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Food Habits of the Steelcolor Shiner, Notropis whipplei (Girard)

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FOOD HABITS OF THE STEELCOLOR SHINER,

NOTROPIS WHIPPLEI (GIRARD)

(TITLE)

BY

MARK A. DYER

THESIS

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ABSTRACT

Specimens of the steelcolor shiner, Notropis whipplei (Girard) were seined at irregular intervals from Polecat Creek (Coles County, Illinois) from October 1974 to September 1975. Drift and benthic samples were taken in conjunction with fish collections. The stomach contents of the fish were analyzed and compared to organisms found in the drift and benthos. More food taxa were represented in the fish collected during the summer. Aquatic insect forms, primarily chironomid larvae, amounted to 75.6% of the total percentage of foods eaten during the winter as compared to 18.8% for the summer. Adult insects, mainly coleopterans and dipterans, were the major components of the diet in the summer samples. More fish had empty stomachs in the winter (67.3%) than during the summer (8.9%).

Food volumes of different sized fish were found to vary linearly with little difference in percent fullness. The smaller fish ate the smallest foods (ants and chironomids). Medium sized fish ate more algae and aquatic insect larvae while the largest fish ate more of the larger coleopterans and some crayfish chelicerae.

Males and females were found to have differences in their diets. Males ate some different food taxa during the winter. Females had the greatest food volume during the winter. Varying amounts of different food taxa were eaten by each sex during the summer.

Great differences were found between foods eaten and foods available. Ivlev's Index of Electivity was applied to the summer collections and it

was determined that the fish selected for terrestrial insect forms. Hymenopterans and coleopterans were found to have high positive Index values. Dipterans (primarily aquatic) were consistently selected against and had low Index values. Electivity was consistent between sexes. Differences in Index values between sexes indicate the possible preference of some food types by each sex. Food consumption may possibly be influenced by availability and density.

Most foods were selected in the same general proportion as they were found in the drift. Evidence exists showing the fish to be surface feeders. Digestion of soft foods was found to be rapid and complete for fish *in vitro*.

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TABLE OF CONTENTS

LIST OF TABLES

Table

Table

LIST OF FIGURES

Figure

INTRODUCTION

The steelcolor shiner, Notropis whipplei (Girard), is a small freshwater minnow. Its distribution extends from central New York to Minnesota, northern Alabama, and Arkansas; it is very abundant in the Ohio Valley (Jordan and Everman 1896).

The steelcolor shiner undergoes a number of physical changes during the breeding season (Gibbs 1963, Trautman 1957) and behavioral changes (Hankinson 1930, Pflieger 1965, Trautman 1957). Reproduction occurs from June to September, with the peak period in Illinois being July and August (Lewis and Gunning 1959). Hybridization may occur with the spotfin shiner, Notropis spilopterus (Cope) in aquaria but isolating mechanisms prevent natural hybridization (Pflieger 1965). Most individuals reach sexual maturity in their third year with the smallest breeding individuals found to be males, 49 mm; females, 38 mm (Pflieger 1965).

Lewis and Gunning (1959) reported the steelcolor to live only two years with young of the year fish averaging 26-28 mm, yearlings 31 mm, and two year olds 53 mm with an approximate maximum length of 2" (51 mm). Trautman (1957) found young of the year to vary from 1 to 2-1/2" (25-63 mm), yearlings 1.6 to 3" (39-76 mm), adults 2.3 to 4.5" (59-114 mm) with the largest being 5.3" (135 mm). Johnston (1965) captured adults in the Embarras River and Kickapoo Creek (Coles County, Illinois) ranging in length up to 166 mm.

The habitat preferences of the steelcolor shiner vary with locality (Forbes and Richardson 1920, Hubbs and Cooper 1936, Trautman 1957). In general it is a species usually found in streams, although it is not uncommon in lakes. In streams it prefers swift, running water over a clean bottom where vegetation is scant. Forbes and Richardson (1920) found the steelcolor to be extremely abundant in the small creeks and rivers of central Illinois.

Foods of the steelcolor shiner include water mites, animal plankton, carp eggs, their own eggs missing the spawning substrate, terrestrial and aquatic insects, small fish, seeds, anthers and pollen, algae, and other aquatic and terrestrial plant material (Forbes 1883, 1888; Forbes and Richardson 1920; Hubbs and Cooper 1936; Johnston 1965; Lewis and Gunning 1959; Pflieger 1965). All these works except Hubbs and Cooper concluded the steelcolor to be primarily insectivorous. Johnston (1965) found a change in diet with an increased dependence on animal life as fall progressed into winter.

Because of its small size, the steelcolor shiner is probably an important forage fish for piscivorous predators. The purpose of this study was to provide quantitative data on the diet of the steelcolor shiner and, as such, contribute to an understanding of biomass transfer through both aquatic and terrestrial ecosystems. Previous works on the diet of the steelcolor shiner have only been qualitative.

METHODS

I. AREA OF STUDY

Polecat Creek (Coles County, Illinois) was the area of study. It is a small tributary to the Embarras River, entering the river 1.15 km downstream from the intersection of Illinois Route 16 with the Embarras. Polecat Creek then goes easterly, nearly parallel with Route 16, to Ashmore, Illinois and east a short distance further to its origin. The creek lies entirely within Coles County, Illinois and traverses several soil types (Brummett 1972). It measures 23.8 km in length and drains approximately 76 km^2.

Three study sites were used in this project. Site 1 was located approximately 150 m upstream from its entrance into the Embarras River (S 1/2 NE 1/4 Sec. 8 T12N-R10E). This site was bordered to the north by a hardwood forest and to the south by pasture land. The substrate was primarily sand with some silt. The stream width averaged 10 m and the depth varied from 0.1-1.0 m during normal flow. Site 2 was located 2.6 km upstream from site 1 at the intersection of the creek with the unimproved road (N 1/2 NE 1/4 Sec. 9 T12N-R10E). This site was bordered to the north by farmed bottomland and to the south by a hardwood forest. The substrate was primarily sand and gravel with little silt. The width averaged 12 m and stream depth varied from 0.1-1.25 m during normal flow. A log jam formed approximately 30 m upstream from site 2 at midsummer. Site 3 was located 4.6 km upstream from site 1 approximately 250 m east of the iron bridge on the secondary road where the creek takes a sharp turn west (N 1/2 NE 1/4 Sec. 10 T12N-R10E). This site was bordered to the north by a hardwood forest and to the south by rolling farmland. The substrate was primarily gravel with some sand and several rock outcroppings present. The width averaged 8 m and depth varied from 0.1-2.0 m during normal flow. The water depth at each site will increase from 1 to 2 m during high water.

Polecat Creek is generally free of debris except in the fall when leaf litter may accumulate in it. Siltation is very light and the water is usually very clear except during high water after heavy rainfall. The creek will overflow its banks at all sites, but flooding is most severe at site 1 where the Embarras contributes to the inundation.

II. COLLECTION AND ANALYSIS OF SAMPLES

Fish

Specimens of *Notropis whipplei* were collected using a 20' X 4' X 1/4" nylon minnow seine and identified using the characters given by Smith (1972). Samples were taken from October 1974 to September 1975 at irregular intervals from the three sites. Each fish species and its abundance was recorded for most seine hauls. Fish specimens were allowed to suffocate prior to preservation in a 10% formalin solution. Approximately 40 fish were weighed and measured prior to preservation to determine the physical effects of preservation.

In the lab each fish was weighed to the nearest 0.01 g, measured for standard length, several scales were removed above the lateral line at the dorsal fin origin, and sex was determined prior to stomach analysis. The stomach was removed and the percent fullness determined. Contents of the stomach to the first loop of the small intestine were scraped and/or washed into a small dissecting bowl and examined under a 10X dissecting microscope and a 10-100X compound microscope. The different foods were separated into taxonomic categories and measured to volume using a comparison of the food volume to a standard, known volume developed by Richardson and described by Larimore (1957). An estimate was made of the percentage composition made up by the different food categories and the number of individual organisms determined. All information gathered was entered on each fish's individual data sheet.

Organisms in the stomach contents were identified to the smallest practical taxonomic category using the following keys and texts: Burks (1953), Chu (1949), Eddy and Hodson (1962), Jacques (1949 & 1951), Pennak (1952), Ross and Horsfall (1965), Ross et al (1971), and Smith (1950).

After data for the sorted food materials had been tabulated, calculations were made of: 1) the number of stomachs in which each kind of food occurred (frequency of occurrence), 2) the average number of items of each kind of food in the stomachs containing the food (average number of items), 3) the average percent of a food item found in the stomachs containing the food item (percent volume/fish), 4) the average of the percentages of volume comprised by each of the kinds of food in each of the stomachs examined (average of volume percentages), and 5) the percentage of the total volume of all foods represented by each kind of food (percent of total volume). Food selectivity was determined using the Index of Electivity by Ivlev (1961). Analysis of gross physical characteristics was done by use of the IBM 360 computer system at Eastern Illinois University.

Benthos

Benthic samples were taken monthly from May 1975 to August 1975. The samples were taken by use of a grab made especially for the rocky substrate using the basic design of Larimore (1970) but with the quantitative features of the grab designed by Jackson (1970). Benthic samples were placed in gallon jars with a 10% formalin solution and transported to the lab. Each sample was treated with rose bengal as described by Mason and Yevich (1967) prior to hand sorting in a shallow, white enamel pan. Organisms found were placed in small jars containing isopropyl alcohol to remove the stain, and were analyzed using 10-100X compound and 10X dissecting microsopes. Organisms were identified using the keys already mentioned above in the stomach analysis section. The number and kind of each taxonomic category found in the sample was recorded. The number of organisms/m^2 and the number of organisms/m^3 were later calculated.

Drift

Drift samples were taken along with fish samples from June 1975 to September 1975 using 40 mesh/inch nylon netting (Turtox/Cambosco Inc., Chicago, Illinois) mounted on 15 X 31 cm aluminum frames. The frames were supported in the stream by steel rods. A drift net was set resting on the bottom and one with its top just out of the water at each site for approximately an hour while fish and benthos samples were taken. All seining was done downstream from the drift nets. The volume of water passing through the net in one collecting period was determined by measuring the water velocity in the mouth of the net with a Gurley pigmy current meter Model 52 and associating the current speed with the time the net was set. Drift samples were preserved in a 10% formalin solution and transported to the lab for analysis. Organisms were identified and enumerated using compound and dissecting microscopes along with the taxonomic keys already mentioned. The number of each type of organism/100 m^3 of water was calculated from these data.

Water Quality

Oxygen concentration and water and air temperature were recorded at each site for each sampling date using a YSI (Yellow Springs Instrument) Model 51 oxygen meter. Other water parameters were not taken after the first few sampling trips as the quality of the water found in Polecat Creek had already been determined to exceed Federal guidelines for surface waters (Brummett 1972) and no obvious source of minicipal pollution was detected at the three sites or upstream.

RESULTS

I. DRIFT

The taxa collected in the drift and their abundance are listed in Table 1. Chironomids and Ephemeroptera naiads were the most frequently collected organisms. Chironomid larvae were collected in 28 of 29 samples and were the most abundant. Chironomid larvae were most numerous at site 2. Ephemeropterans of the genus Baetis were caught in 16 of 29 samples and were also most numerous at site 2. Cladocerans were numerous at site 3 but all of their number were caught on September 16. While the remaining taxa generally occurred in low numbers in few samples, site 3 had a greater number of taxa.

The surface drift collections contained more taxa than did those from the bottom (Table 1). Generally higher values of abundance were recorded in each taxa for the surface collections as compared to the bottom samples because of a difference in vertical distribution (Waters 1965). A greater abundance of terrestrial insects and arthropods, as well as aquatic insect larvae and naiads, were found in the surface samples. The bottom samples had the greatest frequency of algae.

II. BENTHOS

Dipteran larvae, especially ceratopogonid, chironomid, and simuliid larvae, were the most abundant organisms found in the benthos (Table 2). Ceratopogonid larvae were most abundant at site 1 while chironomid and simuliid larvae were most abundant at sites 2 and 3 respectively. Coleopteran

Table 1. Organisms found in the drift expressed as the average number of organisms/100 m^3 where a=adult, l=larva, I=numph, n=naiad, p=pupa. Numbers in parentheses below site number indicate sample size.

Organism	Site 1 (10)	Site 2 (8)	Site 3 (11)	Surface (15)	Bottom (14)
Coleoptera					
Carabidae a)	0.89			0.59	
Chrysomelidae l)	0.24				0.17
Coccinellidae a)			0.26	0.19	
Dytiscidae l)			0.23		0.18
Elmidae Unknown l)	1.58	0.15	0.52	1.27	0.26
Elsianus sp. a)		0.57		0.30	
l)	0.37	0.22	0.33	0.24	0.38
Simsonia sp. a)	1.06		0.33	0.95	
Stenelmis sp. a)			0.10	0.07	
Heteroceridae a)		0.22			0.13
l)	0.45			0.30	
Mycetophilidae a)		0.32		0.09	
Psephenidae a)	0.37	0.27	0.36	0.51	0.15
Scolytidae l)	0.45			0.30	
Silphidae a)	2.44				0.17
Unknown a)		0.27			0.15
p)			0.12		0.09
Orthoptera					
Locustidae a)	0.45	0.32		0.38	
Diptera					
Anthomyiidae l)	0.25			0.17	
Ceratopogonidae a)	1.03	0.82	0.28	0.62	0.47
l)		4.00		0.26	
Chironomidae a)	0.68	1.11	1.72	1.77	0.42
l)	11.43	32.98	17.14	23.73	15.05
p)	3.35	7.96	8.89	9.19	4.09
Culicidae					
Aedes sp. l)			0.43	0.21	0.12
Anopheles sp. l)	0.89	2.44		1.52	0.40
Chaoborus sp. l)		0.21	0.15		0.24
Dixidae p)		0.50		0.26	
Dolichopidae a)			0.10	0.07	
Drosophilidae a)	0.68		1.82	0.82	1.06
Empidae a)			2.54	0.07	1.92
Muscidae a)	1.05		0.17	0.60	0.24
Mycetophilidae a)			1.55	1.13	
Psychodidae a)	0.45		0.58	0.73	
Phoridae a)			0.15		0.12
Pteromalidae a)			0.26	0.19	
Rhagionidae a)			1.04	0.76	
Simuliidae a)			1.38	0.07	
l)	0.37	0.65		0.90	0.67
Syrphidae a)	0.69		0.10	0.37	
Unidentified a)		0.32		0.17	
p)	0.33				0.24
Ephemeroptera					
Ameletus sp. n)	0.59	0.82	0.19	0.58	0.42
Baetis sp. n)	2.76	3.71	1.63	2.57	2.62
Caenis sp. a)			0.35	0.26	
n)		0.30	1.63	0.33	0.31
Cloeon sp. n)		0.27	1.67	0.90	0.51
Ephemerella sp. n)		0.55		0.29	
Unidentified a)			0.35	0.26	
n)		0.27			0.15

Table 1, Continued.

Organism	Site 1 (10)	Site 2 (8)	Site 3 (11)	Surface (15)	Bottom (14)
Lepidoptera					
Unidentified l)	0.25		0.36	0.43	
Hemiptera					
Gerridae a)	0.84	0.48	0.17	0.94	
I)			0.65	0.47	
Pentatomidae a)		0.48		0.26	
Veliidae I)	0.45			0.30	
Homoptera					
Aphidae a)	0.37	0.71	0.23	0.24	0.58
Cicadellidae a)			0.35	0.55	
I)	0.89			0.30	
Membracidae a)	0.45			0.30	
Phylloxeridae a)			0.10	0.07	
Neuroptera					
Hemerobiidae a)			0.10	0.07	
Hymenoptera					
Formicidae Unid. a)			0.19	0.14	
<u>Neivamyrmex</u> sp. a)			0.10	0.07	
<u>Solonopsis</u> sp. a)			0.10	0.07	
Pteromalidae a)			0.17	0.27	
Vespidae a)			0.28	0.21	
Thysanoptera					
Aelothripidae a)			0.25	0.07	0.12
Trichoptera					
Hydropsychidae					
<u>Diplectrona</u> sp. l)			1.88	0.07	1.40
Unknown l)			0.39	0.29	
Odonata					
<u>Hagenius</u> <u>brevistylus</u> n)		0.55		0.17	0.13
Unidentified Eggs			2.11	1.54	+
Arachnida					
Lycosidae	0.37			0.24	
Agelenidae	1.80		0.10	1.26	
Clubionidae			0.26	0.19	
Dyseridae	0.89			0.59	
Pisauridae	0.77			0.30	0.24
Thomisidae			0.10	0.07	
Hydrachnalidae			0.17	0.12	
Hydracarina					
<u>Sperchnopsis</u> <u>verrucosa</u>			0.63	0.46	
<u>Arrenurus</u> sp.			0.28	0.21	
Annelida					
Oligochaeta		0.55		0.29	
Cladocera					
<u>Ceriodaphnia</u> sp.		0.22		6.39	0.13

Table 1, Continued.

Organism	Site 1 (10)	Site 2 (8)	Site 3 (11)	Surface (15)	Bottom (14)
Nematoda		0.27	0.48	0.35	0.15
Copepoda	0.25			0.17	
Amphupoda					
Hyalella azteca			0.35	0.26	
Coelenterata					
Hydra americana (Hyman)			0.30		0.23
Unidentified Fish Fry	0.93		0.57	0.51	0.58
Algae*					
Cladophora sp.		C	C	C	C
Ulothrix sp.	C	A	C	C	A
Vaucheria sp.			R	R	C

+ Present but no record of abundance.

* Algae only classed as to relative abundance where A=abundant, C=common, R=rare.

Table 2. The average number of organisms found in the benthos at each site from May 18, 1975 to August 23, 1975; where a=adult, l=larva, p=pupa, n=naiad. The ratio of m^2/m^3 is equal to 1/22.479.

Taxon	Site 1		Site 2		Site 3		All Sites	
	$\#/m^2$	$\#/m^3$	$\#/m^2$	$\#/m^3$	$\#/m^2$	$\#/m^3$	$\#/m^2$	$\#/m^3$
Coleoptera								
Elmidae								
Elsianus sp. l)	11.2	281.0	18.7	468.3	28.1	702.5	17.5	437.1
Simsonia sp. a)	2.8	70.2	3.7	93.7	5.6	140.5	3.7	93.7
Unidentified l)	1.1	28.1					0.5	12.5
Psephenidae l)			3.7	93.7			1.2	31.2
Diptera								
Ceratopogonidae a)			3.7	93.7			1.2	31.2
Stilobezzia sp. l)	38.8	969.5	22.5	562.0			24.7	618.2
Palpomyia sp. l)	5.6	140.5			28.1	702.5	8.7	218.6
Culicoides sp. l)	22.5	562.0	11.2	281.0			13.7	343.4
Chironomidae l)	776.1	19402.6	4915.5	122887.9	2225.5	55636.7	2478.0	56642.1
p)	13.5	337.2	146.1	3652.9	73.1	1826.5	70.9	1773.4
Culicidae								
Chaoborus sp. l)	39.3	983.5					17.5	437.1
Tabanidae								
Chrysops sp. p)	2.8	70.2					1.2	31.2
Tetanoceridae l)					5.6	140.5	1.2	31.2
Simuliidae l)	2.8	70.2	26.2	655.7	73.1	1826.5	26.2	655.7
Unidentified p)	2.8	70.2					1.2	31.2

Table 2, Continued.

Taxon	Site 1 #/m2	Site 1 #/m3	Site 2 #/m2	Site 2 #/m3	Site 3 #/m2	Site 3 #/m3	All Sites #/m2	All Sites #/m3
Ephemeroptera								
Ameletus sp. n)			3.7	93.7			1.2	31.2
Caenis sp. n)	9.6	238.8	7.5	187.3	16.9	421.5	10.5	199.8
Hexagenia sp. n)	2.8	70.2					1.2	31.2
Arachnida								
Argiopidae			3.7	93.7			1.2	31.2
Hydracarina								
Frontipoda sp.	2.8	70.2					1.2	31.2
Nematoda			11.2	281.0	16.9	421.5	7.5	187.3
Annelida								
Oligochaeta	89.4	2233.9	138.6	3465.6	16.9	421.5	89.7	2241.7
Copepoda								
Cyclops sp.	2.8	70.2	33.7	843.0	67.5	1686.0	27.9	686.9
Amphipoda								
Hyalella azteca	5.6	140.5					2.5	62.4
Mollusca								
Sphaerium sp.			3.7	93.7	16.9	421.5	5.0	124.9

Table 2, Continued.

	Site 1		Site 2		Site 3		All Sites	
	#/m^2	#/m^3	#/m^2	#/m^3	#/m^2	#/m^3	#/m^2	#/m^3
Bryozoa								
Fredricella sp.					16.9	421.5	3.7	93.7
Egg Masses Unid.	5.6	140.5	2248.0	56198.7			751.8	18795.3
Algae*								
Mougeotia sp.	A							
Pithophora sp.	R							
Spirogyra sp.	R							
Ulothrix sp.	A							

*Algae measured by relative abundance where A=abundant, R=rare.

larvae, especially Elsianus sp., were abundant as were ephemeropteran naiads of the genus Caenis. Oligochaeta were most abundant at site 2 as were unidentified egg masses. Copepods increased in abundance from site 1 to 3. Filamentous algae were detected only in samples from site 1. Other taxa occurred sporadically or in small numbers.

III. FISH

Specimens of N. whipplei were collected from a variety of habitats but most were taken in pools or quiet waters having at least some brush or roots in the water nearby, especially during the breeding season. The species of fish caught and their abundance at each site is shown in Table 3. Most of the fish species showing a preference for clean, swift water (i.e., northern hog sucker, most darters) were found only at sites 2 and 3. Other fish (i.e., spotted sucker, channel catfish) were found only at site 1 where the habitat is similar to that found in the Embarras River. Steelcolor shiners decreased in abundance upstream as was also found by Larimore and Smith(1973).

There were physical differences found in the specimens of N. whipplei collected from the three sites (Table 4). Standard length increased from site 1 to 3 as did percent fullness for both seasons. Weight and food volume also increased upstream but only during the summer. A decrease in weight as well as food volume occurred during the winter at site 3. A comparison of the physical parameters of the fish at each site using Student's t test gives no significant difference in any of the parameters between sites 2 and 3 during the winter but does give a significant difference in the average standard length of fish at site 2 and food volume at site 3 when comparisons are made between winter and summer values. Significant differences do exist in the standard length of fish between each site during the summer (Table 4).

Table 3. Species of fish captured in Polecat Creek and their relative abundance expressed in percent.

Species	Site 1 14 Samples	Site 2 24 Samples	Site 3 21 Samples
Grass Pickerel Esox americanus Gmelin	0.6	*	0.2
Stoneroller Campostoma anomalum (Rafinesque)	*	2.9	9.2
Silverjaw Minnow Ericymba buccata Cope	1.1	31.6	12.4
Striped Shiner Notropis chrysocephalus (Rafinesque)	*	1.9	2.4
Spotfin Shiner Notropis spilopterus (Cope)	7.4	1.0	2.9
Sand Shiner Notropis stramineus (Cope)	0.6	2.2	4.4
Redfin Shiner Notropis umbratilis (Girard)	5.7	16.9	25.6
Steelcolor Shiner Notropis whipplei (Girard)	33.1	12.2	11.7
Suckermouth Minnow Phenacobius mirabilis (Girard)	*	0.3	*
Bluntnose Minnow Pimephales notatus (Rafinesque)	22.9	21.7	17.4
Creek Chub Semotilus atromaculatus (Mitchill)	*	3.9	4.8
Northern Hog Sucker Hypentelium nigricans (Lesueur)	*	0.5	0.2
Spotted Sucker Minytrema melanops (Rafinesque)	0.6	*	*
Channel Catfish Ictalurus punctatus (Rafinesque)	0.6	*	*
Brindled Madtom Noturus miurus Jordan	1.7	0.2	0.3
Blackstripe Topminnow Fundulus notatus (Rafinesque)	*	*	0.5
Sunfish Lepomis sp.	22.3	2.0	2.5
Largemouth Bass Micropterus salmoides (Lacepede)	1.1	0.3	1.0
Greenside Darter Etheostoma blennioides Rafinesque	*	0.5	1.7
Rainbow Darter Etheostoma caeruleum Storer	*	1.0	1.3
Fantail Darter Etheostoma flabellare Rafinesque	*	0.7	1.1
Logperch Perca flavescens (Mitchill)	2.3	*	0.2
Johnny Darter Etheostoma nigrum Rafinesque	*	0.2	0.2
Orangethroat Darter Etheostoma spectabile (Agassiz)	*	+	+

*Not recorded from this site.

+Present but no record of abundance.

Table 4. Physical parameters of steelcolor shiners collected from each site with information on food bulk given as sample means.

Parameter	Winter 55 Fish			Summer 236 Fish		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Standard Length (mm)	ND	55.6+	56.1	45.6*	51.9*+	56.6*
Weight (grams)	ND	3.12	2.85	1.58	2.25	3.13
Food Volume (mm^3)	ND	1.0	0.9+	4.5	10.3	10.7+
Percent Fullness	ND	3.1	4.1	36.5	46.6	50.0

ND Indicates no data.

* Indicates a significant difference between sites at the 95% confidence level.

\+ Indicates a significant difference seasonally between sites at the 95% confidence level.

A comparison of the physical parameters between sexes (Table 5) shows no significant difference between them at the 95% level of confidence. While standard length and weight were greater in the males, the food volume and percent fullness were greater in females.

Because scale annuli were difficult to detect in the specimens collected by the scale imprint method (Lagler 1956), a length-frequency plot was made (Fig. 1) to determine the age of the fish at a given length. Specimens of less than 40 mm standard length were able to go through the 1/4" mesh of the seine, thus excluding those fish from application to the length-frequency plot. Lewis and Gunning (1959) found yearling N. whipplei to be 31 mm in length, Trautman (1957) found them to be 39-76 mm, and Emery and Wallace (1974) in their work on the blacknose shiner (Notropis heterolepis) found an annulus formed at 41 mm standard length. For this reason it is reasonable to say that the steelcolor shiners in this study at or about 40 mm SL are beginning their second year of life. A similar frequency of capture between 40-49 mm and 50-59 mm groups indicate they belong to the same age class. Differences in the 60-69 mm and 70-80 mm groups indicate the existence of two, possibly three, age classes besides the young of the year (1975) class.

A varying relationship of length to weight was found (Fig. 2). Greater variation in weight to length existed between the larger fish. Preserved weight increased 20.35% while standard length decreased 1.23% compared to fresh specimens.

Fish captured during the winter and summer were analyzed separately and a difference in diet composition was noted (Table 6). More food items were represented in the diet of the fish collected in the summer. The fish in the winter collections ate proportionally more aquatic insect larvae, naiads, and nymphs than did those in the summer. Aquatic insect forms

Table 5. Physical characteristics of male and female steelcolor shiners collected from the three sites. All numbers given are mean values.

Measurement	Males 171 Fish	Females 120 Fish	$\overline{X}$
Standard length (mm)	51.8	51.3	51.6
Weight (grams)	2.39	2.36	2.38
Food Volume (mm^3)	5.9	7.0	6.4
Percent Fullness (Stomachs)	34.5	37.8	35.9

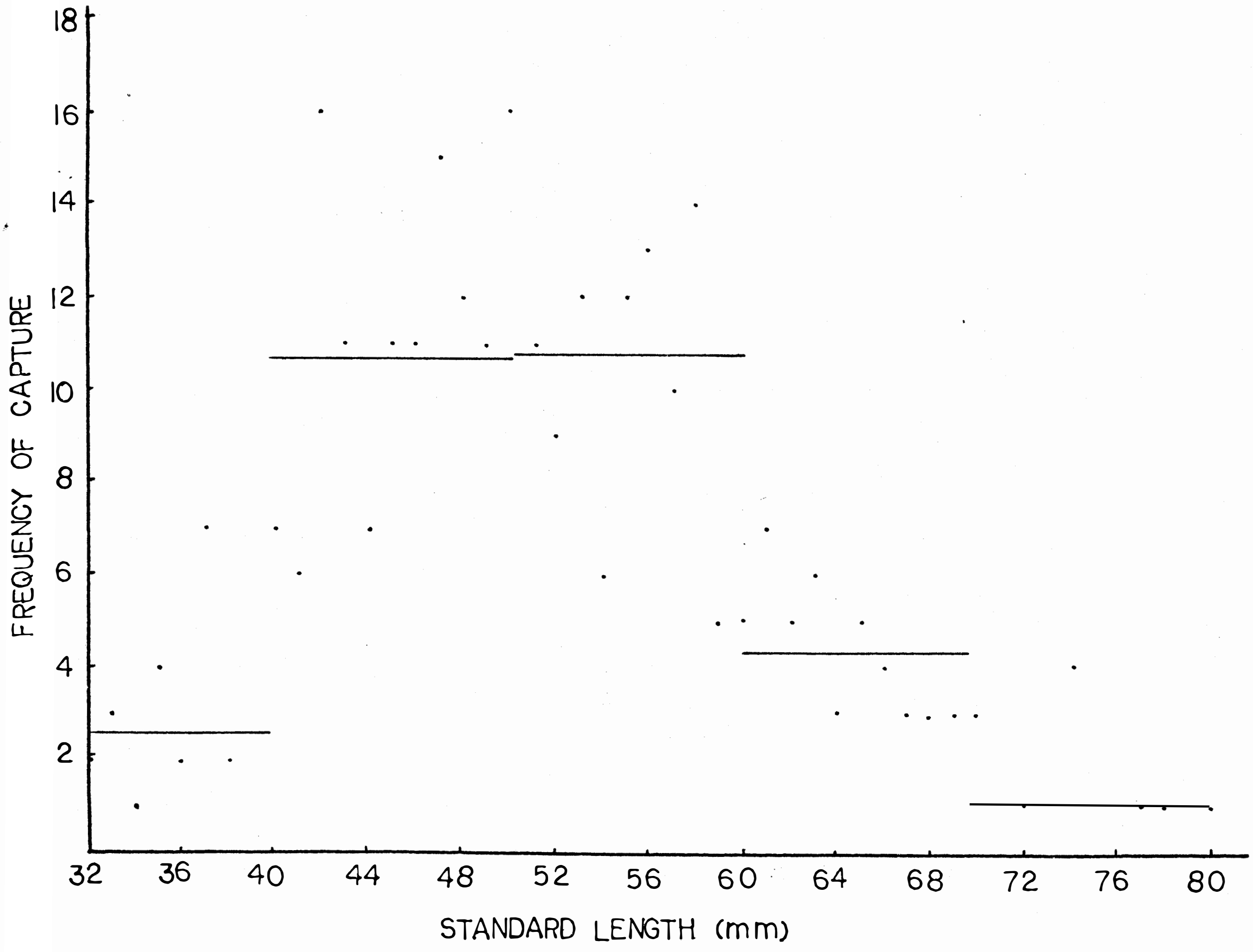

Fig. 1. Frequency of capture plotted vs. standard length for the entire N. whipplei population sampled. Solid lines indicate an average number of individual captures/length group.

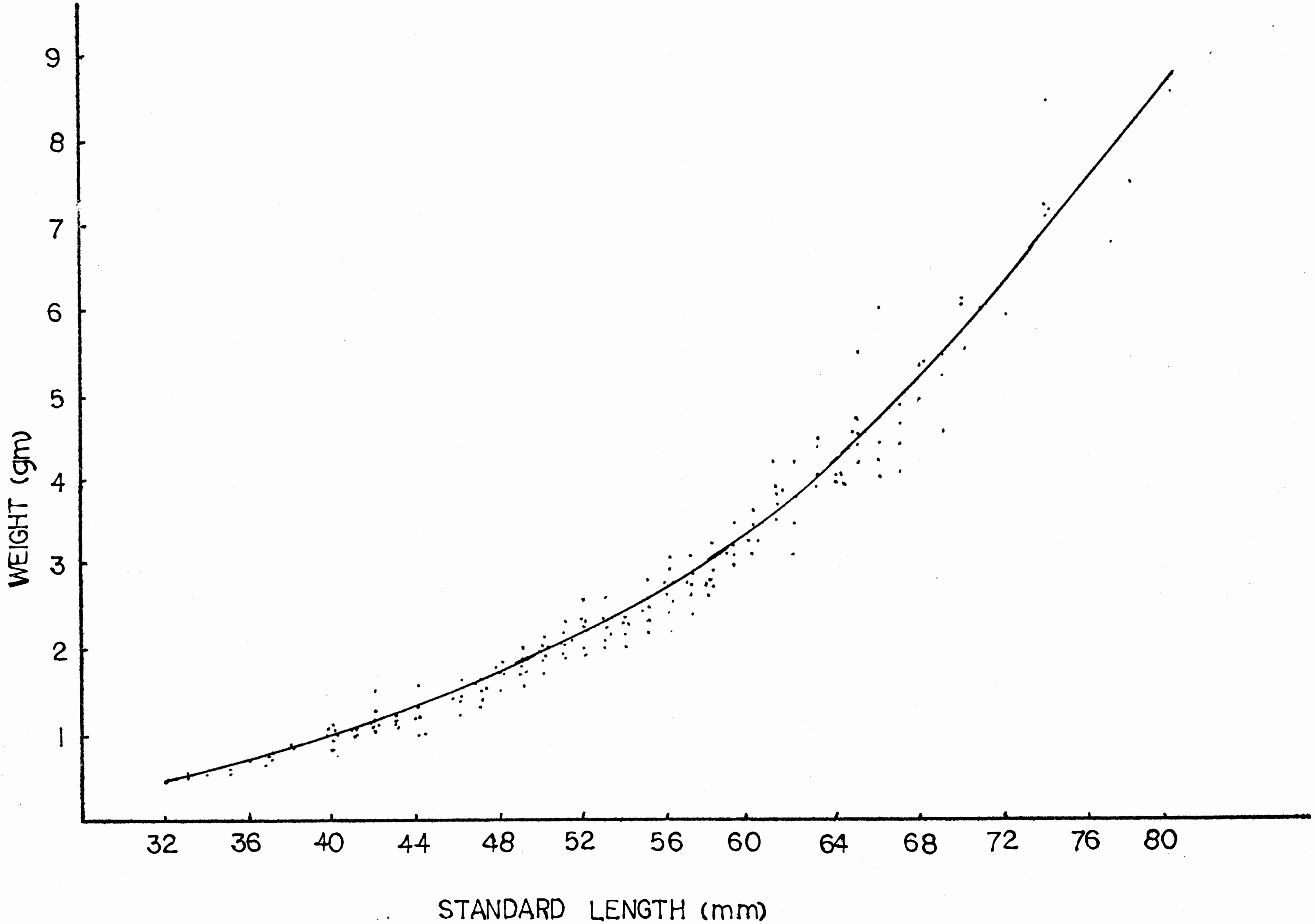

Fig. 2. Preserved weight and length of all <u>N. whipplei</u> collected from October 1974 to September 1975.

Table 6. Seasonal variation in the diet of steelcolor shiners collected during the winter (October 20, 1974-April 10, 1975) and those collected during the summer (June 10, 1975-September 16, 1975); where a=adult, l=larva, I=nymph, n=naiad, p=pupa, T=trace amount.

Taxon	Winter 55 Fish					Summer 236 Fish				
	Number with Food Item	Average Number of Items/Fish	Percent Volume/ Individual Fish	Average of Volume Percentages	Percent of Total Volume	Number with Food Item	Average Number of Items/Fish	Percent Volume/ Individual Fish	Average of Volume Percentages	Percent of Total Volume
Coleoptera										
Rhyncophera a)						1	2.0	40.0	0.2	0.8
Carabidae a)						4	1.3	67.5	1.3	0.8
Chrysomelidae a)						3	1.0	50.0	0.7	1.2
l)						1	1.0	70.0	0.3	0.4
Coccinellidae a)						1	1.0	85.0	0.4	0.5
l)						2	1.0	40.0	0.4	0.3
Curculionidae a)						1	1.0	35.0	0.2	0.2
Elmidae a)						3	1.0	61.7	0.9	0.7
l)						3	1.0	13.3	0.2	0.4
Erotylidae a)						1	1.0	55.0	0.3	0.1
Histeridae a)						2	1.0	40.0	0.4	0.9
Hydrophilidae a)						1	1.0	5.0	T	0.5
Omophronidae a)						1	1.0	35.0	0.2	0.2
Psphenidae l)						1	1.0	35.0	0.2	0.1
Staphylinidae a)						1	1.0	70.0	0.3	0.4
Unidentified a)	1	1.0	50.0	2.8	1.1	31	1.1	33.3	4.8	6.1
l)						12	1.0	55.0	3.1	7.4
Diptera										
Cecidomyidae a)						1	1.0	10.0	T	T
Ceratopogonidae a)						6	1.3	18.0	0.5	0.2
Chironomidae a)						23	1.7	27.9	3.0	1.1
l)	13	7.5	46.9	33.9	39.5	28	2.1	31.8	4.1	2.5
p)						9	1.2	23.3	1.0	0.4
Culicidae										
Culicinae l)						2	1.0	35.0	0.3	0.2
Chaoborinae l)	1	1.0	50.0	2.8	1.1	1	1.0	59.0	0.3	0.5
Drosophilidae a)						4	2.3	36.3	0.7	0.4
Muscidae a)						1	1.0	50.0	0.2	0.1
Simuliidae a)						4	1.3	16.0	0.2	0.2
l)	1	7.0	50.0	2.8	22.3					
Tetanoceridae l)						1	1.0	10.0	T	0.5
Unidentified a)						39	1.5	40.7	7.4	8.9
Ephemeroptera										
Baetis sp. n)						3	1.7	84.8	1.2	2.9
Caenis sp. n)	1	1.0	45.0	2.5	2.0					
Isonychia sp. n)						1	1.0	100.0	0.5	2.3
Unidentified n)	1	1.0	25.0	1.4	1.1	24	1.3	49.4	5.5	3.9
Lepidoptera										
Unidentified a)						2	1.0	25.0	0.2	0.3
l)						8	1.0	57.5	2.1	5.5
Hemiptera										
Corixidae a)						12	1.0	26.8	1.5	2.0
I)						2	1.0	40.0	0.4	0.1
Gerridae n)	1	1.0	45.0	2.5	2.0	5	1.0	20.4	0.5	0.9
Pleidae a)	1	4.0	25.0	1.4	1.1	2	3.0	45.0	0.4	0.1
Unidentified a)						2	1.0	30.0	0.3	0.2

Table 6, Continued.

Taxon	Winter 55 Fish: Number with Food Item	Winter: Average Number of Items/Fish	Winter: Percent Volume/ Individual Fish	Winter: Average of Volume Percentages	Winter: Percent of Total Volume	Summer 236 Fish: Number with Food Item	Summer: Average Number of Items/Fish	Summer: Percent Volume/ Individual Fish	Summer: Average of Volume Percentages	Summer: Percent of Total Volume
Homoptera										
Aphidae a)						1	1.0	2.0	T	T
Neuroptera										
Sialidae a)						1	2.0	70.0	0.3	0.6
Hymenoptera										
Braconidae a)						1	1.0	35.0	0.2	1.2
Formicidae a)						31	1.3	41.6	6.0	5.4
Pteromalidae a)						1	1.0	20.0	0.1	0.1
Unidentified a)						16	1.0	32.4	2.4	4.0
Trichoptera										
Hydropsychidae l)	2	1.5	19.0	2.1	7.6	2	1.0	30.0	0.3	0.6
Unidentified l)						2	1.0	22.5	0.2	0.3
Odonata										
Anisoptera n)						5	1.4	66.0	1.5	2.6
Zygoptera a)						2	1.0	73.0	0.4	0.6
n)						1	1.0	40.0	0.2	T
Unid. Insect Frag.	4		39.0	8.7	2.0	65		45.8	13.8	8.3
Unid. Arthropod Frag.						4		15.0	0.3	0.1
Unid. Plant Material						10		34.3	1.6	0.6
Detritus	1		30.0	1.7	5.3	65		33.8	10.2	8.9
Plant Seeds						14	9.6	20.9	1.4	1.3
Sand Grains	4	3.0	25.5	5.7	1.4	17	2.4	17.5	1.4	0.5
Unidentified Eggs						5		44.0	1.0	2.1
Arthropoda										
Arachnida										
Attidae						1	1.0	25.0	0.1	0.1
Lycosidae						1	1.0	20.0	0.1	0.2
Clubionidae						1	1.0	10.0	T	0.1
Unidentified						1	1.0	25.0	0.1	0.2
Hydrachnalidae						1	1.0	T	T	T
Hydracarina						2	1.0	T	T	T
Collembola						5	1.0	1.0	T	T
Cladocera						1	1.0	5.0	T	T
Copepoda	3	3.7	66.7	11.1	0.9	4	1.0	12.5	0.2	T
Isopoda										
<u>Asellus</u> sp.						1	1.0	100.0	0.5	1.1
Unidentified						1	2.0	50.0	0.2	T
Amphipoda Unid.	2	1.5	7.5	0.8	4.6	5	1.2	35.0	0.8	0.7
Decapod Fragments						2	1.0	50.0	0.5	2.1

Table 6, Continued.

Taxon	Winter 55 Fish: Number with Food Item	Winter: Average Number of Items/Fish	Winter: Percent Volume/ Individual Fish	Winter: Average of Volume Percentages	Winter: Percent of Total Volume	Summer 236 Fish: Number with Food Item	Summer: Average Number of Items/Fish	Summer: Percent Volume/ Individual Fish	Summer: Average of Volume Percentages	Summer: Percent of Total Volume
Rotifera	1	1.0	1.0	0.1	0.4	12	1.0	12.4	0.7	T
Nematoda	2	1.0	18.0	2.0	0.8	3	1.0	13.0	0.2	0.1
Nematomorpha						1	1.0	1.0	T	T
Annelida										
Tubificidae						1	4.0	3.0	T	0.1
Unidentified	1	1.0	65.0	3.6	0.7					
Algae										
Anabaena sp.						4		5.8	0.1	0.1
Cladophora sp.	2		85.0	9.4	5.8	3		30.0	0.4	0.7
Closterium sp.						3		8.0	0.1	T
Diatoms Unid.	1		1.0	0.1	T	12		2.8	0.2	T
Amphora sp.						1		T	T	T
Cymbella sp.						62		4.4	1.0	0.6
Fragilaria sp.						10		3.4	0.1	0.1
Gyrosigma sp.						21		3.8	0.3	0.1
Navicula sp.	2		50.5	5.6	T	56		7.1	1.5	0.1
Nitzschia sp.						15		T	T	T
Filamentous Unid.	1		1.0	0.1	T	4		15.0	0.3	0.1
Hormidium sp.						5		11.0	0.3	0.1
Hydrodictyon sp.						1		T	T	T
Microspora sp.						24		4.0	0.4	0.3
Mougeotia sp.						10		18.8	0.9	0.6
Oocystis sp.	1		4.0	0.2	0.2					
Oscillatoria sp.						5		T	T	T
Pediastrum sp.						3		12.3	0.2	T
Rhizoclonium sp.						3		38.3	0.5	0.7
Scenedesmus sp.						1		5.0	T	T
Ulothrix sp.						2		49.0	0.5	0.2
Zygnema sp.						1		7.0	T	T
Gonium sp.						1		T	T	T
Cosmarium sp.						8		25.0	0.9	T
Coccoid Greens Unid.	1		1.0	0.1	T	20		T	T	T
Number of Stomachs Empty	37 (67.3%)					21 (8.9%)				

amounted to 75.6% of the total percentage of foods eaten in the winter as compared to 18.8% for the summer. Chironomid and simuliid larvae made up the majority of the winter foods. Adult insects, particularly coleopterans and dipterans, were the major component of the diet in the summer samples. A greater diversity of algae was eaten in the summertime. A greater percentage of fish had empty stomachs in the winter (67.3%) than in the summer (8.9%). While the proportions of the individual components in the diet differed for winter and summer collections, the percentage of each food category remained stable (Fig. 3).

Different length groups corresponding to the length-frequency plot (Fig. 1) were analyzed and found to have a linear relationship of food volume to length (Fig. 4) while percent fullness varied slightly (Fig. 5). The percentage composition of each food category is found to remain relatively stable (Table 7) while there is a compensatory effect of plant to animal matter (Fig. 6). While most components in the diet have a similar percentage of total volume, some differences can be noted (Table 8). The 32-39 mm group ate more dipteran pupae (primarily chironomids) and hymenopterans (primarily ants) than the other groups. These foods were some of the smaller foods available. Coleoptera and Lepidoptera larvae were eaten more by the 40-49 mm group than by the other groups. The 50-59 mm group ate more adult dipterans and algae while the 60-69 mm group ate more ephemeropterans than the other groups. The 70-80 mm group had 45.4% of their diet made up of coleopterans and ate more other animal matter of larger size (primarily crayfish chelicerae) than the other groups.

Males and females were compared seasonally (Table 9) and found to have some differences in their respective diets. Males had several taxa in their diets for the winter that were not represented in females; notably hemipterans,

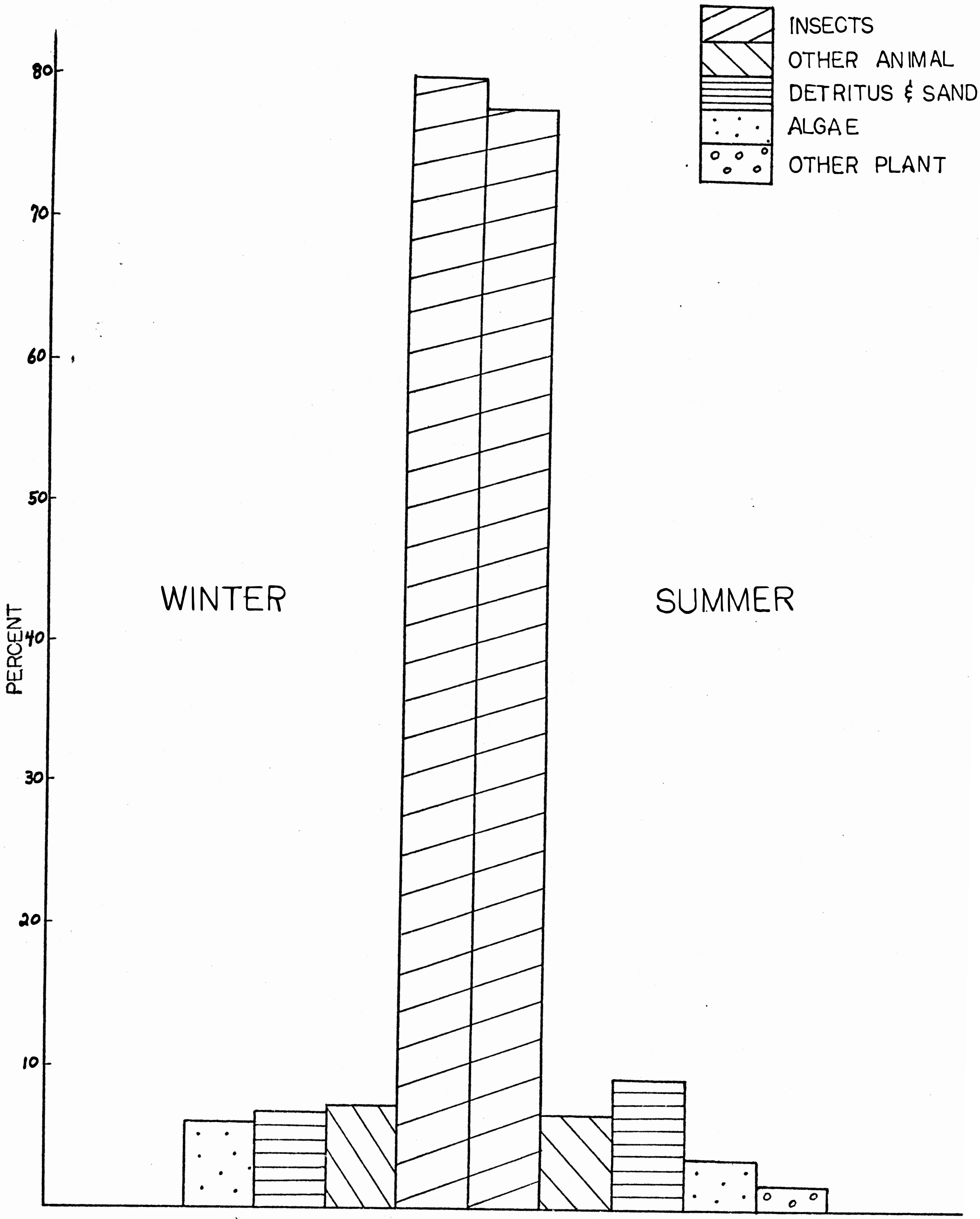

Fig. 3. Composition of the diet from N. whipplei collected during the winter (October 20, 1974-April 10, 1975) and summer (June 10-September 16, 1975) expressed as the percent of total volume.

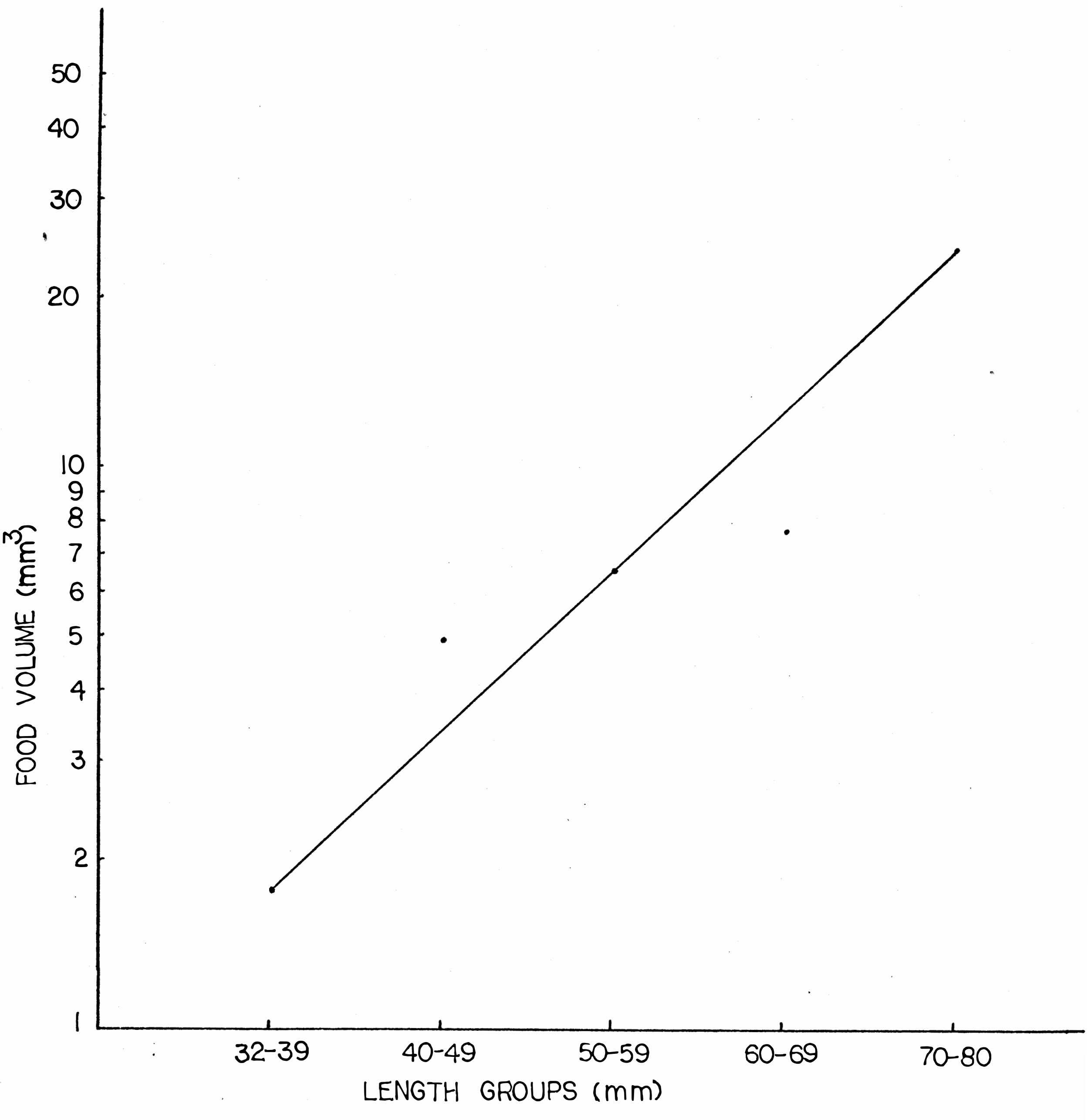

Fig. 4. The relationship of food volume to standard length when comparing different N. whipplei length groups.

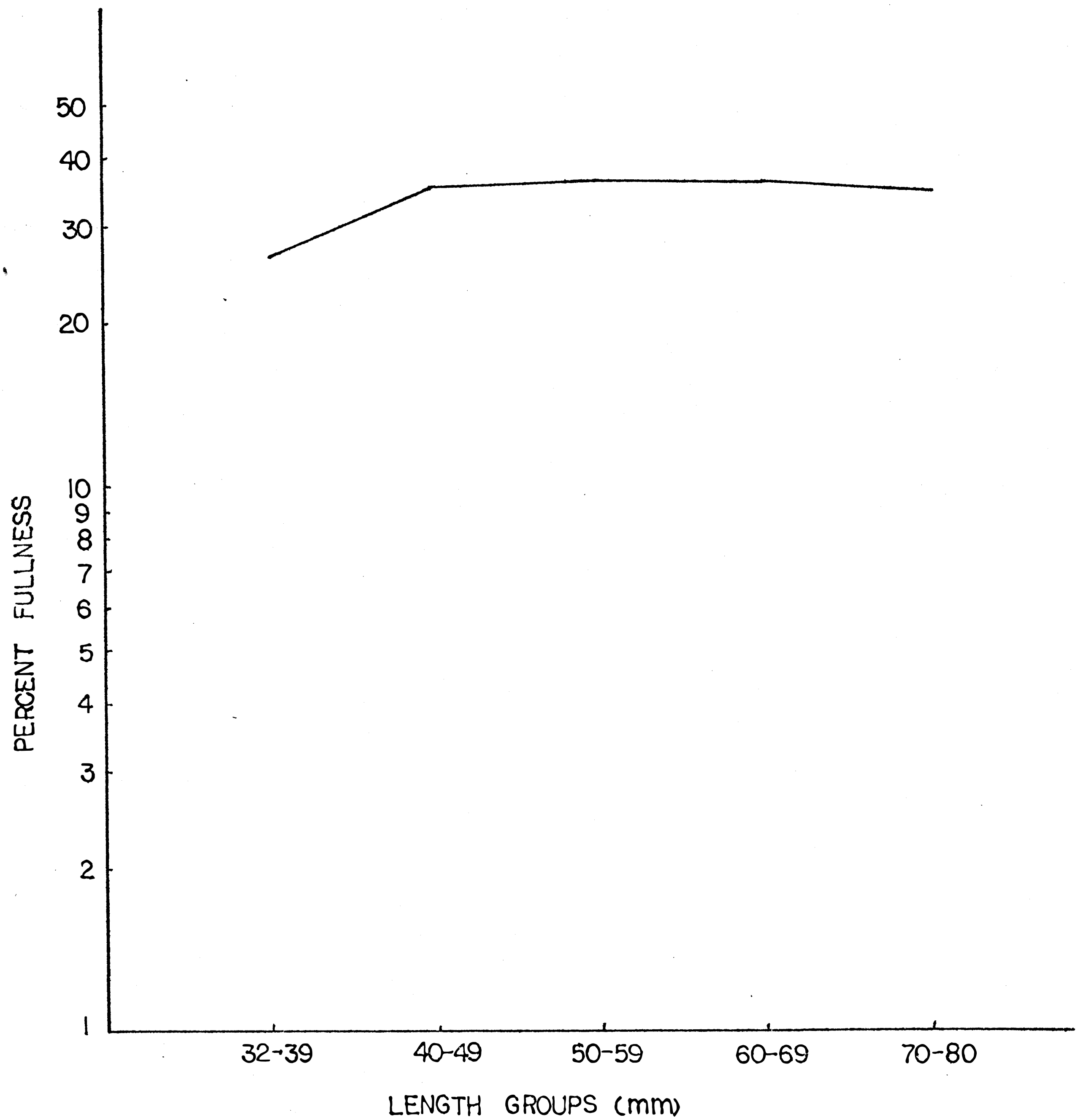

Fig. 5. Variability in percent fullness of stomachs taken from different N. whipplei length groups.

Table 7. Percent of total volume of food groups for the different length classes and for male and female steelcolor shiners.

Length class	Sample Size	Insects	Other Animal	Detritus and Sand	Algae	Other Plant
32-39 mm	21	83.0	4.0	10.1	3.0	0.0
40-49 mm	107	86.3	1.4	7.3	2.5	2.5
50-59 mm	108	70.1	10.9	9.6	7.1	2.2
60-69 mm	44	77.6	7.3	9.8	1.5	0.9
70-80 mm	11	76.8	10.1	12.5	0.0	1.3
Males	171	74.2	6.8	11.3	3.7	3.1
Females	120	79.1	7.4	7.6	5.2	1.4

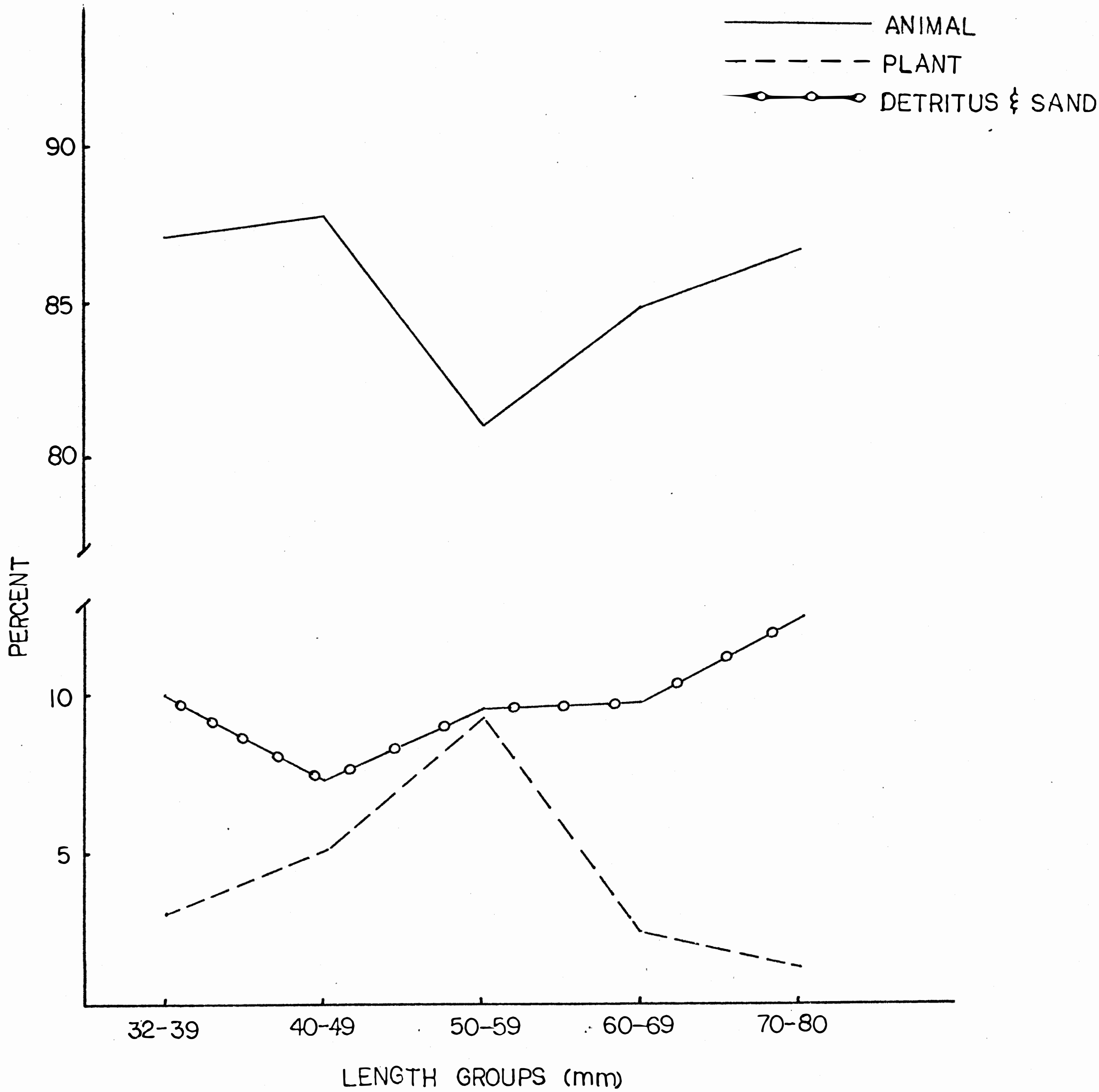

Fig. 6. Percent of animal and plant matter found in different length groups from all N. *whipplei* collected.

Table 8. Percent of total volume of all foods for 236 steelcolor shiners collected during the summer (June 10-September 16, 1975) for five length groupings where a=adult, l=larva, I=nymph, n=naiad, p=pupa, T=trace amount.

Taxon	Length Group (mm) 32-39 21 Fish	40-49 107 Fish	50-59 108 Fish	60-69 44 Fish	70-80 11 Fish
Coleoptera a)	10.8	7.6	10.9	10.3	29.8
l)	4.3	18.3	1.0	2.0	15.6
Diptera a)	9.8	11.7	15.8	5.0	5.4
l)	1.2	5.4	4.1	0.1	4.5
p)	3.8	0.2	0.5	0.6	0.0
Ephemeroptera n)	1.0	5.3	12.4	17.8	0.0
Lepidoptera a)	0.1	0.1			
l)		12.4	1.5	2.6	5.2
Hemiptera a)	2.4	2.6	1.8	4.9	
I)	4.0	0.6	0.6	2.9	
Homoptera a)		0.1			
Hymenoptera a)	18.7	8.8	9.0	11.3	11.0
Neuroptera a)		2.0			
Odonata a)	0		0.8	2.0	
n)	8.7	0.2	3.8	6.9	
Trichoptera l)			0.6	0.7	4.1
Unid. Insect Fragments	18.3	11.2	6.8	12.4	0.8
Unid. Arthropod Frag.	1.1	0.2	T		
Unid. Plant Material		1.1	0.8		
Detritus	8.6	7.1	9.1	10.7	11.0
Sand Grains	1.5	0.3	0.6	0.2	0.8
Plant Seeds		1.5	1.4	1.0	1.4
Eggs Unidentified			6.0		
Arachnida			1.8		
Other Animal Matter	2.9	1.2	3.2	7.1	10.4
Algae					
Cyanophyta		T	T	0.3	
Chlorophyta	3.0	1.5	6.2	0.3	
Bacillariophyta	T	0.8	1.0	1.0	
Number of Empty Stomachs	0	11	7	4	0
Number of Fish	21	95	80	34	6

Table 9. Percent of total volume of all foods eaten by male and female steelcolor shiners from October 20, 1974 to April 10, 1975 (winter) and from June 10 - September 16, 1975 (summer). Numbers in parentheses below sex denotes sample size.

Food	Winter		Summer	
	Males (29)	Females (26)	Males (142)	Females (94)
Coleoptera a)		8.2	14.8	9.1
l)			13.4	3.3
Diptera a)			10.4	11.1
l)	62.0	66.1	3.5	4.3
p)			0.4	0.4
Ephemeroptera n)		14.8	5.3	13.6
Lepidoptera a)			0.1	0.6
l)			2.1	10.2
Hemiptera a)	1.4		2.3	2.1
I)	2.4		1.2	0.7
Homoptera a)				T
Neuroptera a)				1.3
Hymenoptera a)			9.7	9.6
Trichoptera l)	9.2		1.2	0.6
Odonata a)				1.3
n)			2.0	3.6
Unidentified Insect Fragments	1.1	8.2	8.8	7.4
Unid. Arthropod Frangments			0.2	T
Unid. Plant Material			1.8	0.3
Detritus	6.5		10.8	7.2
Plant Seeds			1.4	1.1
Sand Grains	1.4	2.0	0.6	0.5
Unid. Eggs			2.2	1.7
Arachnida			0.2	1.1

Table 9, Continued.

Food	Winter Males (29)	Winter Females (26)	Summer Males (142)	Summer Females (94)
Collembola			0.1	0.2
Amphipoda	5.4	0.8	0.6	0.9
Isopoda			2.2	
Decapod Fragments			1.1	3.4
Other Animal Matter	3.2	0.1	0.1	0.2
Algae				
Cyanophyta			T	0.2
Chlorophyta	7.3	T	2.6	3.2
Bacillariophyta	0.1		0.9	0.8
Number of Stomachs Empty	17	20	13	7

trichopterans, and annelids. Females had a greater average of volume percentage and percent of total volume of dipteran larvae while having important amounts of coleopteran adults and ephemeropteran naiads that were not present in the males' diet for the winter. Summer differences amounted primarily to greater amounts of coleopteran adults and larvae eaten by males, with greater amounts of ephemeropteran naiads and Lepidoptera larvae for females. Summer differences in food consumption between males and females were slight (Fig. 7).

When drift and benthos were compared with stomach contents, great differences were revealed between foods eaten and foods available (Fig. 7). Hymenoptera were scarce in the drift and absent from the benthos but comprised 13.8% of the fishes' food. Diptera were abundant in both drift and benthos but made up only about 40% of the diet. Coleopterans were found more often in the stomachs than in the foods available.

Differences in the percentages of a food available and the same food in the fish stomachs indicate a selection of preferred foods (Ivlev 1961). The different food categories chosen for Figure 7 were examined for evidence of selection of food items from the benthos and drift and the results are given in Table 10. Diptera were consistently selected against with positive selection for all other categories. Selection or non-selection was consistent between sites and sexes. Index values for each site consistently corresponded to the relative abundance of each food type (Fig. 7, Tables 1 and 2) except at site 2 where dipterans were selected indirectly with respect to their relative abundance. Males had a greater preference for coleopterans, ephemeropterans, and dipterans while females had a slightly greater preference for hymenopterans and organisms in the "other" category. High Index values for coleopterans and hymenopterans indicate they are especially

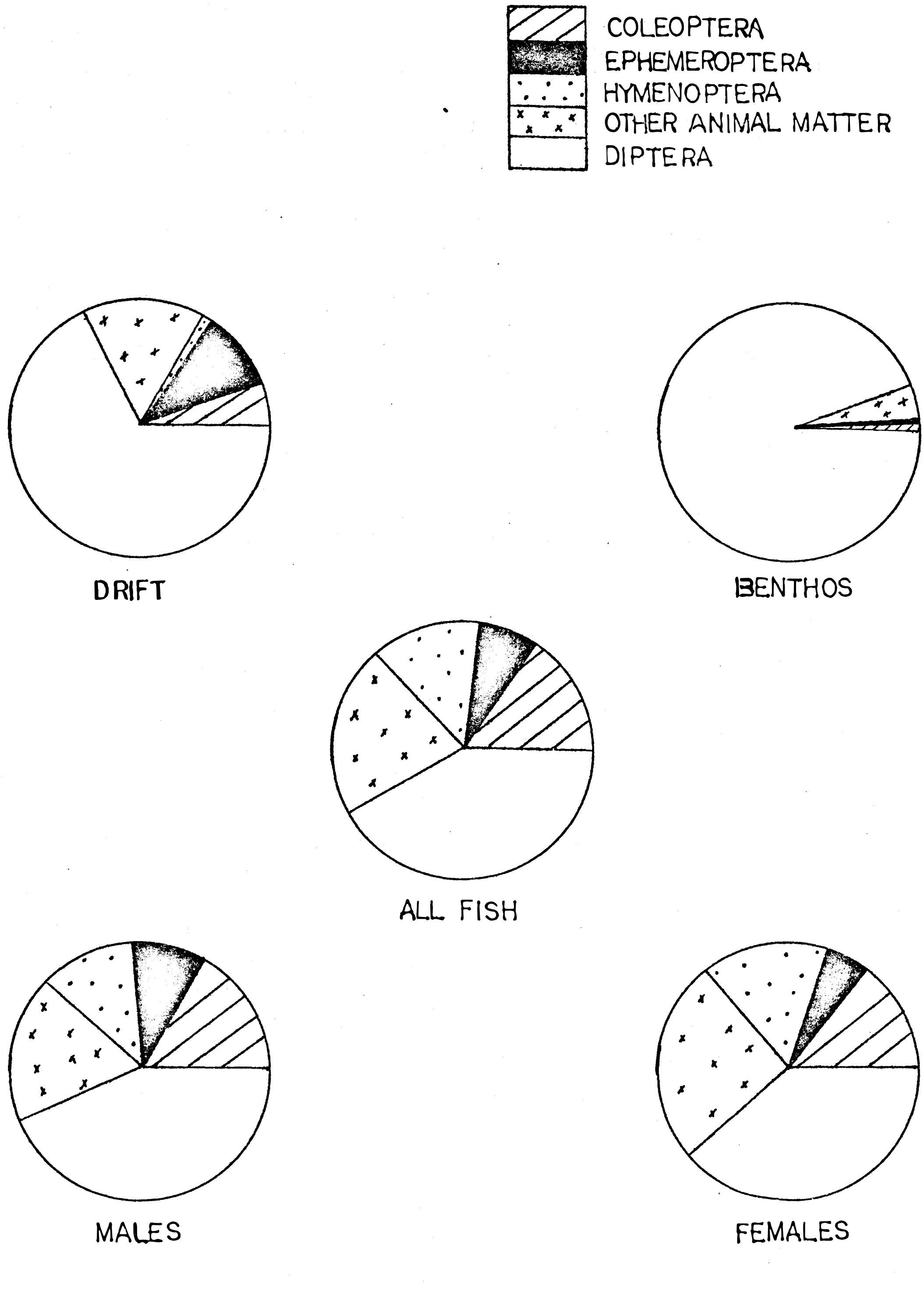

Fig. 7. Composition of drift, benthos, and N. whipplei stomach contents taken from May 18 to September 16, 1975 at the three sampling sites.

Table 10. Selection of foods available during the summer (June 10 - September 16, 1975) by feeding N. whipplei from combined benthos and drift as expressed by the Index of Electivity.[1]

Food	Site 1	Site 2	Site 3	All Sites	Males	Females
Coleoptera	+ .58	+ .80	+ .74	+ .70	+ .79	+ .70
Diptera	- .38	- .30	- .36	- .36	- .35	- .39
Ephemeroptera	+ .22	+ .66	+ .24	+ .40	+ .50	+ .30
Hymenoptera[2]	+ .94	+ .70	+ .83	+ .86	+ .90	+ .94
Other Animal	+ .36	+ .62	+ .25	+ .47	+ .40	+ .54
Aquatic Insects	- .61	- .28	- .58	- .51	- .44	- .42
Terrestrial Insects	+ .58	+ .56	+ .32	+ .52	+ .57	+ .55

[1]The Index of Electivity (Ivlev 1961) expresses the relationship between the ratio of an organism present in the food complex and the ratio of the same organism in the fishes' diet. Positive values indicate selection for the food item, negative values indicate selection against, with a range from +1 to -1.

[2]Hymenoptera found only in drift samples.

preferred foods. When aquatic insects and terrestrial insects were compared by the Index, consistent patterns of selection against aquatic forms and selection for terrestrial insect forms was found (Table 10).

While one does not know what food items are selected from the benthic community and not the drift, the amounts of food contained in the stomachs most closely resembles the amounts of the same food found in the drift (Fig. 7). When comparing the amount and type of food in the drift between surface collections (Table 1) one finds more coleopterans, hymenopterans, and "other" animals in the surface collections. As these taxa were found to be especially preferred, the steelcolor shiner probably chooses food items from the surface or waters above the bottom. My experiments in aquaria indicate this to be true.

The summer collections of fish contained mostly insects or other arthropods with hardened exoskeletons, and those soft-bodied food items found were often in an advanced state of digestion. As the rate of digestion of foods could have had a significant impact on the results of stomach analysis, a rate of digestion experiment was carried out and digestion was found to be quite rapid on soft-bodied food (Fig. 8). While fruit fly larvae were digested to the point of non-recognition within 2.5 hours, adults and pupae were recognizable to order at least 4 hours after feeding at 19.6°C. In general, digestion had not rendered the hardened body parts unrecognizable for the duration of their passage through the stomach.

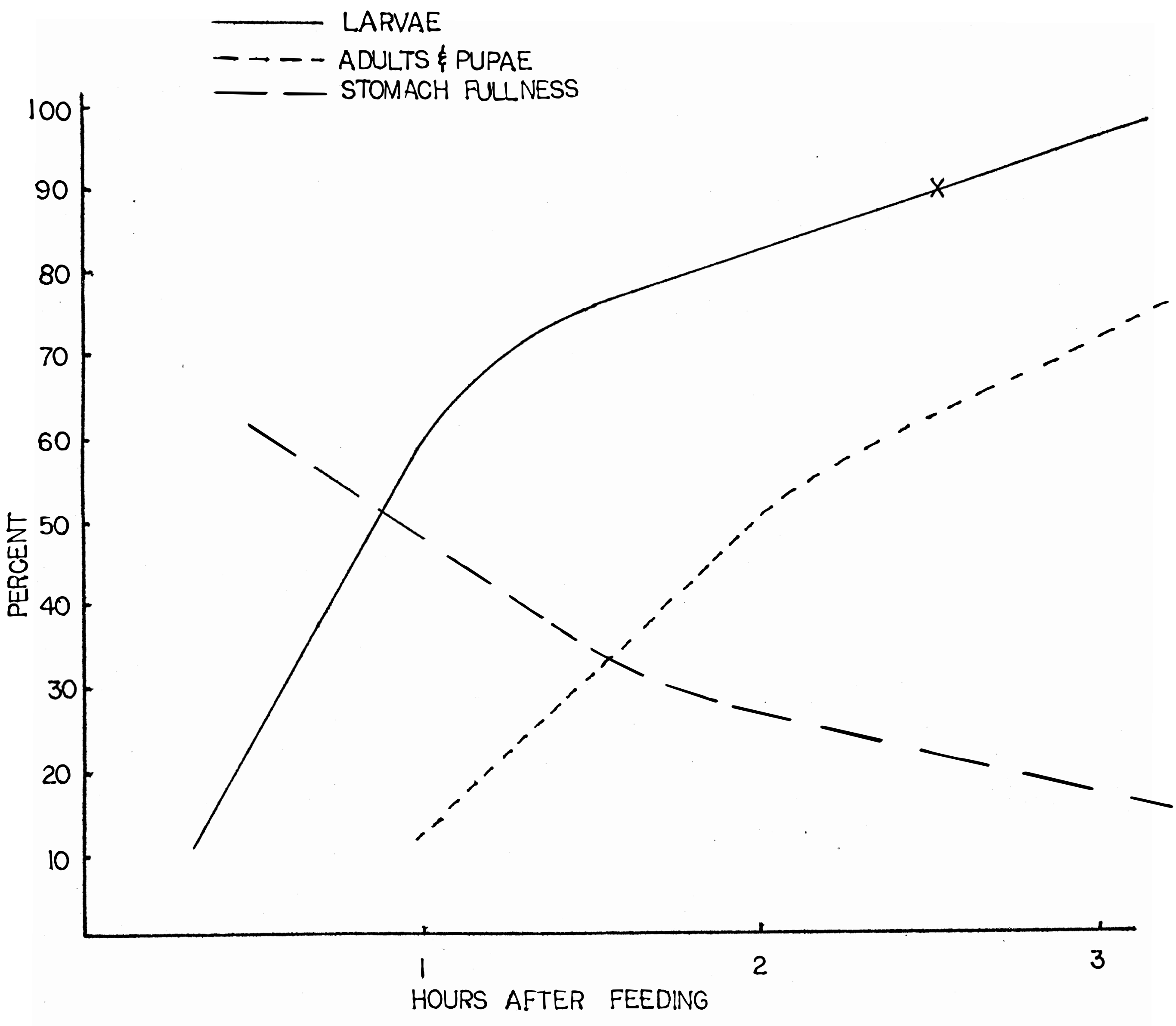

Fig. 8. Relative amounts of digestion of Drosophila melanogaster larvae, adults, and pupae occurring in N. whipplei in aquaria at 19.6 C. The point at which over 50% of the organisms became unrecognizable to order is indicated by (X).

DISCUSSION

A number of factors may influence the food a fish eats. The availability and distribution of prey species as well as defenses the prey might have such as protective armor or coloration, toxicity, size, or speed of movement may all contribute to the organisms a predator can sieze and eat. Progressive satiation of the predator will increase selectivity of preferred foods (Ivlev 1961). Increased numbers of predators will decrease electivity because of more feeding pressure on the prey population (Ivlev 1961). The results found in this study have reflected those variables.

Evidence that the drift of the stream benthos is density related (Dimond 1967) exists between sites for chironomid and ceratopogonid larvae. Dipteran larvae were about the only organisms occurring in high enough numbers to be tested. The log jam that formed at site 2 during midsummer probably had an important effect on the drift of organisms (Larimore 1972) because of the rapid colonization of log substrates by chironomids and other invertebrates (Nilsen 1968).

Chironomid and ceratopogonid larvae were an important component in the foods of fish collected in the winter. The dipteran larvae, ephemeropteran naiads, and other aquatic invertebrates that overwinter in the stream make up the important food base upon which the Notropis whipplei population survives the winter when adult insect forms are unavailable. The shift in diet from the winter and summer seasons indicates a difference in availability of aquatic vs. terrestrial foods. The high rates of consumption of insect larvae and aquatic macroinvertebrates during the winter may also be only a means to prevent starvation; eating only to survive the winter to eat the more desirable summer foods when available. The large percentage of empty stomachs indicates the fish feed infrequently during the winter since foods would be retained in the gut longer because of the lower water temperatures and the corresponding decrease in Q_{10} values (Prosser 1973). My experiments in aquaria indicate N. whipplei to be able to survive up to six months by only feeding occasionally on rotifers and algae. Data from the winter collections indicate that the steelcolor shiner eats fewer kinds of algae but greater volumes of those they do eat.

One would expect differences in the diet from fish taken from different habitats or even collecting sites. A decrease in weight as well as food volume during the winter at site 3 in comparison to the fish at site 2, while standard length remained greater at site 3 indicates the possible decrease or extinction of an important food resource at site 3 during the winter. As drift and benthos were not taken during the winter, the exact cause of the weight difference is unknown. What is significant is the consistent dependence of the steelcolor shiner on the insects occurring in or falling into the water when those insects are available. While some variation in the diet was detected between sites it must be concluded that the steelcolor shiner is primarily an insectivore and could possibly be excluded from areas devoid of large numbers of insects available for food.

The composition of the diet for the different length classes indicates an increase in selectivity for invertebrates other than insects with an increase in standard length (Table 7). The differences in diet for the length classes is probably a result of the size of prey eaten, the degree of mobility of both prey and fish, the level of feeding in the stream (i.e., surface, bottom), or possible interaction with other fish (Raney and Lachner 1946). Ivlev (1961) states there is an increase in selectivity with progressive satiation. The high positive electivity values (Table 10) for insects in general indicate feeding by the steelcolor shiner at or near the surface since most insects would either float or be supported by the waters' surface tension. The consumption of aquatic invertebrates found more often in the surface drift collections (ex. ephemeropteran genera Baetis compared to Caenis) further support this hypothesis. The ingestion of sand is probably incidental or accidental. Plant seeds may be injested because they fit into the ideal size range for prey.

Differences in the diet for males and females indicate either a varied preference for certain foods, a difference in feeding level, or differing metabolic requirements. However, this is inconclusive for the winter samples because of the small number of individuals of each sex having something in their stomach. Enough summer collections were made to say the differences found between sexes, especially in the amounts of coleopterans and ephemeropterans eaten, indicate differences in feeding.

The selectivity of the different food types (Table 10) is especially significant. Since the winter collection contained primarily dipteran larvae (chironomid and simuliid) and since some feeding does take place, there is a probable shift in food preference because of availability (Ivlev 1961). The selection against dipteran larvae (primarily chironomid) during the summer in preference for other forms indicates a shift in selectivity because of availability between the winter and summer seasons. This is supported by noting that selection of foods in the summer is primarily for terrestrial insects (Table 10) and against aquatic forms. While no benthic or drift samples were taken during the winter and selectivity cannot be measured, it seems reasonable that a shift in food preference does take place during the winter.

SUMMARY

The results of this study indicate the steelcolor shiner to be an insectivore which is probably a result of its surface feeding tendency. Foods eaten were diverse and primarily small insects and other arthropods. There is a tendency for more intense feeding during the warmer summer months. Food volume was in proportion to the fish's length.

Males and females had differences in the proportion of each food taxon eaten. These differences may not be significant or are related to metabolic requirements. Especially preferred foods were found to be hymenopterans (primarily ants) and small coleopterans. Other foods were selected in about the same proportion as they were found in the drift. Steelcolor shiners have a rapid digestion rate.

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