



Food habits of the longnose dace, *Rhinichthys cataractae*
by Jerry Wayne Gerald

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Zoology
Montana State University
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Abstract:

Samples of longnose dace, *Rhinichthys cataractae*, and bottom organisms were taken approximately every two weeks from 9 June to 5 Sept., 1963, from a 46,000 Ft² riffle of the Yellowstone River. The organisms from the fish digestive tracts were identified to family and enumerated. The volume of each family was calculated from the average volume per individual in each family. Organisms from each 10 Ft² bottom sample were identified to family and then counted and measured volumetrically by water displacement.

The fish were divided into three size groups (0-49 mm, 50-69 mm, and 70-100 mm) for the analysis of digestive tract contents. The frequency occurrence of all organisms in the fish digestive tracts, percent volume and average number of insects were considered for each of these groups. Baetidae had the highest percent volume and the highest average number in each size group except that Tendipedidae had the highest average number in the 50-69 mm size group. Algae had the highest frequency occurrence in the 0-49 mm group. Tendipedidae was highest in the 50-69 mm group, and Baetidae and Tendipedidae were equally high in frequency occurrence in the 70-100 mm group. Seasonal variation of food was about the same in all three size groups.

Forage ratios were calculated for each size group. Baetidae had the highest forage ratio with 3.9, 5.0, and 6.8 in the small, medium, and large size groups, respectively. The only other family with a ratio greater than 3.0 was Simuliidae which had 5.3 in the 70-100 mm group but less than 1.0 in the other two groups. The ratios of Baetidae, Siphonuridae, and Simuliidae were highest for the largest size group of fish while the ratios of Tendipedidae and all Plecoptera were highest for the smallest size group of fish. While some of the bottom organisms were too large for the fish to eat, the ones found in the digestive tract contents were generally those that were most available and abundant.

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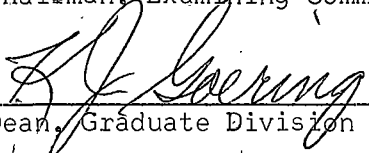
Approved:



Head, Major Department



Chairman, Examining Committee



Dean, Graduate Division

MONTANA STATE COLLEGE
Bozeman, Montana

June, 1965

ACKNOWLEDGEMENT

Thanks are due especially to Dr. C.J.D. Brown who suggested the project and aided with the preparation of the manuscript, and to Dr. Robert E. Moore for his council and encouragement. The field work could not have been done without the cheerful assistance of many friends. The major part of the study was conducted while the writer was recipient of a graduate teaching assistantship at Montana State College. Equipment for collecting fish was provided by the Montana Fish and Game Department and the Fisheries Unit at Montana State College.

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ABSTRACT

Samples of longnose dace, Rhinichthys cataractae, and bottom organisms were taken approximately every two weeks from 9 June to 5 Sept., 1963, from a 46,000 Ft² riffle of the Yellowstone River. The organisms from the fish digestive tracts were identified to family and enumerated. The volume of each family was calculated from the average volume per individual in each family. Organisms from each 10 Ft² bottom sample were identified to family and then counted and measured volumetrically by water displacement.

The fish were divided into three size groups (0-49 mm, 50-69 mm, and 70-100 mm) for the analysis of digestive tract contents. The frequency occurrence of all organisms in the fish digestive tracts, percent volume and average number of insects were considered for each of these groups. Baetidae had the highest percent volume and the highest average number in each size group except that Tendipedidae had the highest average number in the 50-69 mm size group. Algae had the highest frequency occurrence in the 0-49 mm group. Tendipedidae was highest in the 50-69 mm group, and Baetidae and Tendipedidae were equally high in frequency occurrence in the 70-100 mm group. Seasonal variation of food was about the same in all three size groups.

Forage ratios were calculated for each size group. Baetidae had the highest forage ratio with 3.9, 5.0, and 6.8 in the small, medium, and large size groups, respectively. The only other family with a ratio greater than 3.0 was Simuliidae which had 5.3 in the 70-100 mm group but less than 1.0 in the other two groups. The ratios of Baetidae, Siphonuridae, and Simuliidae were highest for the largest size group of fish while the ratios of Tendipedidae and all Plecoptera were highest for the smallest size group of fish. While some of the bottom organisms were too large for the fish to eat, the ones found in the digestive tract contents were generally those that were most available and abundant.

INTRODUCTION

The longnose dace, Rhinichthys cataractae, is common throughout the United States except for the southeastern coastal region. In Montana, this fish is generally found in the shallow portions of cool, rubble-bottomed streams with moderately swift current where it feeds primarily on bottom insects.

Previous studies on the food habits of the longnose dace have been based entirely on stomach analyses. Kuehn (1949) analyzed one collection of 196 stomachs from southeastern Minnesota taken in June, while Reed (1959) studied the stomachs of 796 longnose dace from Pennsylvania taken in September. Gee and Northcote (1963) examined the stomachs of 112 juvenile specimens collected in British Columbia between June and October. In all instances, immature forms of Simuliidae Tendipedidae (Chironomidae) and Ephemeroptera made up about 90% of the stomach contents. No studies were found which gave information based on collections of all age classes over an extended period or which included information on food availability.

The primary purpose of the present study was to determine food habits of the longnose dace over an extended period and to compare the food eaten with that available as indicated by samples of bottom organisms from the area where the fish were taken.

This study was confined to the Yellowstone River and extended from late June to early November, 1963. The study area was a riffle 400 feet long and 140 feet wide on the Yellowstone River near Emigrant, Montana. It had a maximum depth of about two feet and an average depth of about 10 inches. The bottom was composed primarily of rubble (3-6 inches diam)

interspersed with gravel and sand. Water temperature, taken on each collection date, varied from 14 to 17 c. During the study period, the water was relatively clear so that bottom details in calm areas were plainly discernable to a depth of 18 inches. Considerable amounts of algae (mostly Enteromorpha sp.) were found in August, but no other vegetation was observed. Besides the longnose dace, other fish captured, in order of decreasing abundance, were: mottled sculpin (Cottus bairdi), longnose sucker (Catostomus catostomus), brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), mountain whitefish (Prosopium williamsoni), and cutthroat trout (Salmo clarki).

Methods

Ingested Organisms. Longnose dace were collected by shocking with a portable 900-watt maximum output (300v, 3amp) d-c generator and preserved within thirty minutes by injection of 10% formalin into the digestive tract. In the laboratory the digestive tract contents of each fish were removed and examined microscopically. The organisms found were identified to family and enumerated. A few individuals could be identified only to order. The volume of insects was calculated for each family by measuring the water displacement of a known number of whole individuals and calculating the average volume per insect. This was then multiplied by the number of insects to give total volume for the family. The percentage that each family contributed to the total volume of all insects was then calculated. Total length of each fish was recorded to the nearest millimeter.

Bottom Organisms. Ten 1 Ft² bottom samples were taken with a Surber sampler more or less at random from the area where the fish were captured on each collection date and preserved in 10% formalin within 3-4 minutes. The bottom sample was taken to the laboratory where the organisms were separated from foreign materials and identified to family. The organisms in each family were counted and volumetrically measured by water displacement (Tables V, VI).

Digestive Tract Contents

The fish were divided into three size groups (0-49 mm, 50-69 mm, 70-100 mm) for the analysis of digestive tract contents (Fig. 1). The choice of these groups was based upon length frequency of all fish taken and presumably represents age classes 0, 1 and 2, 3 and 4, respectively. These sizes conform to the calculated growth curve of this species presented by Kuehn (1949).

The frequency occurrence of all organisms in the fish digestive tracts, percent volume and average number of insects are considered for each size group (Tables I, II, III, IV). Frequency occurrence is expressed as the percentage of all fish in the sample having a particular food item. Percent volume is the percent each family contributes to the total volume of insects eaten on a collection date. The average number of insects is the quotient of the number eaten divided by the number of fish having this insect group in the digestive tract.

Size Group 0-49 mm (Table I)

Frequency Occurrence. Algae had the highest frequency of all organisms for this size group, but was found in only three of the bimonthly samples. Tendipedidae was second most frequent in the combined total and increased through the study period. Baetidae and debris, which included bark, leaves, sand, and insect fragments, had a rather high frequency occurrence. No other category had more than 10% in the combined total. The frequency occurrence of insects for each order was as follows: Diptera 57%, Ephemeroptera 29%, Plecoptera 8%, and Trichoptera 1%.

Percent Volume. Baetidae and Tendipedidae accounted for 63% the volume of all insects eaten by the 0-49 mm size group. No other category constituted more than 10% of the insect volume. The percent volume of each order represented was as follows: Ephemeroptera 50%, Diptera 30%, Plecoptera 18%, and Trichoptera 3%. In general, the volume of Ephemeroptera and Diptera increased and that of Plecoptera decreased throughout the sampling period. Most Plecoptera were identified only to order because most specimens were damaged.

Average Number of Insects Per Fish. Baetidae had the highest average number of insects per fish and was followed closely by Tendipedidae. When considered by orders, Ephemeroptera and Diptera increased progressively throughout the study period while Plecoptera remained fairly constant.

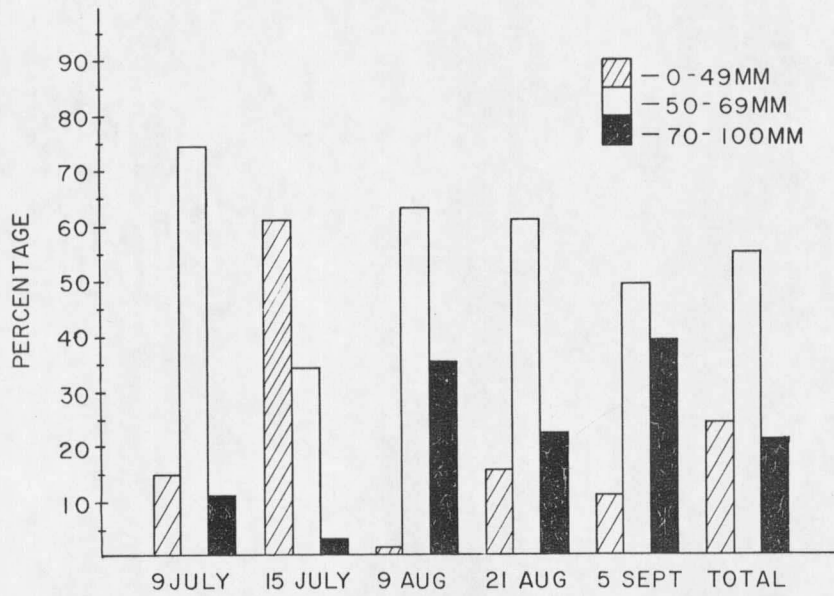


Fig. 1 Percentages of size groups of longnose dace in the bimonthly samples.

Table I. Digestive tract contents of longnose dace in size group 0-49 mm.

Date	9 July 63			15 July 63			9 Aug 63			21 Aug 63			5 Sep 63			Total For Size Group		
	% F.O.*	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.
Baetidae	15	7	1.0	6	6	1.0	50	57	2.0	93	57	5.8	29	19	2.5	22	34	4.1
EphemereIIDae										47	13	1.3	14	9	1.0	7	8	1.2
Heptageniidae	8	5	1.0	3	7	1.5	50	43	1.0	27	7	1.7	14	6	1.0	8	8	1.4
ALL																		
EPHEMEROPTERA	23	13	1.0	12	14	1.1	50	100	3.0	100	73	6.5	57	34	1.7	29	50	3.8
Simuliidae										7	Tr	2.0				1	Tr	2.0
Tendipedidae	23	6	1.7	59	51	2.3				80	18	6.7	71	66	10.0	57	29	3.7
ALL																		
DIPTERA	23	6	1.7	59	51	2.3				80	18	6.8	71	66	10.0	57	29	3.8
Pteronarcidae										7	Tr	2.0				1	Tr	2.0
ALL																		
PLECOPTERA	23	81	1.7	7	35	1.0				7	6	2.0				8	18	1.3
Limnephilidae										7	3	1.0				1	3	1.0
ALL																		
TRICHOPTERA										7	3	1.0				1	3	1.0
Acari										7	Tr	3.0				1	Tr	3.0
Algae	61	--	---	74	--	---				47	--	---				62	--	---
Unknowns				1	Tr	1.0										1	Tr	1.0
Debris	54	--	---	51	--	---	50	--	---	7	--	---	14	--	---	43	--	---
No. of Fish	13			69			2			15			7			106		
No. Empty	1 (8%)			3 (4%)			1 (50%)			0			0			5 (5%)		

* F.O. = Frequency Occurrence
Tr = Less than 1.0

Table II. Digestive tract contents of longnose dace in size group 50-69 mm.

Date	9 July 63			15 July 63			9 Aug 63			21 Aug 63			5 Sep 63			Total For Size Group		
	% F.O.*	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.
Baetidae	11	3	1.1	19	11	1.4	58	18	2.5	88	62	11.6	93	42	8.5	51	41	7.4
Ephemeroellidae	3	2	1.0				35	23	2.2	33	10	21.6	22	3	1.0	19	10	2.0
Heptageniidae	36	22	1.5	11	10	1.5	32	9	1.5	31	3	1.1	4	Tr	1.0	26	6	1.4
Siphonuridae	2	2	1.0													Tr	Tr	1.0
Tricorythidae										2	Tr	1.0				Tr	Tr	1.0
ALL																		
EPHEMEROPTERA	62	30	1.5	27	21	1.7	82	50	3.3	96	75	11.7	96	45	8.4	74	57	6.2
Simuliidae							14	1	2.4	17	1	1.6	22	1	1.3	10	1	1.7
Tendipedidae	17	5	3.1	63	55	6.2	56	16	6.8	90	15	8.0	93	48	27.8	59	23	10.5
ALL																		
DIPTERA	17	5	3.1	63	55	6.2	58	18	7.2	90	15	8.3	93	48	28.1	59	24	10.7
Chloroperlidae	2	Tr	4.0	3	Tr	1.0							4	Tr	1.0	1	Tr	2.0
Perlodidae	2	Tr	1.0													Tr	Tr	1.0
ALL																		
PLECOPTERA	36	61	1.4	11	20	1.0	17	10	1.1	9	3	1.2	4	1	1.0	18	11	1.2
Limnephilidae										10	3	1.0	15	3	1.0	4	2	1.0
Hydropsychidae	5	4	1.0	3	3	1.0	35	19	1.4	21	4	1.2	11	2	1.0	16	6	1.3
Hydroptilidae							3	Tr	1.0	2	Tr	1.0	4	Tr	1.0	2	Tr	1.0
ALL																		
TRICHOPTERA	5	4	1.0	3	3	1.0	35	19	1.5	31	7	1.2	26	5	1.1	20	8	1.3
Halplidae							3	2	1.0							1	1	1.0
ALL																		
COLEOPTERA	2	Tr	1.0				3	2	1.0				4	Tr	1.0	2	1	1.0
HYMENOPTERA	2	Tr	1.0										7	Tr	1.0	1	Tr	1.0
HEMIPTERA	2	Tr	1.0													Tr	Tr	1.0
ALGAE	41	--	---	73	--	---	25	--	---	38	--	---	22	--	---	39	--	---
Unknowns	3	Tr	1.0				2	Tr	3.0							1	Tr	1.7
Debris	45	--	---	19	--	---	53	--	---	9	--	---	7	--	---	30	--	---
No. of Fish	64			37			57			58			27			243		
No. Empty	5 (8%)			3 (8%)			5 (9%)			1 (2%)			0			14 (6%)		

* F.O. = Frequency Occurrence
Tr = Less than 1.0

Table III. Digestive tract contents of the longnose dace in size group 70-100 mm.

Date	9 July 63			15 July 63			9 Aug 63			21 Aug 63			5 Sep 63			Total For Size Group		
	% F.O.*	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.	% F.O.	% Vol.	Avg. No.
Baetidae	9	3	1.0	67	14	2.0	34	53	15.0	95	55	22.1	82	56	14.1	59	53	16.8
Ephemerellidae	27	31	1.7				28	12	1.9	41	11	4.7	9	1	1.5	25	9	2.9
Heptageniidae	18	12	1.5	100	26	1.7				18	1	1.0	4	Tr	1.0	11	1	1.3
Siphonuridae										4	6	11.0				1	3	11.0
Tricorythidae										4	Tr	1.0				1	Tr	1.0
ALL																		
EPHEMEROPTERA	64	46	1.6	100	40	3.0	47	66	12.3	100	73	23.8	82	58	14.3	72	66	15.2
Simuliidae							16	7	11.2	36	4	11.0	45	4	5.0	25	4	8.4
Tendipedidae	45	6	1.4				25	8	8.7	95	16	18.4	86	22	1.5	59	15	14.3
ALL																		
DIPTERA	45	6	1.4				28	14	13.9	95	19	7.5	91	26	1.7	61	20	17.3
ALL																		
PLECOPTERA	18	47	2.0				6	3	1.0	9	1	1.0	9	2	1.0	9	3	1.2
Limnephilidae										9	1	1.0	23	6	1.2	8	2	1.1
Hydropsychidae							25	17	2.2	45	6	1.7	36	8	1.6	29	8	1.8
Hydroptilidae							3	Tr	1.0							1	Tr	1.0
ALL																		
TRICHOPTERA							28	17	2.1	54	7	1.6	54	14	1.6	37	11	1.7
Haliplidae				33	60	3.0										1	1	3.0
ALL																		
COLEOPTERA				33	60	3.0										1	1	3.0
HYMENOPTERA	9	Tr	1.0										4	Tr	1.0	2	Tr	1.0
Acari										4	Tr	1.0	4	Tr	1.0	2	Tr	1.0
ALGAE	36	--	---		--	---	25	--	---	45	--	---	64	--	---	40	--	---
Unknowns													4	Tr	3.0	1	Tr	3.0
Debris	91	--	---	33	--	---	16	--	---	9	--	---	--	--	---	20	--	---
No. of Fish	11			3			32			22			22			90		
No. Empty	1 (9%)			0			14 (44%)			0			1 (4%)			16 (18%)		

* F.O. = Frequency Occurrence

Tr = Less than 1.0

Table IV. Digestive tract contents of all longnose dace.

Organism	% F.O.*	% Vol.	Avg. No.
Baetidae	45	45	9.5
Ephemerellidae	18	9	2.2
Heptageniidae	19	4	1.4
Siphonuridae	Tr.	1	6.0
Tricorythidae	Tr.	Tr	1.0
EPHEMEROPTERA	63	60	8.0
Simuliidae	11	2	5.0
Tendipedidae	58	20	9.7
DIPTERA	59	22	10.5
Pteronarcidae	Tr.	Tr**	2.0
Chloroperlidae	1	Tr	2.0
Perlodidae	Tr.	Tr	1.0
PLECOPTERA	14	8	1.3
Limnephilidae	4	2	1.0
Hydropsychidae	15	7	1.5
Hydroptilidae	1	Tr	1.0
TRICHOPTERA	19	9	1.5
Haliplidae	1	1	1.7
COLEOPTERA	1	1	1.4
HEMIPTERA	Tr.	Tr	1.0
HYMENOPTERA	1	Tr	1.0
ACARI	1	Tr	1.7
ALGAE	45	--	---
Unknowns	1	Tr	1.8
Debris	31	--	---
No. of fish		439	
No. empty		35 (8%)	

* F.O. = Frequency Occurrence

** Tr = Less than 1.0

Size Group 50-69 mm (Table II)

Frequency Occurrence. Tendipedidae had the highest frequency occurrence in the total followed by Baetidae. Both families increased through the sampling period. Algae was next in frequency occurrence and reached its peak in the second sample but then decreased steadily. Debris, Heptageniidae, Ephemerellidae, Hydropsychidae, and Simuliidae were the only other categories with frequencies greater than 10%. The frequency occurrence for each order was as follows: Ephemeroptera 74%, Diptera 59%, Trichoptera 20%, Plecoptera 18%, Coleoptera 2%, and Hemiptera 0.4%. The frequency of Ephemeroptera and Diptera increased through the study period while Plecoptera decreased. Trichoptera had a low frequency in the first two samples but increased in the last three.

Percent Volume. Baetidae had the highest percent volume of all insect groups in the total and showed an increase in succeeding bimonthly samples. Tendipedidae was next in percent volume and was fairly low in the bimonthly samples except for peaks in the second and fifth samples. Ephemerellidae was the only other family to contribute as much as 10% of the insect volume. While Hydropsychidae had only 6% of the total, it showed an unusually high peak on August 9th. The percent volume for each order follows: Ephemeroptera 57%, Diptera 24%, Plecoptera 11%, Trichoptera 8%, and Coleoptera 1%. Hymenoptera and Hemiptera had less than 0.1% (Trace). Plecoptera was the only order to show a definite trend. It decreased consistently through the sampling period.

Average Number of Insects Per Fish. Tendipedidae had the highest average number of organisms for the 50-69 mm size group and increased progressively through the bimonthly samples. Baetidae was slightly less in the total and rose from low averages in the first three samples to high in the last two. No other category showed more than two organisms per fish. The orders had the following averages: Diptera 10.7, Ephemeroptera 6.2, Trichoptera 1.3, and Plecoptera 1.2. The average number of Diptera and Ephemeroptera increased through the study period while the other orders remained fairly constant.

Size Group 70-100 mm (Table III).

Frequency Occurrence. Baetidae and Tendipedidae both had a frequency occurrence of 59% in this size group. Algae was next in frequency being lowest in the first two bimonthly samples but high in the others. Other families that occurred in most of the samples were Hydropsychidae, Ephemerellidae, Simuliidae, and Heptageniidae. No other family had a frequency occurrence greater than 10%. The frequency occurrence for each order was as follows: Ephemeroptera 72%, Diptera 61%, Trichoptera 37%, Plecoptera 9%, Hymenoptera 2%, and Coleoptera 1%. Ephemeroptera varied irregularly through the same period while Trichoptera and Diptera were low in the first three samples and high in the last two. Plecoptera decreased as the study period progressed.

Percent Volume. Baetidae had the highest percent volume of all families in the total and increased progressively in the bimonthly samples. Tendipedidae had a volume about one-third that of Baetidae

and was the only other family to exceed 10%. The percent volume for each order was as follows: Ephemeroptera 66%, Diptera 20%, Trichoptera 11%, Plecoptera 3%, Coleoptera 1%, and Hymenoptera - less than 0.1%. The percent volume of Diptera increased and Plecoptera decreased through the study period. No other order showed important differences in the bi-monthly samples.

Average Number of Insects Per Fish. Baetidae had the highest average number of insects in the 70-100 mm size group and increased through the study period except for the last sample. Tendipedidae was also abundant. No other family had more than ten organisms per fish except for Siphonuridae which had eleven, but all in one fish. The average number of organisms for each order was: Diptera 17.3, Ephemeroptera 15.2, Coleoptera 3.0, Trichoptera 1.7, and Plecoptera 1.2. The average number of Ephemeroptera increased to the fourth sample and then decreased, while Diptera increased to the third sample and then decreased. The other orders were fairly consistent through the study period.

The analysis of digestive tract contents of all longnose dace showed that Baetidae had the highest percent volume and the highest average number in each size group except that Tendipedidae had the highest average number in the 50-69 mm size group. Algae had the highest frequency occurrence in the 0-49 mm group, Tendipedidae was highest in the 50-69 mm group, and Baetidae and Tendipedidae were equally high in the 70-100 mm group. All size groups are combined in Table IV.

The average amount of food eaten increased through the study period, Fig. 2. In general, the three size groups of fish reflect the same seasonal variation in food over the study period. Baetidae and Tendipedidae increased, while Heptageniidae and all Plecoptera decreased. The other groups were fairly constant except for Hydropsychidae and Ephemerellidae which had peaks on August 9.

Bottom Organisms

The total volume of organisms found in the bottom samples increased steadily throughout the study period from 0.139 cc/Ft² in the first sample to 1.831 in the last. The total number per square foot also increased throughout this period from 24.7 to 1,180.6. Hydropsychidae had the highest total volume but was third in total number (Tables V, VI). This family was absent from the first two samples but became increasingly abundant in later collections. Tendipedidae was second in total volume but had the greatest number of individuals. The number and volume of Tendipedidae increased greatly throughout the sampling period. Ephemerellidae was next in volume and remained fairly constant except for a peak on August 9.

Other families which accounted for more than 1% of the total volume of the bottom samples were: Heptageniidae, Perlodidae, Pteronarcidae, Baetidae, Dolichopodidae, Tricorythidae, and Hydroptilidae. Trichoptera had the highest total volume of all orders. It only appeared as traces in the first two samples but composed larger volumes in the other three samples. Ephemeroptera was second in total volume and increased steadily

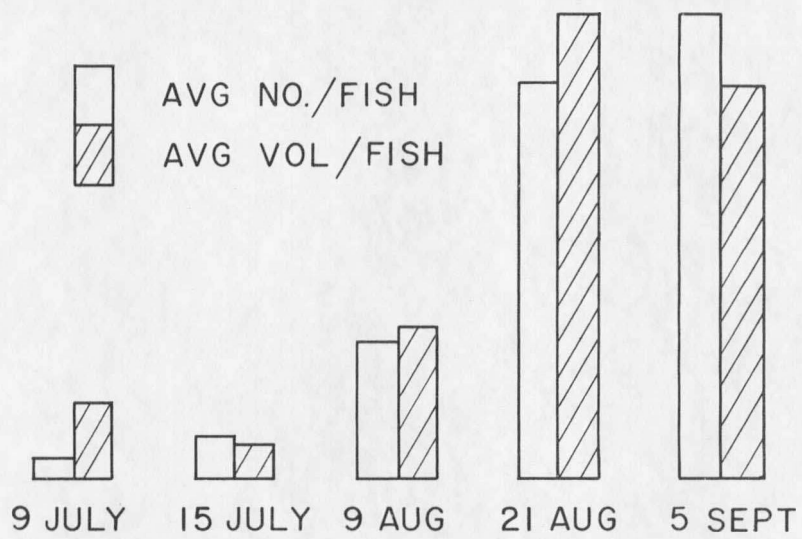


Fig. 2 Seasonal fluctuations in average amount of food taken by individual longnose dace.

Table V. Average volume of organisms per square foot for each bimonthly bottom sample of ten square feet.

Date	9 July 63		15 July 63		9 Aug 63		21 Aug 63		5 Sep 63		TOTAL	
Organism	Vol.*	%	Vol.	%	Vol.	%	Vol.	%	Vol.**	%	Vol.	%
Baetidae	5	4	7	4	29	5	44	8	99	5	184	6
Ephemerelellidae	24	17	12	6	169	29	81	15	29	2	315	10
Heptageniidae	57	41	51	26	25	4	32	6	60	3	225	7
Leptophlebiidae							5	1	6	.3	11	.3
Siphonuriidae	Tr***	Tr	9	5			Tr	Tr	7	.4	16	.5
Tricorythidae					Tr	Tr	57	11	74	4	131	4
EPHEMEROPTERA	86	62	79	41	223	39	219	41	275	15	882	29
Dolichopodidae			70	36					97	5	167	5
Rhagionidae	5	4					Tr	Tr	Tr	Tr	5	.1
Simuliidae	Tr	Tr			16	3	Tr	Tr	10	.5	26	1
Tendipedidae	Tr	Tr	29	15	36	6	143	27	247	13	455	14
Tipulidae					5	1	7	1	26	1	38	1
DIPTERA	5	4	99	51	57	10	150	28	380	21	691	21
Chloroperlidae	4	3	5	3	5	1	Tr	Tr			14	.4
Nemouridae					Tr	Tr					Tr	Tr
Perlidae					28	5					28	1
Perlodidae	30	22	5	3	6	1	22	4	177	10	240	7
Pteronarcidae	5	4			41	7	15	3	171	9	232	7
PLECOPTERA	39	28	10	5	80	14	37	7	348	19	514	16
Glossomatidae							Tr	Tr	Tr	Tr	Tr	Tr
Limnephilidae	Tr	Tr	Tr	Tr	13	2	Tr	Tr	6	.3	19	.6
Hydropsychidae					199	34	110	21	707	39	1,016	31
Hydroptilidae					Tr	Tr	Tr	Tr	84	5	84	2
Psychomyiidae					5	1	Tr	Tr	6	.3	11	.3
TRICHOPTERA	Tr	Tr	Tr	Tr	217	37	110	21	807	44	1,134	35
Dysticidae					3	.5	3	.6			6	.2
Elmidae					Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Haliplidae	4	3			Tr	Tr	Tr	Tr	Tr	Tr	4	.1
COLEOPTERA	4	3			3	.5	3	.6	Tr	Tr	10	.3
Hebridae	Tr	Tr									Tr	Tr
Notonectidae							3	.6			3	.1
Hemiptera	Tr	Tr					3	.6	Tr	Tr	3	.1
HYMENOPTERA									4	.2	4	.1
MOLLUSKA									Tr	Tr	Tr	Tr
ACARI							Tr	Tr	Tr	Tr	Tr	Tr
PLANARIA									Tr	Tr	Tr	Tr
Unknowns					Tr	Tr	Tr	Tr			Tr	Tr
Fish Fry			Tr	Tr	Tr	Tr	Tr	Tr			Tr	Tr
All Tr Totald	5	4	5	3	8	1	10	2	17	1	45	1
TOTAL	139		193		588		532		1,831		3,238	

* Volume is given as cc x 10³.** This sample is from only 8 Ft² due to accidental loss of 2 Ft² of the bottom sample.*** Tr = less than 1.0 cc/Ft² or 0.1%.

Table VI. Average numbers of organisms per square foot for each bimonthly bottom sample of ten square feet.

Date Organism	9 July 63		15 July 63		9 Aug 63		21 Aug 63		5 Sep 63		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.*	%	No.	%
Baetidae	1.9	8	3.8	4	20.5	8	32.6	8	70.1	6	128.9	6
EphemereUidae	3.7	15	4.0	4	40.0	15	14.0	3	10.7	1	72.4	4
Heptageniidae	14.0	57	20.4	21	7.7	3	6.1	1	50.5	4	98.7	5
Leptophlebiidae							1.3	.3	1.2	.1	2.5	.1
Siphonuriidae	.1	.4	.2	.2			.6	.1	2.6	.2	3.5	.2
Tricorythicae					2.6	1	39.0	10	29.6	2	71.2	4
EPHEMEROPTERA	19.7	80	28.4	29	70.8	27	93.6	23	164.7	14	377.2	19
Dolichopodidae			.1	.1					1.7	.1	1.8	.1
Rhagionidae	.1	.4					.1	Tr**	1.1	Tr	1.3	.1
Simuliidae	.2	1			21.8	8	2.1	.5	12.2	1	36.3	2
Tendipedidae	.8	3	66.4	68	83.9	32	284.1	69	354.5	30	789.7	40
Tipulidae					.9	.3	7	.2	1.1	Tr	2.7	.1
DIPTERA	1.1	4	66.5	68	106.6	41	287.0	70	370.6	31	831.8	42
Chloroperlidae	.6	2	1.3	1	1.3	.5	.1	Tr			3.3	.2
Nemouridae					.3	.1					.3	Tr
Perlidae					.1	Tr					.1	Tr
Perlodidae	2.5	10	.4	.4	3.8	1	4.1	.1	14.6	1	25.4	1
Pteronarcidae	.1	.4			11.5	4	.6	.1	8.2	.6	20.4	1
PLECOPTERA	3.2	13	1.7	2	17.0	6	4.8	.2	22.8	2	49.5	2
Glossomatidae							.8	.2	.2	Tr	1.0	Tr
Limnephilidae	.1	.4	.2	.2	1.4	.5	.5	.1	2.0	.2	4.2	.2
Hydropsychidae					62.3	24	17.4	4	170.9	14	250.6	13
Hydroptilidae					.3	.1	.1	Tr	351.0	30	351.4	18
Psychomyiidae					.6	.2	.1	Tr	87.5	7	88.2	4
TRICHOPTERA	.1	.4	.2	.2	64.6	25	18.9	5	619.6	52	703.4	36
Dysticidae					1.4	.5	1.1	.3			2.5	.1
Elmidae					.1	Tr	.3	Tr	.6	Tr	1.0	Tr
Haliplidae	.5	2	.2	.2	.2	Tr	.2	Tr	.2	Tr	1.3	.1
COLEOPTERA	.5	2	.2	.2	1.7	.5	1.6	.3	.8	Tr	4.8	.2
Hebridae	.1	.4									.1	Tr
Notonectidae							.7	.2			.7	Tr
HEMIPTERA	.1	.4					.8	.2	.1	Tr	1.0	Tr
HYMENOPTERA									1.5	.1	1.5	.1
MOLLUSKA									.2	Tr	.2	Tr
ACARI							.1	Tr	.2	Tr	.3	Tr
PLANARIA									.1	Tr	.1	Tr
Unknowns					.4	.1	.1	Tr			.5	Tr
Fish Fry			.2	.2	.3	.1					.5	Tr
TOTAL	24.7		97.3		261.4		406.9		1,180.6		1,970.9	

* This sample is from only 8 ft² due to accidental loss of 2 ft² of the bottom sample.

** Tr = less than 0.1.

throughout the sampling period. However, in spite of this increase, the percentage of total number and volume in each bimonthly sample decreased over the same period due to the relatively greater increases in the other organisms. Diptera and Plecoptera were the only other orders in the bottom samples contributing more than 1% of the total volume. The number and volume of Diptera increased over the study period. The number of Plecoptera was fairly constant but the volume fluctuated greatly in the bimonthly samples.

Forage Ratios

A direct comparison of the organisms in the bottom samples with those in the digestive tract contents (Fig. 3) indicates that abundance of particular food items had an important effect on the diet of longnose dace. The exceptions are explainable on the basis of greater or lesser habitat (or behavioral) availability.

If the numerical percentage of a given kind of organism in the digestive tract contents is divided by its numerical percentage in the bottom sample, the resulting ratio is termed the forage ratio. This is another way of comparing the digestive tract contents of fish with the bottom organisms. A forage ratio of one indicates that an organism occurred in the same relative abundance in the digestive tract as in the bottom samples; a ratio greater than one indicates that an organism was either being selected in preference to other organisms, or that it was more available; and a ratio of less than one indicates that an organism was either less preferable or less available (Usinger, 1956). Baetidae

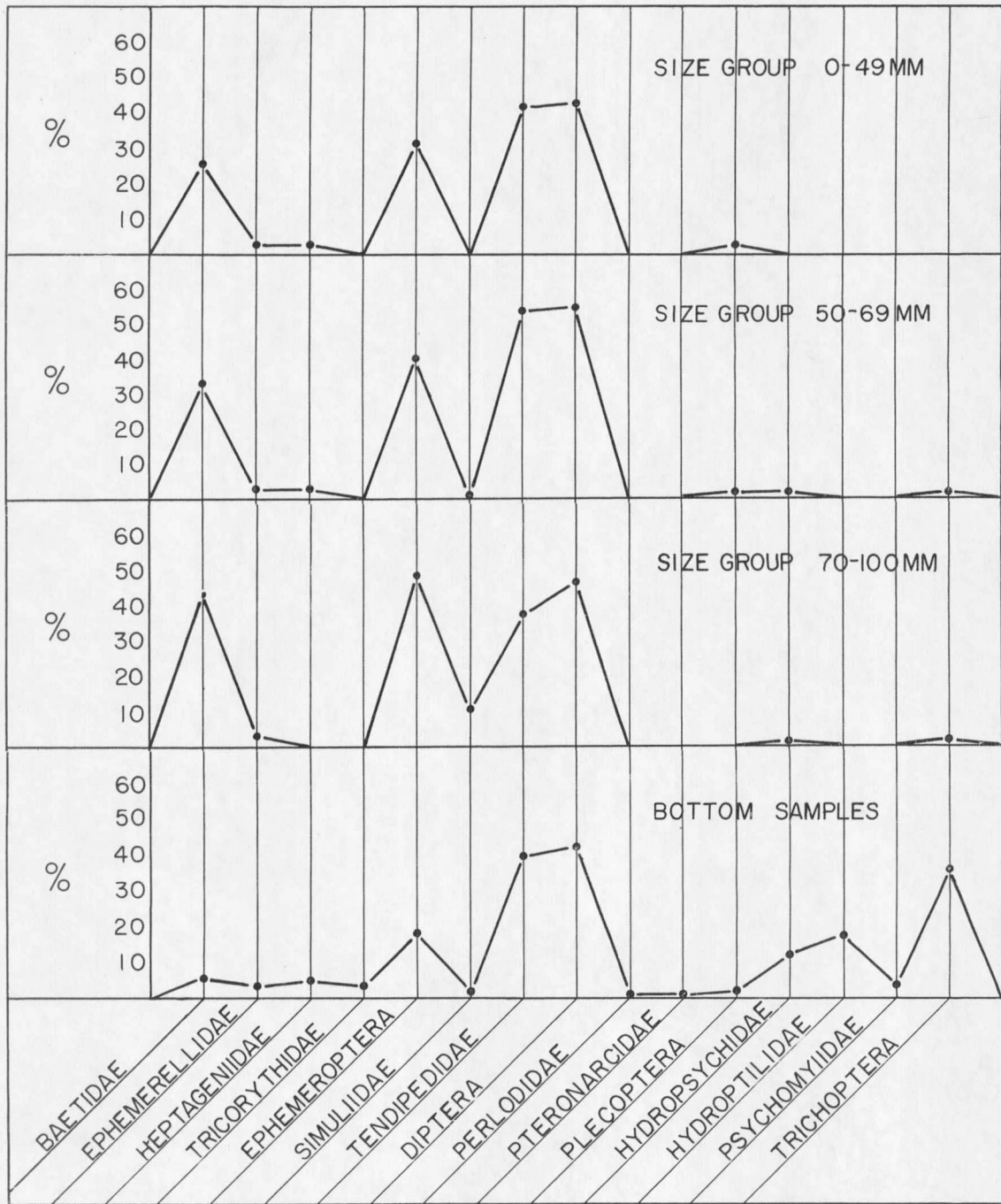


Fig. 3 A comparison of numerical percentage of organisms in the bottom samples and the digestive tract contents of longnose dace.

had the highest forage ratio with 3.9, 5.0, and 6.8 in the small, medium, and large size groups, respectively (Fig. 4). The only other family with a ratio greater than 3.0 was Simuliidae which had 5.3 in the 70-100 mm group but less than one in the other two groups.

The forage ratios of longnose dace varied considerably with size of the fish. The ratios of Baetidae, Siphonuridae, and Simuliidae were highest for the largest size group of fish while the ratios of Tendipedidae and all Plecoptera were highest for the smallest size group of fish. The forage ratios of the middle size group had values between the forage ratios of the other two size groups.

The forage ratio of Baetidae for all size groups combined was about twice (5.6) that of any other family. This indicates that Baetidae was either twice as available or preferable as any other food group. Simuliidae had the second highest forage ratio with 2.5 and Limnephilidae was third with 2.0. Tendipedidae had a ratio of 1.2 and was the only other family greater than 1.0.

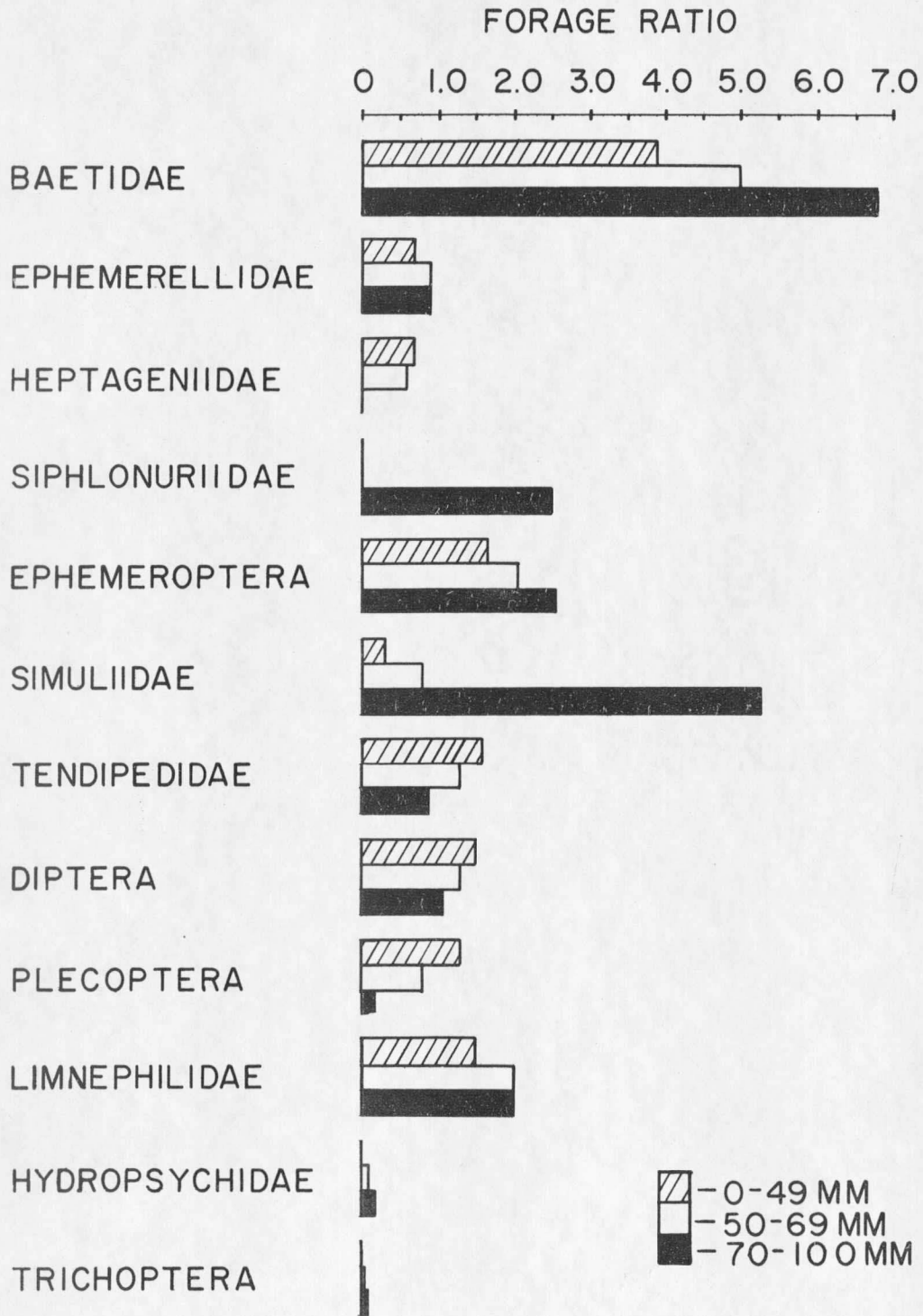


Fig. 4 Forage ratios for three size groups of longnose dace.

DISCUSSION

Since the longnose dace eat relatively few terrestrial organisms, their diet is ultimately controlled by what is present in the water where they live. Therefore, a food study should be directed toward the determination of the factors which decide which of the animals present are eaten and to what extent. Size, appearance, habits, and taste of potential food organisms most likely determine their frequency and abundance in the digestive tract of fishes (Allen, 1941). Because the habits of potential food organisms largely determine their vulnerability to feeding fish, an attempt was made to correlate the forage ratios with known habits of the food organisms.

Ephemeroptera. Food organisms in this order were divided into two subgroups, the swimmers with high forage ratios and the creepers with low forage ratios. Baetidae (Baetis sp.) and Siphonuridae (Ameletus sp.), in the first group, swim about even in swift currents with quick darting movements and cling to bottom materials whenever they come to rest. Thus, their high forage ratios correspond to their high availability. However, siphonuridae occurred in only two fish. Ephemerellidae (Ephemerella sp.) and Heptageniidae (Rhithrogena sp. and Cinygmula sp.) in the second group, creep slowly over the bottom materials and are found most frequently in crevices and on the lower surfaces of stones. Thus, their lower availability is reflected in their lower forage ratio.

Diptera. Simuliidae depend upon a rapid current of water for their food supply and live only in exposed locations. They are attached only by the posterior end, with the body projecting upward into the current probably making them conspicuous to feeding fish (Allen, 1941). The swift current may be a deterrent to feeding by small fish and this may explain the very low forage ratios in the two smaller size groups. Large fish have a high forage ratio expected for this conspicuous food organism.

Most of the Tendipedidae live on the upper surfaces of stones in tubes composed of bits of sediment held together by body secretions. The larvae seem less conspicuous than the simuliids since they are partially hidden by algae and sediments. This difference may partially account for the lower forage ratios of the tendipedids. The forage ratios of these organisms may be affected because they are soft-bodied and pass through the digestive tract more rapidly than heavily chitinized forms such as stonefly nymphs (Hess and Rainwater, 1939). Consequently, this group may be more important than the forage ratios indicate.

Plecoptera. Most of the stream Plecoptera live in exposed positions, but tend to remain stationary for considerable periods (Allen, 1941). Their relatively low forage ratios may be partially due to their inconspicuousness.

Trichoptera. Little is known concerning the habits of Limnephilidae except that they all build protective cases. Allen (1941) indicates that large fish may better utilize organisms with hard outer coverings or cases than do smaller fish. This may account, at least in part, for the higher

forage ratios in the larger fish.

Hydropsychidae spend much of their time partially emerged from tube-like retreats concealed in crevices or camouflaged by bits of wood, leaves, or similar material. Presumably the relative inaccessibility of these larvae to the fish corresponds to the low forage ratios of this family.

The remaining insect families were not frequent in either the digestive tract contents or the bottom samples and their habits are not considered.

The general interpretations gleaned from studying the habits of bottom organisms are similar to those discussed by Allen (1941). There is fairly good correlation between the forage ratios and the apparent availability of the insect to the fish. It is possible to divide the insects into four categories based upon these observations.

- (a) Insects with high forage ratios, 2.5 or more. These animals live in exposed positions and are either active or conspicuous in appearance, or both. Examples are Baetidae, Siphonuridae and Simuliidae.
- (b) Insects with a medium forage ratio, 1.0-2.5. Most of these live in exposed positions, but are either inactive or inconspicuous in appearance or both. Examples are Tendipedidae and Plecoptera.
- (c) Insects with low forage ratios, less than 1.0. These usually live in sheltered positions. Examples are Hydropsychidae and Ephemerellidae.

- (d) Insects with a forage ratio of zero. These are burrowing forms which are rarely visible and are seldom eaten by fish.

The food habits of the longnose dace conform with the conclusions of previous workers (Allen, 1951, and Neil, 1938) in that availability and abundance of the food organisms appear to determine the diet of the fish.

The problems involved in a food habits study of this sort are numerous. An accurate measurement of the food available is an almost impossible task. Time of day, weather, water current, bottom type, and many other things, affect the availability of food organisms and compound the usual problems of sampling. Also, the process of sorting, identifying, counting, and volumetrically measuring the organisms is extremely time consuming. Total volume of the digestive tract contents of many of the fish was less than 0.05 cc which made accurate, direct measurement exceedingly difficult and the exact identification of the partially digested organisms was often impossible. In spite of the many limitations, studies of this sort provide the necessary background for more detailed work in the future.

SUMMARY

1. Samples of longnose dace, Rhinichthys cataractae, and bottom organisms were taken approximately every two weeks, from 9 June to 5 Sept. 1963, from a 46,000 Ft² riffle of the Yellowstone River.
2. The organisms from the fish digestive tracts were identified to family and enumerated. The volume of each family was calculated from the average volume per individual in each family.
3. The organisms from each 10 Ft² bottom sample were identified to family and then counted and measured volumetrically by water displacement.
4. The fish were divided into three size groups (0-49 mm, 50-69 mm, and 70-100 mm) for analysis of digestive tract contents. The frequency occurrence of all organisms in the fish digestive tracts, percent volume, and average number of insects were considered for each of these groups.
5. Baetidae had the highest percent volume and the highest average number in each size group except that Tendipedidae had the highest average number in the 50-69 mm size group. Algae had the highest frequency occurrence in the 0-49 mm group, Tendipedidae was highest in the 50-69 mm group, and Baetidae and Tendipedidae were equally high in frequency occurrence in the 70-100 mm group. Seasonal variation of food was about the same in all three size groups.

6. Forage ratios were calculated for each size group. Baetidae had the highest forage ratio with 3.9, 5.0, and 6.8 in the small, medium, and large size groups, respectively. The only other family with a ratio greater than 3.0 was Simuliidae which had 5.3 in the 70-100 mm group but less than one in the other two groups. The ratios of Baetidae, Siphonuridae, and Simuliidae were highest for the largest size group of fish, while the ratios of Tendipedidae and all Plecoptera were highest for the smallest size group of fish.
7. While some of the bottom organisms were too large for the fish to eat, the ones found in the digestive tract contents were generally those that were most available and abundant.

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