
Notropis rubellus
Pro-larvae N=43
Meso-larvae N=34
Meta-larvae N=30
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
0
10
20
30
40
50
60
70
80
FREQUENCY OF OCCURRENCE, %

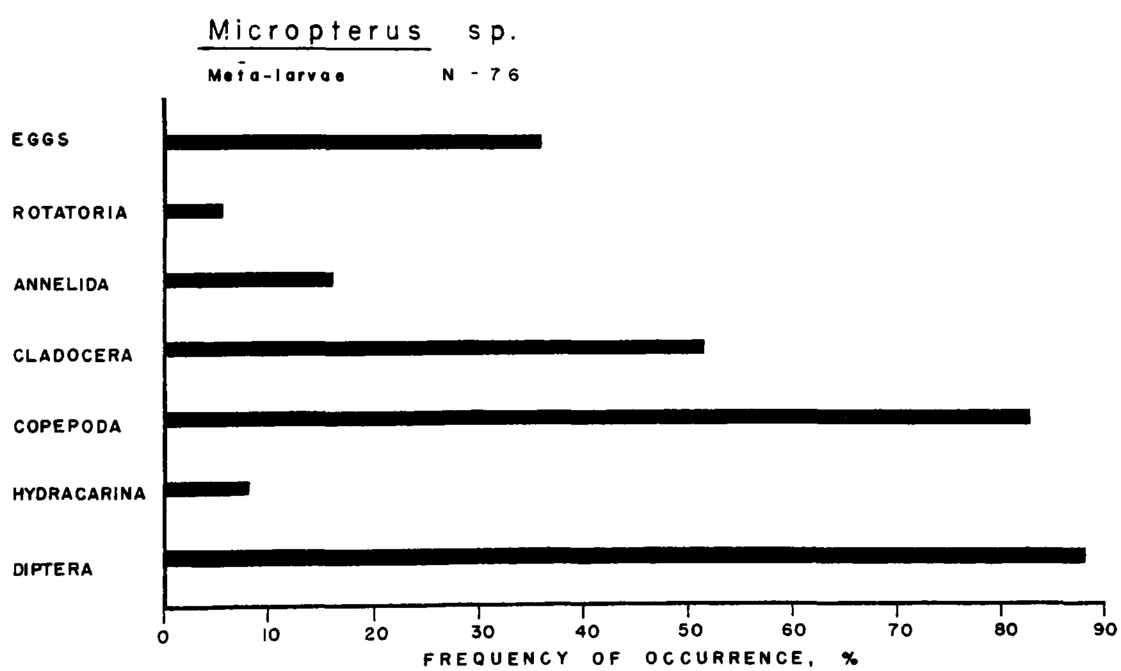
Figure 5. Percentage frequency of occurrence of various food organisms in the digestive tracts of *Notropis cornutus* during three developmental stages.



Notropis cornutus
Pro-larvae N=34
Meso-larvae N=35
Meta-larvae N=34
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
0
10
20
30
40
50
60
70
80
FREQUENCY OF OCCURRENCE, %

Figure 6. Percentage frequency of occurrence of various food organisms in the digestive tracts of *Micropterus* sp. during two developmental stages.


Micropterus sp.
Meso-larvae
N = 75
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
0
10
20
30
40
50
60
70
80
90
FREQUENCY OF OCCURRENCE, %


Micropterus sp.
Meta-larvae
N - 76
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
0
10
20
30
40
50
60
70
80
90
FREQUENCY OF OCCURRENCE, %

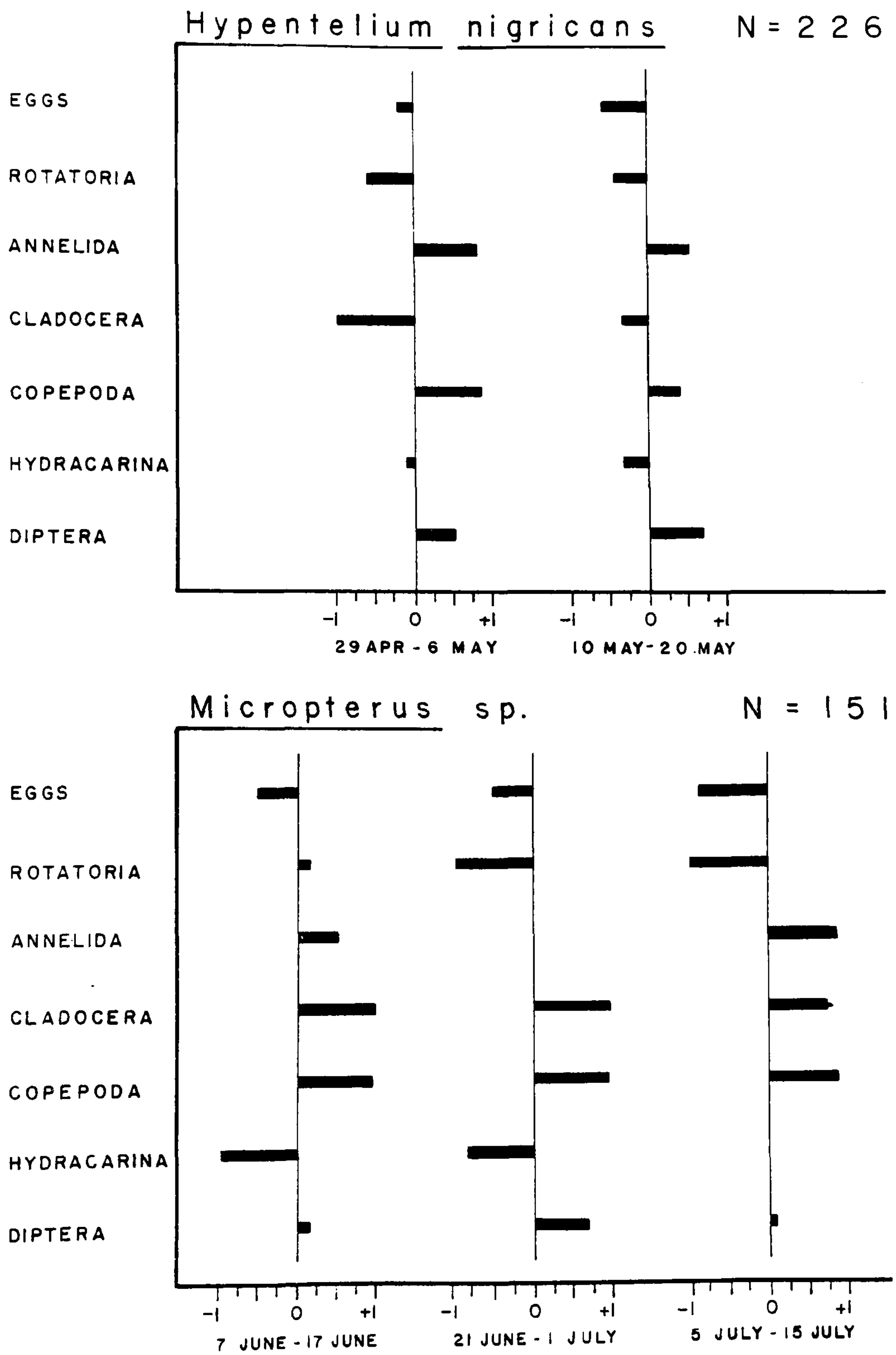
of all the four species with less than 10% frequency of occurrence for all but one dietary component, dipteran larvae (Figure 4).

With the exception of *Micropterus* sp., larvae ingested progressively more food groups as they developed from pro- to meta-larval stages (Appendices II - V). Piscivory was observed in *Micropterus* sp. during the third week of life with 12% of the meta-larvae consuming other fish larvae. The identifiable larval fish ingested were *Notropis* spp., and those which could be specifically identified were *N. rubellus*. It was observed that at this developmental stage, *Micropterus* sp., as opposed to the other non-piscivorous species, had a highly coiled digestive tract which allowed for accomodation of fish larvae equal to or exceeding its own body length (11.5 mm TL at the onset of piscivory). The shiner's digestive tract remained straight and the northern hog sucker, though it had a straight gut, had a greater gut-to-total-length ration (Appendices II - V).

Generally, size of prey organisms increased from pro-larval to meta-larval stages. However, in each developmental stage, the prey taxa consumed were usually the same, i.e. *Euchlanis* sp. was the major rotifer observed in all species in all developmental stages. As fish species increased in size, dipterans increased in size from exclusively larval forms in meso-larval stomachs to larvae and pupae in meta-larval guts.

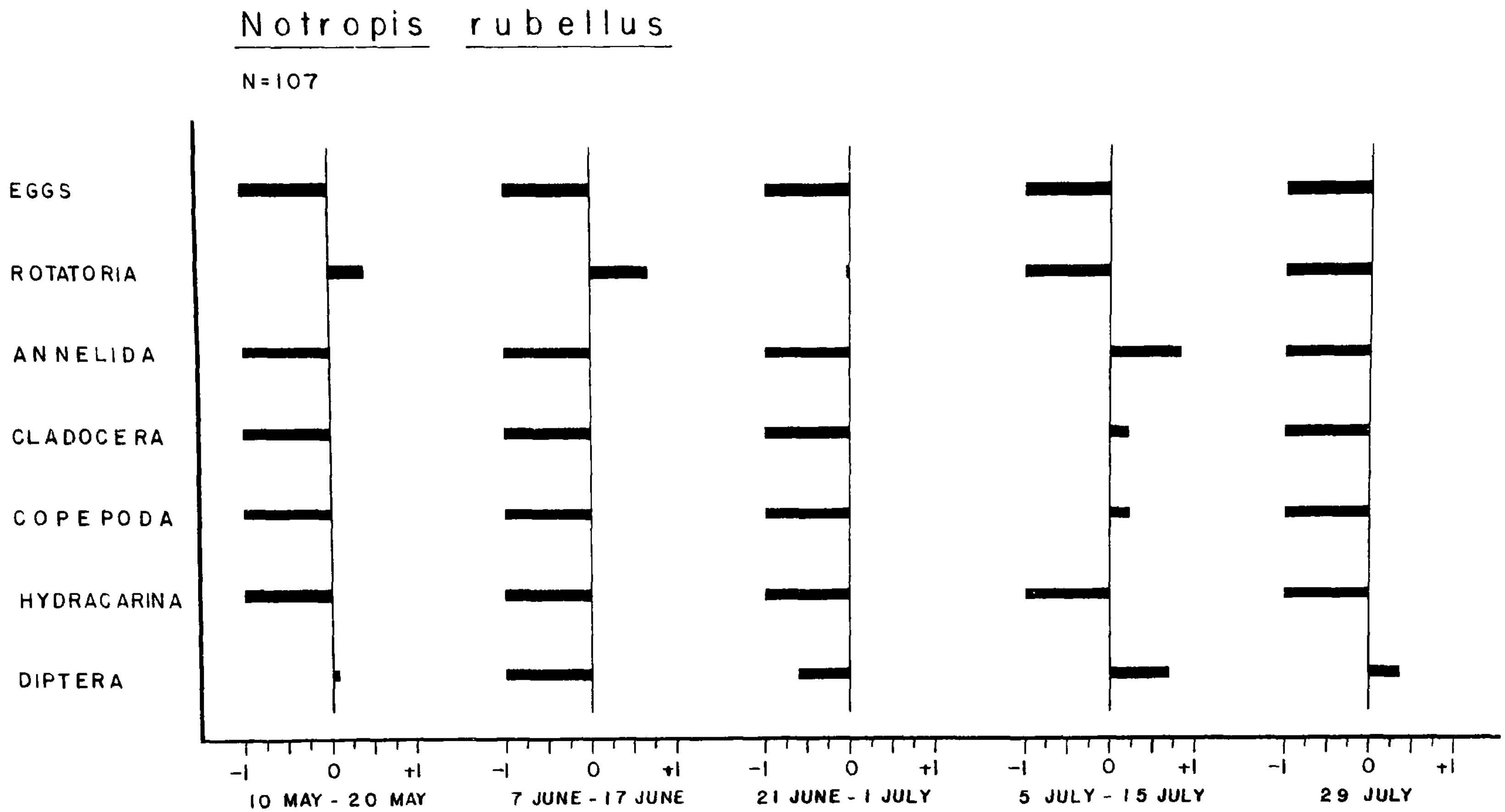
Electivity Indices - Considerable variation was observed among the four fish species as to their selection for and against the seven major food groups throughout the larval period. Indices of electivity (Figures 7 - 9) showed that northern hog suckers selected for annelids, copepods, and

Figure 7. Electivity indices, "E", for the major food organisms consumed by larval *Hypentelium nigricans* and *Micropterus* sp. from 29 April through 20 May and from 7 June through 15 July, respectively.



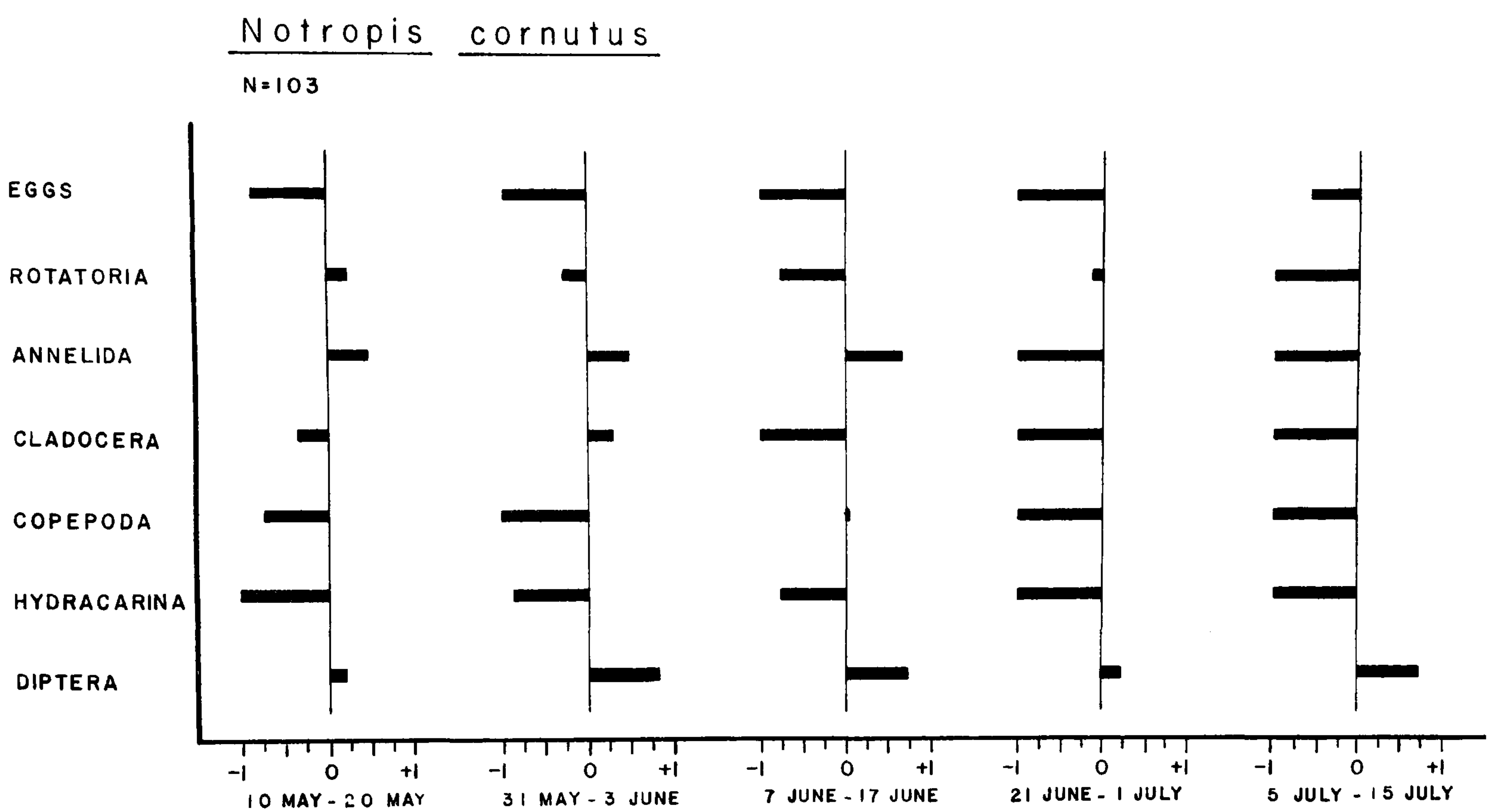
Hypentelium nigricans N = 226
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
-1 0 +1 -1 0 +1
29 APR - 6 MAY
10 MAY - 20 MAY
Micropterus sp. N = 151
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
-1 0 +1 -1 0 +1 -1 0 +1
7 JUNE - 17 JUNE
21 JUNE - 1 JULY
5 JULY - 15 JULY

Figure 8. Electivity indices, "E", for the major food organisms consumed by larval *Notropis rubellus* from 10 May through 29 July 1982.



Notropis rubellus
N=107
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
-1 0 +1
10 MAY - 20 MAY
7 JUNE - 17 JUNE
21 JUNE - 1 JULY
5 JULY - 15 JULY
29 JULY

Figure 9. Electivity indices, "E", for the major food organisms consumed by larval *Notropis cornutus* from 10 May through 15 July 1982.


Notropis cornutus
N=103
EGGS
ROTATORIA
ANNELIDA
CLADOCERA
COPEPODA
HYDRACARINA
DIPTERA
-1
0
+1
10 MAY - 20 MAY
31 MAY - 3 JUNE
7 JUNE - 17 JUNE
21 JUNE - 1 JULY
5 JULY - 15 JULY

dipterans and against cladocerans and rotifers, despite their high frequency of occurrence in the diet (Figure 7). Rosyface shiners selected for rotifers in their diet during their first four weeks of life, increasing their selectivity to annelids, cladocerans, copepods, and dipterans during the seventh and eighth week and finally selecting only for dipterans during their last week as larvae (Figure 8). The common shiner selected for a wide variety of organisms during the first six weeks, including rotifers, annelids, and dipterans, while selecting only for dipterans during the last week as larvae (Figure 9). Basically, *Micropterus* sp. selected for annelids, cladocerans, and copepods throughout the larval stages (Figure 7). Comparing dates of prey selection, *Micropterus* sp. decreased the selectivity for cladocerans and dipterans on 5 July (Figure 7) when the rosyface shiner began selecting these taxa (Figure 8).

Pro-larvae - As pro-larvae, the northern hog sucker selected against the major food groups during the first two weeks and selected for copepods, hydracarina, and cladocerans during the second two weeks (Table 5). No pro-larvae were available for analysis of *Micropterus* sp. Both the rosyface shiner (Table 6) and the common shiner (Table 7) selected rotifers during their first two weeks as pro-larvae. In addition, the rosyface shiner selected dipteran larvae which became the only food item selected during the second two weeks. From the sixth week through the end of the pro-larval period, the rosyface shiner selected against all seven food categories. The general pro-larval selectivity pattern, therefore, showed

TABLE 5. Changes in feeding selectivity of different larval stages of *Hypentelium nigricans* through time in the Middle Fork of Drake's Creek, 1982.

LIFE STAGE	PREY	Apr 29 - May 6 % in gut (r)	Apr 29 - May 6 % in nets (p)	Apr 29 - May 6 Electivity Index (E)	May 10 - May 20 % in gut (r)	May 10 - May 20 % in nets (p)	May 10 - May 20 Electivity Index (E)
Pro-larvae:							
	EGGS	0	20.00	-1.00	21.05	35.00	-0.24
	ROTATORIA	0	69.00	-1.00	10.52	40.00	-0.58
	ANNELIDA	0	2.00	-1.00	0	3.00	-1.00
	COPEPODA	0	0.49	-1.00	10.52	2.00	+0.68
	CLADOCERA	0	4.00	-1.00	5.26	5.00	+0.25
	HYDRACARINA	0	1.00	-1.00	5.26	2.00	+0.44
	DIPTERA	0	0.04	-1.00	0	2.00	-1.00
Meso-larvae:							
	EGGS	14.62	20.00	-0.15	13.31	35.00	-0.44
	ROTATORIA	17.54	69.00	-0.59	11.41	40.00	-0.55
	ANNELIDA	25.73	2.00	+0.85	12.17	3.00	+0.60
	COPEPODA	3.51	0.49	+0.75	5.32	2.00	+0.45
	CLADOCERA	0	4.00	-1.00	0.95	5.00	-0.68
	HYDRACARINA	1.17	1.00	+0.07	1.71	2.00	-0.07
	DIPTERA	16.96	0.04	+0.99	28.33	2.00	+0.86
Meta-larvae:							
	EGGS	9.68	20.00	-0.34	10.31	35.00	-0.54
	ROTATORIA	19.35	69.00	-0.56	16.41	40.00	-0.41
	ANNELIDA	22.58	2.00	+0.83	10.55	3.00	+0.55
	COPEPODA	3.22	0.49	+0.73	5.23	2.00	+0.44
	CLADOCERA	0	4.00	-1.00	1.84	5.00	-0.46
	HYDRACARINA	0	1.00	-1.00	1.26	2.00	-0.22
	DIPTERA	3.22	0.04	+0.97	28.27	2.00	+0.86

Table 6. Changes in feeding selectivity of different larval stages of Notropis rubellus through time in the Middle Fork of Drakes' Creek, 1982.

TAXON	May 10 - May 20			Jun 7 - Jun 17			Jun 21 - Jul 1			Jul 5 - Jul 15			Jul 29		
	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)
Pro-larvae:													no pro-larvae taken		
EGGS	0	35.00	-1.00	0	28.00	-1.00	0	21.00	-1.00	0	49.00	-1.00			
ROTATORIA	94.00	40.00	+0.40	63.16	15.00	+0.61	61.11	69.00	-0.06	0	17.00	-1.00			
ANNELIDA	0	3.00	-1.00	0	1.00	-1.00	0	1.00	-1.00	0	0.56	-1.00			
COPEPODA	0	2.00	-1.00	0	0.88	-1.00	0	0.30	-1.00	0	4.00	-1.00			
CLADOCERA	0	5.00	-1.00	0	6.00	-1.00	0	4.00	-1.00	0	12.00	-1.00			
HYDRACARINA	0	2.00	-1.00	0	28.00	-1.00	0	2.00	-1.00	0	3.00	-1.00			
DIPTERA	5.88	2.00	+0.49	0	0.05	-1.00	0	0.05	-1.00	0	2.00	-1.00			
Meso-larvae:													no meso-larvae taken		
EGGS	0	35.00	-1.00	0	28.00	-1.00	0	21.00	-1.00	0	49.00	-1.00			
ROTATORIA	0	40.00	-1.00	65.43	15.00	+0.62	68.75	69.00	0	0	17.00	-1.00			
ANNELIDA	0	3.00	-1.00	0	1.00	-1.00	0	1.00	-1.00	0	0.56	-1.00			
COPEPODA	0	2.00	-1.00	0	0.88	-1.00	0	0.30	-1.00	0	4.00	-1.00			
CLADOCERA	0	5.00	-1.00	0	6.00	-1.00	0	4.00	-1.00	0	12.00	-1.00			
HYDRACARINA	0	2.00	-1.00	0	28.00	-1.00	0	2.00	-1.00	0	3.00	-1.00			
DIPTERA	0	2.00	-1.00	0	0.05	-1.00	0	0.05	-1.00	100.00	2.00	+0.96			
Meta-larvae:	no meta-larvae taken			no meta-larvae taken											
EGGS							0	21.00	-1.00	0	49.00	-1.00	0	32.00	-1.00
ROTATORIA							0	69.00	-1.00	0	17.00	-1.00	0	3.00	-1.00
ANNELIDA							0	1.00	-1.00	9.52	0.56	+0.88	0	5.00	-1.00
COPEPODA							0	0.30	-1.00	9.52	4.00	+0.40	0	8.00	-1.00
CLADOCERA							0	4.00	-1.00	4.76	12.00	-0.43	0	12.00	-1.00
HYDRACARINA							0	2.00	-1.00	0	3.00	-1.00	0	12.00	-1.00
DIPTERA							50.00	0.05	+0.99	52.38	2.00	+0.92	45.45	2.00	+0.91

Table 7. Changes in feeding selectivity of different larval stages of *Notropis cornutus* through time in the Middle Fork of Drakes' Creek, 1982.

TAXON	May 10 - May 20			May 31 - Jun 3			Jun 7 - Jun 17			Jun 21 - Jul 1			Jul 5 - Jul 15		
	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)	%/gut (r)	%/net (p)	Electiv. Index (E)
Pro-larvae:				no pro-larvae taken			no pro-larvae taken			no pro-larvae taken			no pro-larvae taken		
EGGS	0	35.00	-1.00												
ROTATORIA	100.00	40.00	+0.42												
ANNELIDA	0	3.00	-1.00												
COPEPODA	0	2.00	-1.00												
CLADOCERA	0	5.00	-1.00												
HYDRACARINA	0	2.00	-1.00												
DIPTERA	0	2.00	-1.00												
Meso-larvae:				no meso-larvae taken			no meso-larvae taken			no meso-larvae taken			no meso-larvae taken		
EGGS	3.22	35.00	-0.83												
ROTATORIA	67.02	40.00	+0.25												
ANNELIDA	10.03	3.00	+0.53												
COPEPODA	0.72	2.00	-0.47												
CLADOCERA	0.72	5.00	-0.74												
HYDRACARINA	0.36	2.00	-0.69												
DIPTERA	7.16	2.00	+0.56												
Meta-larvae:															
EGGS	3.10	35.00	-0.83	1.09	57.00	-0.96	0	28.00	-1.00	46.94	21.00	+0.38	12.00	49.00	-0.60
ROTATORIA	0	40.00	-1.00	17.39	14.00	+0.10	2.27	15.00	-0.73	30.61	69.00	-0.38	0	17.00	-1.00
ANNELIDA	0	3.00	-1.00	4.35	2.00	+0.37	0	1.00	-1.00	0	1.00	-1.00	0	0.56	-1.00
COPEPODA	0	2.00	-1.00	3.26	3.00	+0.04	1.14	0.88	+0.12	0	0.30	-1.00	0	4.00	-1.00
CLADOCERA	20.00	5.00	+0.60	3.26	3.00	+0.04	0	6.00	-1.00	0	4.00	-1.00	0	12.00	-1.00
HYDRACARINA	0	2.00	-1.00	9.78	10.00	-0.01	4.54	28.00	-0.72	0	2.00	-1.00	4.00	3.00	+0.14
DIPTERA	50.00	2.00	+0.92	42.39	1.00	+0.95	50.00	0.05	+0.99	10.20	0.05	+0.99	80.00	2.00	+0.95

no overlapping among the four species. The only exception was the selection for rotifers by both the rosyface shiner and the common shiner. However, selection for this taxon occurred during a time when rotifers constituted 40% of the community (Table 2).

Meso-larvae - Meso-larval northern hog suckers (Table 5) selected for dipterans, annelids, and copepods throughout this four week developmental stage eliminating hydracarina as a preferred food item after the first two weeks. The rosyface shiner meso-larvae responded negatively to most food items with a preference for rotifers by the fifth week and a selection for dipterans by the sixth week (Table 6) while common shiner meso-larvae selected for dipterans, annelids, and rotifers (Table 7). *Micropterus* sp. selected for dipterans, copepods, annelids, and rotifers as young meso-larvae and for copepods and dipterans as late meso-larvae (Table 8). Though meso-larval northern hog suckers (Table 5) continued to select annelids, that selection decreased on 10 May when the common shiner meso-larvae (Table 7) started feeding on the same food item.

Meta-larvae - Meta-larval northern hog suckers continued to select for copepods in their diet as they did throughout earlier stages (Table 5). In addition, dipterans and annelids were also selected. Rosyface shiner meta-larvae had a high selectivity for dipterans with only annelids and copepods appearing in the diet at mid-meta-larval stages (Table 6). Common shiner meta-larval food preferences changed throughout this developmental stanza. While dipteran larvae were selected for throughout the period, alternate selections for cladocerans, annelids, rotifers, copepods, miscellaneous eggs, and hydracarina were observed (Table 7).

TABLE 8. Changes in feeding selectivity of different larval stages of *Micropterus* sp. through time in the Middle Fork of Drake's Creek, 1982.

LIFE STAGE	PREY	Jun 7 - Jun 17 % in gut (r)	Jun 7 - Jun 17 % in nets (p)	Jun 7 - Jun 17 Electiv. Index (E)	Jun 21 - Jul 1 % in gut (r)	Jun 21 - Jul 1 % in nets (p)	Jun 21 - Jul 1 Electiv. Index (E)	Jul 5 - Jul 15 % in gut (r)	Jul 5 - Jul 15 % in nets (p)	Jul 5 - Jul 15 Electiv. Index (E)
Pro-larvae:		no pro-larvae taken			no pro-larvae taken			no pro-larvae taken		
Meso-larvae:								no meso-larvae taken		
	EGGS	7.34	28.00	-0.58	6.10	21.00	-0.54			
	ROTATORIA	20.21	15.00	+0.14	0	69.00	-1.00			
	ANNELIDA	4.57	1.00	+0.64	0	1.00	-1.00			
	COPEPODA	33.81	0.88	+0.94	82.44	0.29	+0.99			
	CLADOCERA	19.61	6.00	+0.53	1.52	4.00	-0.44			
	HYDRACARINA	0	28.00	-1.00	0	2.00	-1.00			
	DIPTERA	9.02	0.05	+0.98	6.87	0.05	+0.98			
Meta-larvae:		no meta-larvae taken								
	EGGS				7.00	21.00	-0.50	3.22	49.00	-0.87
	ROTATORIA				1.83	69.00	-0.94	0	17.00	-1.00
	ANNELIDA				1.29	1.00	+0.12	9.67	0.56	+0.89
	COPEPODA				49.01	0.29	+0.98	38.70	4.00	+0.81
	CLADOCERA				10.60	4.00	+0.45	16.13	12.00	+0.14
	HYDRACARINA				0.33	2.00	-0.71	3.22	3.00	+0.03
	DIPTERA				20.87	0.05	+0.99	16.13	2.00	+0.77

Micropterus sp. had the greatest selection pattern of the four species by positively selecting for four taxa as early meta-larvae and five taxa during later meta-larval development (Table 8).

Generally, the four fish species selected for more and larger prey organisms as they advanced from pro-larval to meta-larval stages.

DISCUSSION

Invertebrate drift is a normal feature of lotic systems (Elliott and Corlett 1971). However, Hynes (1970) found that these type environments are poorly suited for the production and maintenance of zooplankton and that streams consequently harbor small zooplankton communities, especially microcrustaceans. His observations were similar to those of this study wherein copepods and cladocerans comprised the smallest percentage of organisms in the community. Rotifers, on the other hand, constituted a high percentage which supported the findings of Winner (1975) that these organisms are found in abundance in lotic environments and often dominate the zooplankton community. It does not appear unusual that eggs would also occupy a high percentage level since they constitute an unresisting status in a moving water body and are consequently swept into the drift. Seasonal abundance peaks are common, if not universal, in the zooplankton community and several studies have reported the occurrence (Pennak 1949, Hudson and Cowell 1966, Elliott and Corlett 1971, and Selgeby 1975). The present study was no exception,for rotifers exhibited two distinct peaks in abundance during the study period.

The observation that pro-larval fishes in Drake's Creek had a higher percentage of empty digestive tracts than fishes of a more advanced developmental stage was similar to that reported by Siefert (1972). This find was suggested by Siefert (1972) to be a result of incompletely developed digestive tracts in smaller larvae. Of the four major species studied from Drake's Creek, rosyface shiners and common shiners exhibited the greatest percentage of empty digestive tracts. Both species exhibited intestines that remained long and straight with little observable morphometric differentiation throughout the larval period. On the other hand, northern hog suckers and *Micropterus* sp. had low percentages of empty guts. The northern hog sucker had a greater gut-to-total length ratio than did the shiners. *Micropterus* sp. demonstrated a highly coiled digestive tract with the loops dividing the gut into definite functional parts.

The utilization of members of 17 different taxa of food organisms by the four species from Drake's Creek was a surprising observation. While it is well known that many adult fishes feed upon a wide variety of organism types, selecting at particular times for individual taxa, the extension of that premise to larval feeding has not been verified and, consequently, was surprising. The greatest feeding diversity observed by the northern hog sucker in Drake's Creek was similar to the findings reported by Siefert (1972) for the white sucker (*Catostomus commersoni*). Pflieger (1975) also reported the northern hog sucker to be an aggressive feeder.

Yolk material was found to occur in pro-larval and meso-larval digestive tracts, often in addition to extraneous food organisms. Lagler et al. (1977) found that many young fishes with tiny mouths began to feed on plankton while still containing yolk bodies. In their study on larval drum (*Aplodinotus grunniens*), Clark and Pearson (1979) observed feeding to commence well before the yolk sac was absorbed and that 26% of the specimens examined had both food and yolk material in the gut. Furthermore, the combination of extraneous food and yolk in the digestive tract has been reported in the spotted sucker (*Minytrema melanops*) (White and Haag 1977) and the walleye (*Stizostedion vitreum*) (Bulkley et al. 1976). As pointed out by Clark and Pearson (1979), it is not unusual for the larval fish to ingest foods before entire absorption of the yolk considering that mouthparts and an oral opening form during the pro-larval stage when the yolk sac is still being absorbed.

As fish size increases, the size, variety, and number of food organisms generally increases. That smaller larvae utilize smaller prey and larger larvae utilize larger prey was illustrated in this study by smaller pro-larvae consuming rotifers while meso- and meta-larvae consumed dipteran larvae. Similar findings have been reported by Silvells (1949), Ivlev (1961), Hickling (1966), Siefert (1968), Scalet (1972), Mathur (1977), Werner (1979), Overmann et al. (1980), Applegate (1981), and Watkins et al. (1981). This is a general phenomenon for many fishes (Hynes 1970). Studies have suggested that mouth sizes determine the size of prey taken (Northcote 1954, Wong and Ward 1972) and that,within a species, as mouth size increases prey size increases (Hartman 1958).

The use of a greater variety of food organisms by larvae as they increased in size in Drake's Creek was similar to the findings of Heins and Clemmer (1975) and Overmann et al. (1980). Wallace (1976) proposed that the use of a larger variety of food with increased fish size could be explained by the increased range of food sizes available with increased mouth size rather than by a change in feeding behavior. Another reason for the shift in preferred food items might be, as reported by Nilsson (1965), that as fish size increases, energy expended in capturing smaller prey becomes uneconomical. This alteration in food habits of larval fishes becomes important as size dependent differences in feeding reduce interspecific competition (Hynes 1970) and allows for more efficient utilization of the habitat resources. Other studies have also shown that fish frequently select the largest species of zooplankton and the largest individuals of those species (Brooks and Dodson 1965, Galbraith 1967). Learned behavior and previous experience have been suggested as reasons for an individual to continue to choose an item in the diet (Ware 1971, Wong and Ward 1972, Hansen and Wahl 1981).

Twelve percent of the *Micropterus* sp. meta-larvae demonstrated piscivory. A review of the literature provided few reports of piscivory with fish less than 20 mm total length. Clark and Pearson (1979) reported 3.8 mm freshwater drum to consume other larvae. Piscivory was reported for 8.0 mm walleye (Bulkley et al. 1976) and for 17 mm longnose gar (*Lepososteus osseus*) (Echelle 1968). Therefore, the Drake's Creek finding of 11.5 mm larvae becoming piscivorous is one of few such observations. There have been reports of cannibalism by *Micropterus* sp. at 18 mm (Chew 1974) and at 23.6 mm (Krammer and Smith (1960) but no cannibalism was found in the Drake's Creek study. The great abundance of shiners in the stream (Floyd 1983) probably explained their utilization by the *Micropterus* sp.

Selection for or against a particular food organism has been reported for a wide variety of fishes. Food habits found in this study suggested that a degree of feeding specialization existed among the larval fish studied. Pro-larvae of each species selecting for different organisms than pro-larvae of the other species supported this contention. This observation of different diet selection by like larval stages of different species was also seen by Bulkley et al. (1976) in their study of cohabiting fishes. Likewise, the Drake's Creek finding of the species, rather than the developmental stage, changing its selection of a food item when another species began selecting the same item suggested a resource sharing adjustment. Bulkley et al. (1976) reported the same observation with other cohabiting species. The Drake's Creek findings of feeding specialization by larval members of different species seems to support resource partitioning as reported by Wynes and Wissing (1982) and George and Hadley (1979), the competitive exclusion principal (Elton 1946, Zaret and Rand 1971), and the existence of positive interrelationships among cohabiting species (Brocksen et al. 1968, Mendelson 1975).

Many authors have postulated as to why fishes select for or against certain food organisms. Brooks and Dodson (1965) suggested size, abundance, and the ability to avoid a predator as properties of a food organism which cause it to be selected for or against. Lagler et al. (1977) also suggested prey abundance as a determining factor in selection. However, the present study showed dipteran larvae to rank low in abundance but yet were selected for by all species during all developmental stages. Siefert (1972) studied shiners and centrarchids and found that early larvae selected food organisms that were small enough and slow enough to be desirable by that group. In addition, Moore and Moore (1976) found that prey organisms probably attract predators by their movements such as cyclopoid copepods swimming by pronounced jerks. Cyclopoid copepods were among the first food items of shiner and sucker larvae in this study as in the Moore and Moore (op cit) study.

Ivlev (1961) reported experience to be a significant influence on prey selection by fishes. Brooks (1967) observed fish to continue to select small prey even after a larger prey type becomes more abundant. Electivity data in this study also showed a continuation in selecting for the same species in later larval stages. Since attack distance of fish is related to prey size (Confer et al. 1978) and dependent on experience (Ware 1971), fish may be more effective at capturing taxa with which they are familiar (Hansen and Wahl 1981). Wong and Ward (1972) also found that experience may induce a continued utilization of smaller, more familiar prey organisms.

Appendix I. Drift organisms/m^3, through time, for Station I-A (upper net) and Station I-B (lower net), for Station II-A (upper net) and Station II-B (lower net) and for Stations I and II.

		Sta. I-A	Sta. I-B	Sta. II-A	Sta. II-B	Sta. I	Sta. II
Mar.	18	285.24	389.73	586.96	1279.36	337.48	933.16
	22	305.35	578.56	269.48	759.73	441.95	514.60
	24	398.02	472.65	393.66	681.00	435.33	537.33
	29	98.03	141.17	459.30	337.21	119.60	398.25
Apr.	1	853.44	1030.15	1882.98	1854.61	941.79	1868.79
	5	*	*	383.01	54.49		
	10	2848.26	2914.21	1319.16	2088.36	2881.24	1703.76
	12	981.03	1528.00	1228.30	518.55	1254.51	873.43
	15	2216.90	3066.19	2317.93	2279.53	2641.54	2298.73
	19	538.14	1234.14	*	*		
	26	1409.36	1473.91	797.95	793.29	1441.63	795.62
	29	473.20	445.36	985.91	889.86	459.28	937.89
May	4	2015.60	2274.22	2057.52	2297.64	2144.91	2177.58
	6	1507.66	1932.78	1686.44	1745.77	1720.22	1716.11
	10	1930.25	1484.18	2018.28	1731.06	1707.22	1874.67
	13	490.55	332.87	751.84	516.89	411.71	634.36
	17	957.04	588.23	1238.53	684.23	772.64	961.38
	20	922.49	1118.53	*	*		
	24	710.90	663.75	398.06	432.94	687.32	415.50
	27	601.39	311.19	397.97	305.70	456.29	351.84
	31	1312.26	1717.59	653.64	505.84	1514.92	579.74
Jun	3	567.81	227.11	437.25	182.37	397.46	309.81
	7	490.57	219.76	508.14	289.79	355.16	398.97
	10	451.67	162.60	420.90	212.88	307.13	316.89
	14	346.82	352.59	480.46	228.01	349.70	354.23
	17	577.21	307.35	683.53	642.51	442.28	663.02
	21	996.92	585.81	796.73	349.96	791.36	573.34
	28	2491.34	1328.71	5207.68	2779.52	1910.03	3993.60
Jul.	1	1465.90	897.30	1236.28	368.89	1181.60	802.59
	5	1067.65	221.99	94.23	231.65	644.82	162.94
	8	752.08	1121.17	705.38	255.58	936.63	480.48
	12	2820.66	1600.45	774.62	2499.98	2210.56	1637.30
	15	550.66	539.53	692.19	405.00	545.10	548.60
	19	241.35	482.71	194.83	80.22	362.03	137.53
	22	294.11	741.97	275.37	423.26	518.04	349.31
	26	432.92	189.04	725.21	153.21	310.98	439.21
	29	580.11	572.63	293.38	276.85	576.37	285.11
Aug.	9	517.40	254.00	92.66	85.53	385.70	89.10
	12	92.50	240.50	86.31	43.15	166.50	64.73

* No data available

Appendix II. Total length category, number of individuals, mean total length, mean gut length, gut length-total length ratio, and mean number of food organisms per stomach contents for each of three developmental stages of *Hypentelium nigricans* from the Middle Fork of Drake's Creek, Kentucky. (E=eggs, R=rotifers, A=annelids, Cop=copepods, Clad=cladocerans, H=hydracarina, and D=dipterans).

Life Stage	Total length category (mm)	N	Mean TL	Mean gut length (mm)	Gut:TL	E	R	A	Cop	Clad	H	D
Pro-larvae	10.00-11.99	18	11.00	5.93	0.54:1	0.05	0.11	0	0	0	0	0
	12.00-13.99	9	13.64	7.36	0.54:1	0	0.22	0	0.11	0	0.11	0
	14.00-15.99	9	14.22	7.22	0.51:1	0	0.11	0	0	0.22	0	0
	10.00-15.99	36	12.46	6.61	0.53:1	0.02	0.14	0	0.03	0.05	0.03	0
Meso-larvae	10.00-11.99	14	11.25	6.21	0.55:1	0.36	0.36	0.36	0.14	0.07	0	0.93
	12.00-13.99	12	12.89	6.54	0.51:1	0.33	0.50	0.25	0.33	0.17	0	1.17
	14.00-15.99	81	14.88	7.91	0.53:1	0.75	0.53	0.52	0.21	0.10	0.11	1.65
	16.00-17.99	9	16.30	8.00	0.49:1	1.33	1.89	3.55	0.78	0.11	0.22	2.11
	10.00-17.99	116	14.35	7.57	0.53:1	0.70	0.61	0.71	0.26	0.10	0.09	1.55
Meta-larvae	15.00-16.99	19	16.08	8.06	0.50:1	3.00	2.21	2.42	1.21	0.26	0.26	6.95
	17.00-18.99	41	17.78	8.63	0.48:1	3.46	6.07	3.93	1.56	0.46	0.32	7.66
	19.00-21.00	14	19.64	9.32	0.47:1	1.78	5.07	2.43	1.36	0.64	1.43	8.71
	15.00-21.00	74	17.69	8.61	0.49:1	3.02	4.89	3.26	1.43	0.44	0.51	7.68

Appendix III. Total length category, number of individuals, mean total length, mean gut length, gut length-total length ratio, and mean number of food organisms per stomach contents for each of three developmental stages of *Notropis rubellus* from the Middle Fork of Drake's Creek, Kentucky. (E=eggs, R=rotifers, A=annelids, Cop=copepods, Clad=cladocerans, H=hydracarina, and D=dipterans).

Life Stage	Total length category (mm)	N	Mean TL	Mean gut length (mm)	Gut:TL	E	R	A	Cop	Clad	H	D
Pro-larvae	5.00- 6.49	22	6.05	2.00	0.33:1	0	0.41	0	0	0	0	0
	6.50- 7.99	21	6.76	2.34	0.35:1	0	1.19	0	0	0	0	0.05
	5.00- 7.99	43	6.40	2.17	0.34:1	0	0.79	0	0	0	0	0.02
Meso-larvae	6.00- 7.49	24	6.77	2.16	0.32:1	0	11.50	0	0	0	0	0
	7.50- 9.99	10	8.15	2.40	0.29:1	0	10.50	0	0	0	1.00	3.00
	6.00- 9.99	34	7.17	2.23	0.31:1	0	11.20	0	0	0	0.29	0.88
Meta-larvae	10.00-11.99	5	10.85	3.70	0.34:1	0	0	0	0	0	1.00	1.00
	12.00-13.99	12	12.67	4.43	0.35:1	0	0	1.00	1.00	0	1.00	2.00
	14.00-15.99	5	15.30	5.95	0.39:1	0	0	1.00	0	0	0	1.00
	16.00-17.99	3	16.58	7.00	0.42:1	0	0	0	0	0	0	1.50
	18.00-19.99	3	18.08	8.58	0.47:1	0	0	0	1.00	0	0	1.00
	22.00-27.99	2	24.25	12.00	0.49:1	0	0	0	0	0	0	0
	10.00-27.99	30	14.51	5.74	0.40:1	0	0	0.57	0.50	0	0.57	1.38

Appendix IV. Total length category, number of individuals, mean total length, mean gut length, gut length-total length ratio, and mean number of food organisms per stomach contents for each of three developmental stages of *Notropis cornutus* from the Middle Fork of Drake's Creek, Kentucky. (E=eggs, R=rotifers, A=annelids, Cop=copepods, Clad=cladocerans, H=hydracarina, and D=dipterans).

Life Stage	Total length category (mm)	N	Mean TL	Mean gut length (mm)	Gut:TL	E	R	A	Cop	Clad	H	D
Pro-larvae	5.00- 5.99	26	5.45	2.13	0.39:1	0	0	0	0	0	0	0
	6.00- 7.99	8	6.16	2.69	0.44:1	0	0.12	0	0	0	0	0
	5.00- 7.99	34	5.62	2.26	0.40:1	0	0.01	0	0	0	0	0
Meso-larvae	6.00- 7.99	8	7.06	2.93	0.42:1	0	0.37	0	0	0	0	0.25
	8.00- 9.99	20	9.05	3.73	0.41:1	0.50	11.75	1.10	0.05	0.15	0	0.75
	10.00-11.99	4	10.31	4.25	0.41:1	0	1.00	2.00	0.25	0.50	0	2.00
	12.00-13.99	3	12.17	4.17	0.34:1	0	0	0	0	0	0.33	2.00
	6.00-13.99	35	9.01	3.64	0.40:1	0.28	6.91	0.86	0.06	0.14	0.03	0.88
Meta-larvae	9.00-12.99	4	10.94	4.56	0.42:1	0	0.25	1.50	0.50	0.75	0.25	6.25
	13.00-16.99	13	14.40	6.54	0.45:1	0.08	0.92	0.15	0	0	0.69	4.46
	17.00-20.99	14	18.39	12.09	0.66:1	0	0.36	0.36	0	0	0.07	2.14
	21.00-24.99	3	21.17	9.75	0.46:1	0	0.33	0.33	0	0	0	2.00
	9.00-24.99	34	16.23	8.87	0.55:1	0.03	0.56	0.41	0.06	0.09	0.32	3.50

Appendix V. Total length category, number of individuals, mean total length, mean gut length, gut length-total length ratio, and mean number of food organisms per stomach contents for each of two developmental stages of *Micropterus* sp. from the Middle Fork of Drake's Creek, Kentucky. (E=eggs, R=rotifers, A=annelids, Cop=copepods, Clad=cladocerans, H=hydracarina, and D=dipterans).

Life Stage	Total length category (mm)	N	Mean TL	Mean gut length (mm)	Gut:TL	E	R	A	Cop	Clad	H	D
Pro-larvae		0										
Meso-larvae	6.00- 8.99	45	8.04	4.00	0.50:1	0.82	1.71	0.09	2.38	2.82	0	0
	9.00-11.99	30	9.86	6.25	0.63:1	1.37	2.87	0.97	9.50	1.73	0	2.10
	6.00-11.99	75	8.77	4.90	0.56:1	1.04	2.17	0.44	5.23	2.38	0	0.37
Meta-larvae	8.00-10.99	13	9.54	5.69	0.60:1	0.23	1.54	0.08	4.61	3.00	0	1.77
	11.00-13.99	17	12.37	8.48	0.68:1	1.29	0.18	0.06	5.53	1.82	0.06	5.35
	14.00-16.99	14	15.52	9.23	0.59:1	1.93	0.21	0.43	9.07	3.14	0.14	4.57
	17.00-19.99	14	18.32	13.21	0.72:1	2.50	0	0.71	11.28	1.36	0.21	8.71
	20.00-23.00	18	21.69	17.87	0.82:1	1.56	0	0.11	17.44	1.61	0	4.83
	8.00-23.00	76	15.77	11.24	0.71:1	1.05	0.34	0.26	9.90	2.13	0.08	5.09

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