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An Analysis of the Feeding Habits of Rainbow Trout and Lake Trout in Birch Lake, Cass County, Michigan[1]

[1] Contribution from the Institute for Fisheries Research

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Abstract

In Birch Lake, an ologotrophic lake in southwestern Michigan, rainbow trout and lake trout have been stocked at various times in an effort to make the deeper waters of the lake provide more fishing. Over a 6-year period, creel census clerks collected stomachs of 322 rainbow trout and 25 lake trout taken by anglers. Analysis of the contents of these stomachs revealed that while the two species of trout were competing with each other for food, neither species preyed upon the indigenous cisco population nor competed with it for food. Aquatic insects and fish made up the greater part of the diet of both species of trout. The bulk of the fish portion of the diet consisted largely of forage species, perch and centrarchids occurring but seldom in the stomachs. Rainbow trout took very little surface food except during late June, when there was a mass emergence of the burrowing mayflies, and in October and early November when many terrestrial insects were consumed.

Introduction

Birch Lake, a popular recreational spot in Cass County, Michigan, has attracted interest in recent years as the site of an experiment designed to provide sport fishing for rainbow trout in a region of the state normally devoid of salmonids. So successful have been the initial attempts to establish and exploit a rainbow trout sport fishery that action has been taken by the Michigan Conservation Commission to extend the open season into spring and fall months and to reduce the creel limits as an aid, in line with research findings, to wider utilization of this species by the angling public.

Since 1941, a continuous creel census has been maintained on all fishing in the lake. It has been the practice of the census clerk to collect various data from the rainbow trout checked by him, among them the stomachs of such fish as have not been cleaned by anglers before reporting to him with their catch.

Little has been published heretofore on the feeding habits of rainbow trout occupying a lake of the type more commonly supporting a game fish population wholly made up of such essentially piscivorous species as mud pickerel, pike, yellow perch, largemouth and smallmouth bass and other centrarchids. Biological inventories made by survey parties operated by the Michigan Institute for Fisheries Research during the past decade have shown that Birch Lake supports a rich and varied population of forage animals, both vertebrate and invertebrate, justifying the assumption that an analysis of the game fishes' diet should reveal feeding habits typical of the species and not unduly weighted by availability of only a few restricted forage sources. The present study embraces

results of analyses of stomachs collected throughout the greater part of the ice-free season, from rainbow trout 7.5 to 22.5 inches in total length, over a 6-year period. It is felt that the collections cover a sufficiently wide range of season, time, and fish size to establish the standard diet of the species in Birch Lake.

One of the more specific reasons for an interest in the problem here reported lies in the fact that ciscoes occur in Birch Lake and have long provided a gill-net fishery yielding sport and food, for a few days each year, to residents of the vicinity, some of whom feared that rainbow trout might, if introduced into the lake, deplete the cisco population by predation. Another reason was the Institute's desire to link up feeding habits with growth rate studies of known-age rainbows. All rainbow and lake trout in Birch Lake have been stocked from hatchery sources, each fish of known age and marked by fin-clipping to insure subsequent age-class recognition. The growth rate will be treated in a separate report at a later date.

Description of Birch Lake

Birch Lake has a surface area of 308.8 acres and a maximum depth of 95 feet. It is 1.1 miles long by 0.77 mile wide, the long axis lying in a NW-SE direction. It is supplied by numerous springs flowing the year around. Through its outlet it is ultimately tributary to the St. Joseph River, which empties into Lake Michigan. The shallow, barren, sandy shoal areas are relatively narrow, and terminate in an abrupt drop-off. The dominant bottom materials of shoals and slope are sand and marl, with some gravel along the shoals of the eastern and western shore.

Marl predominates between the 5-foot and 70-foot contours while pulpy peat forms the bottom at depths greater than 70 feet. The lake is surrounded by wooded, rolling hills.

A sruvey made on July 8, 1937, revealed the presence of a thermocline between the depths of 15 and 36 feet. On this date dissolved oxygen was present in the amount of 8.3 p.p.m. at the surface, the same at 45 feet, and 4.6 p.p.m. at the bottom (95 feet); pH was 8.4 at the surface, 7.5 at the bottom, as determined with a Hellige disc comparator; methyl orange alkalinity was 122 p.p.m. at the surface, 140 p.p.m. at the bottom; free CO_2, absent from the surface to a depth of 27 feet, was present at the rate of 0.3 p.p.m. at 45 feet, 0.6 p.p.m. at the bottom. A Secchi Disc was visible to a depth of 17 feet at 9:00 a.m. on a clear day. With the air temperature standing at 90° F. on July 8, the water temperature ranged from 80° F. at the surface through 75° F. at 12 feet, 50° F. at 39 feet, to 45° F. at 95 feet.

Aquatic vegetation is not abundant, and is largely confined to shoal areas. Anacharis canadensis is common to a depth of 18 feet, Ceratophyllum demersum and Myriophyllum spicatum to the 15-foot contour. Chara sp. occurs to a depth of 10 feet. Few other species[2] occur beyond a depth of 6 feet.

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[2] Other plants known from Birch Lake include Hydrocotyle umbellata, Najas flexilis, Nymphaea odorata, Nuphar advenum, Potamogeton angustifolius, P. friesii, P. natans, P. pectinatus, P. panormitanus, P. zosteriformis, Ranunculus longirostris, and Scirpus acutus.

Samples of the invertebrate fauna were taken with plankton net and Ekman dredge on July 8. A vertical haul of the plankton net from a depth of 90 feet to the surface yielded plankton organisms at the rate of 2.7 cubic centimeters per cubic meter; a horizontal haul of 100 feet taken at the surface yielded 2.1 cubic centimeters per cubic meter. Both samples were dominated by Entomostraca. Results of the Ekman dredge samples are shown in Table 1. Although many more samples, taken throughout the year, would be required as a basis for an accurate estimate of the total invertebrate fauna production of the lake, the data available indicate a production equal to the average for other oligotrophic lakes in southwestern Michigan that have been surveyed by the Institute (unpublished data).

Species of fish known to occur in Birch Lake are listed in Table 2. It is quite possible that additional species are present as well, especially other cyprinids. All species of trout shown in the table have been introduced at various times from hatchery stocks.

Rainbow Trout Diet Analyses

In all, 322 rainbow trout stomachs were available for analysis. Of the total, 165 were from fish between 7-5/8 and 12 inches total length; 157 were from specimens between 12-1/8 and 22-1/2 inches total length. Practically all of the collections were taken by anglers using a wide variety of baits, including night-crawlers, minnows, cheese, meat, viscera of fish, wet and dry artificial flies, spinners, plugs and spoons. A very small number were obtained from experimental gill-net catches. Collections were made over the 6-year period from 1941 to 1946,

Table 1.--Summary, by major categories, of bottom organisms obtained by Ekman dredge from Birch Lake, Michigan, 9:00 - 11:30 a.m., July 8, 1937. Four 1/4-square foot samples taken at each station.

Station number	I	II	III	IV	V
Depth in feet	2	5	29	42	62
Type of bottom	Sand & marl	Sand	Marl	Marl	Marl & pulpy peat
Vegetation	Abundant	Abundant	None	None	None
Volume of organisms per square foot (cubic centimeters)	0.03	1.1	1.3	0.6	0.5
Organisms (numbers)					
Oligochaete worms	...	...	...	45	69
Snails	...	15	...	...	...
Clams	...	6	22	65	1
Scuds	1	14	...	...	...
Crayfish	...	1	...	...	...
Mayfly nymphs	...	3	6	...	1
Dragonfly nymphs	...	4	...	...	...
Midge larvae	4	17	113	92	133
Total organisms per square foot	5	60	141	202	204

Table 2.--Species of fish[1] known to occur in Birch Lake. The four species of trout have been introduced by man.

Northern longnose gar	Lepisosteus osseus oxyurus	Western mudminnow	Umbra limi
Cisco	Leucichthys artedi subsp.	Mud pickerel	Esox vermiculatus
Brown trout	Salmo trutta fario	Western banded killifish	Fundulus diaphanus menona
Coast rainbow trout	Salmo gairdnerii irideus	Yellow perch	Perca flavescens
Common brook trout	Salvalinus f. fontinalis	Logperch	Percina caprodes subsp.
Common lake trout	Cristivomer n. namaycush	Iowa darter	Poecilichthys exilis
Common white sucker	Catostomus c. commersonnii	Northern least darter	Microperca m. microperca
Northern creek chub	Semotilus a. atromaculatus	Northern smallmouth bass	Micropterus d. dolomieu
Western golden shiner	Notemigonus crysoleucas auratus	Largemouth bass	Huro salmoides
Central common shiner	Notropis cornutus chrysocephalus	Green sunfish	Lepomis cyanellus
Blackchin shiner	Notropis h. heterodon	Pumpkinseed	Lepomis gibbosus
Northern mimic shiner	Notropis v. volucellus	Common bluegill	Lepomis m. macrochirus
Northern blacknose shiner	Notropis h. heterolepis	Northern rock bass	Ambloplites r. rupestris
Bluntnose minnow	Hyborhynchus notatus	Northern brook silverside	Labidesthes s. sicculus
Northern brown bullhead	Ameiurus n. nebulosus	Northern muddler	Cottus b. bairdii
Tadpole madtom	Schilbeodes gyrinus	Ninespine stickleback	Pungitius pungitius

[1] Common and scientific names used here follow Hubbs and Lagler (1941).

inclusive, and cover a 26-week span from June 25 to December 19, inclusive. A point of interest noted in passing is that with a single exception no fish of the smaller size group were taken after August 31.

On a basis of total volume of stomach contents, the various materials recognizable as bait made up approximately one-fourth (24.8 percent) of the total bulk. In subsequent treatment of the data, known bait materials are excluded from consideration. Only contents of gullet and stomach were studied; intestinal contents were not examined.

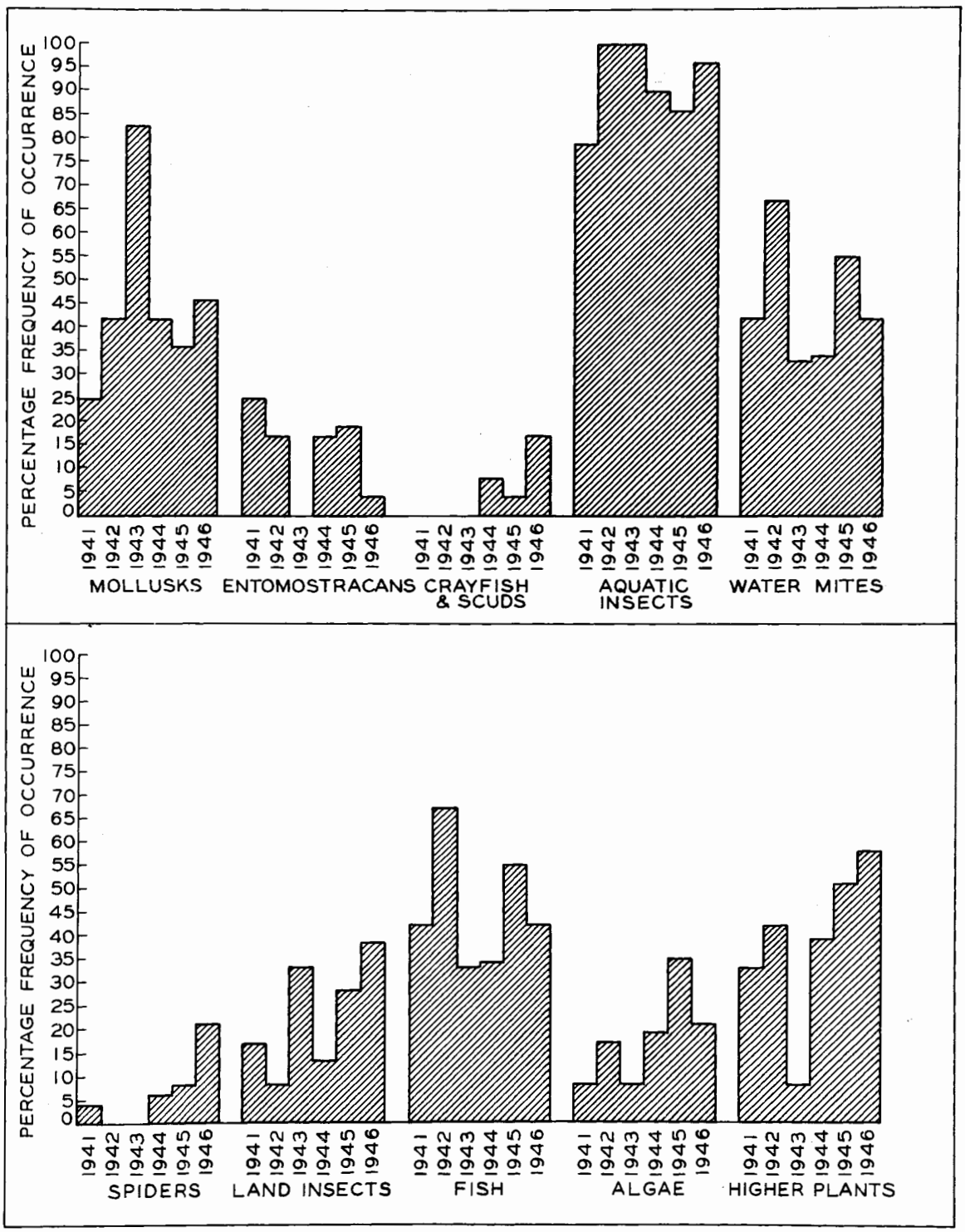
Various methods of recording results of stomach analyses have been employed by the many workers in this field. The tabulations to follow have been arranged in a manner which, it is hoped, will provide the reader with a complete picture of the relative dietary importance of the various food organisms, and permit ready comparison with results published elsewhere. Frequency of occurrence of a given food organism in fish stomachs is an important consideration. This factor is given in the tables, together with figures showing the maximum and average numbers of each item in the stomachs containing them. Since many published reports have used volume as the sole criterion for relative importance of food organisms, volumetric figures obtained by fluid displacement are included here. It is the feeling of the writers, however, that volumetric data may often be misleading, especially if unaccompanied by information on numbers and frequency of occurrence of organisms as well, and when based on small series of stomachs. A single bulky specimen, actually of rare occurrence, may assume an unwarranted position of dominance over smaller but commoner food items, while digestive action may obscure the real value of rare and common food organisms alike. If stomachs have been collected in large numbers, and over a wide range of time, inequalities

due to digestive action will, of course, tend to adjust themselves to the end that certain conclusions may be drawn from volumetric figures.

Figure 1 has been prepared to show the sharp differences which occurred, from year to year, in the frequency of occurrence of the various major food categories in the rainbow stomachs. The inter-annual disparity was not great for aquatic insects, but was considerable for other groups. Crayfish and scuds, for example, which accounted for 3 percent of the total diet (computed on a volumetric basis for the entire 6-year period), were completely absent from stomachs collected from 1941 to 1943, inclusive; fish were found in two-thirds of the stomachs taken in 1942, in only one-third of those taken in 1943; mollusk frequency varied from 25 percent in 1941 to 88 percent in 1943.

In order to determine the extent of differences in feeding due to size of the predator, the trout were arbitrarily divided into two size groups, one comprising specimens 12 inches or less in total length, the other containing the larger fish, from 12-1/8 to 22-1/2 inches. Results appear in Table 3, plotted under major food organism categories, and are broken down further in Table 4 so far as species of fishes consumed are concerned. No further breakdown of other food groups has been made on a predator size basis, since the same species of invertebrates predominated in the stomachs of both size groups.

Table 3 shows clearly that the two most important groups of food organisms in the diet of the Birch Lake rainbow trout were aquatic insects (with few exceptions in immature growth stages) and fishes, the former occurring in 89 percent of all stomachs and accounting for


PERCENTAGE FREQUENCY OF OCCURRENCE
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
1941
1942
1943
1944
1945
1946
MOLLUSKS
ENTOMOSTRACANS
CRAYFISH & SCUDS
AQUATIC INSECTS
WATER MITES
SPIDERS
LAND INSECTS
FISH
ALGAE
HIGHER PLANTS

Food Items	Stomachs from 165 trout 7-5/8 to 12 inches					Stomachs from 157 trout 12-1/8 to 22-1/2 inches					All stomachs combined				
	Number of species	Percent of stomachs containing organism	Number of organisms in stomachs containing them		Percent of total volume	Number of species	Percent of stomachs containing organism	Number of organisms in stomachs containing them		Percent of total volume	Number of species	Percent of stomachs containing organism	Number of organisms in stomachs containing them		Percent of total volume
			Maximum	Average				Maximum	Average				Maximum	Average	
Mollusks	8	38	51	5.7	3	9	41	142	7.2	3	10	39	142	6.5	3
Microcrustaceans	...	24	...	...	5	...	10	...	...	trace	...	17	...	...	1
Crayfish and scuds	2	1	1	1.0	trace	3	10	8	1.5	3	3	5	8	1.4	3
Aquatic insects	36	86	478	24.2	40	37	91	1042	29.8	18	49	89	1,042	26.9	23
Water mites	3	30	38	4.1	trace	3	19	90	6.5	trace	3	25	90	5.0	trace
Terrestrial insects	34	18	19	2.4	1	64	26	302	24.7	3	87	22	302	15.3	3
Spiders	8	5	1	1.0	trace	12	10	11	2.5	trace	18	7	11	2.0	trace
Fish	8	32	24	3.9	30	14	51	72	5.4	48	16	41	72	4.8	43
Algae	...	20	...	...	1	...	31	...	...	3	...	26	...	...	3
Higher plants	...	35	...	...	1	...	54	...	...	3	...	44	...	...	3
Animal debris	...	40	...	...	12	...	39	...	...	7	...	39	...	...	8
Mixed debris	...	12	...	...	6	...	18	...	...	11	...	15	...	...	9
Inorganic debris	...	1	...	...	trace	...	4	...	...	trace	...	3	...	...	trace
Combined traces	...	...	...	...	1	...	...	...	...	1	...	...	...	...	1
Totals	99	...	...	...	100	142	...	...	...	100	186	...	...	...	100

Table 4.--List of fishes found in stomachs of rainbow trout from Birch Lake, Michigan, showing frequency of occurrence, maximum and average numbers per stomach, and percent of total volume of fish eaten. "Trace" denotes values less than one-half of one percent.

Food Item	165 stomachs from trout 7-5/8 to 12 inches				157 stomachs from trout 12-1/8 to 22-1/2"				All stomachs combined			
	Percent of stomachs containing organism	Number of organisms in stomachs containing them		Percent of total volume	Percent of stomachs containing organism	Number of organisms in stomachs containing them		Percent of total volume	Percent of stomachs containing organism	Number of organisms in stomachs containing them		Percent of total volume
		Maximum	Average			Maximum	Average			Maximum	Average	
Lepisosteus osseus oxyurus	...	...	...	...	1	1	1.0	3	trace[1]	1	1.0	2
Salmonidae	...	...	...	...	1	1	1.0	[1]	trace	1	1.0	[1]
Cyprinidae	17	7	1.9	19	17	22	3.5	7	17	22	2.7	9
Semotilus a. atromaculatus	trace	1	1.0	2	1	1	1.0	1	1	1	1.0	1
Notemigonus crysoleucas auratus	1	2	1.5	4	1	1	1.0	1	1	2	1.3	2
Notropis sp.	3	9	4.4	5	7	31	5.6	4	5	3.1	5.3	4
Notropis cornutus	...	...	...	...	1	4	2.5	5	1	4	2.5	4
Notropis heterodon	...	...	...	...	1	1	1.0	trace	trace	1	1.0	trace
Notropis v. volucellus	5	20	4.0	19	10	47	7.8	14	8	47	6.4	15
Notropis h. heterolepis	1	2	1.5	3	2	2	1.3	[1]	2	2	1.4	1
Hyborhynchus notatus	2	2	1.3	11	3	2	1.5	3	2	2	1.4	4
Fundulus diaphanus menona	...	...	...	...	1	1	1.0	trace	trace	1	1.0	trace
Perca flavescens	...	...	...	...	7	2	1.2	24	3	2	1.2	20
Centrarchidae	trace	1	1.0	trace	4	1	1.0	2	2	1	1.0	1
Huro Salmoides	...	...	...	...	3	1	1.0	8	1	1	1.0	7
Lepomis sp.[2]	3	13	3.8	2	4	3	1.7	1	3	13	2.6	1
Lepomis gibbosus	...	...	...	...	1	1	1.0	[1]	trace	1	1.0	[1]
Lepomis m. macrochirus	...	...	...	...	3	2	1.5	6	1	2	1.5	5
Cottus sp.	...	...	...	...	1	1	1.0	1	trace	1	1.0	1
Cottus bairdii	...	...	...	...	1	1	1.0	trace	trace	1	1.0	trace
Pungitius pungitius	3	4	1.8	2	10	4	1.4	2	6	4	2.5	2
Fish remains	15	...	...	32	25	...	...	17	20	...	...	20
Combined traces	...	...	...	1	...	...	...	1	...	...	...	1
Total	...	...	...	100	...	...	...	100	...	...	...	100

[1] Volume included with fish remains

[2] Includes one Lepomis cyanellus

23 percent of the total volume, the latter occurring in 41 percent of all stomachs and comprising 43 percent of the total volume. The volumetric values for aquatic insects and fish are approximately reversed in the two size groups of trout, the insects being more important than fish in the smaller trout, as would be expected. It is interesting to note, however, that even the larger trout did not lose their taste for insects, but fed upon them freely, nearly half (49 percent) of the larger trout having no fish in their stomachs. The occurrence of algae and higher plant materials shows that utilization of vegetable material by lake-inhabiting rainbows increases rather than decreases with the size of the trout. Microcrustaceans, represented by various undetermined species of Cladocera and Copepoda, occurred in about one-fourth of the smaller trout, in only one-tenth of the larger. Since ciscoes are considered to feed largely on plankton, it is apparent that the rainbows offer them but little food competition. Decapod crustaceans were taken very infrequently, and composed 3 percent of the diet, volumetrically, almost solely because of 11 large crayfish (Cambarus sp.) taken by trout of the larger size group. Only 10 specimens of Hyalella knickerbockeri and 2 of Gammarus fasciatus appeared in the 322 stomachs. Mollusks, which also made up 3 percent of the diet volumetrically, occurred in over one-third of the stomachs of trout of both size groups, and were represented by species of 10 different genera[3], 9 of them gastropods,

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[3] Lymnaea, Helisoma, Planorbis, Physa, Valvata, Bythinia, Amnicola, Pyrgulopsis, Paludestrina and Pisidium.

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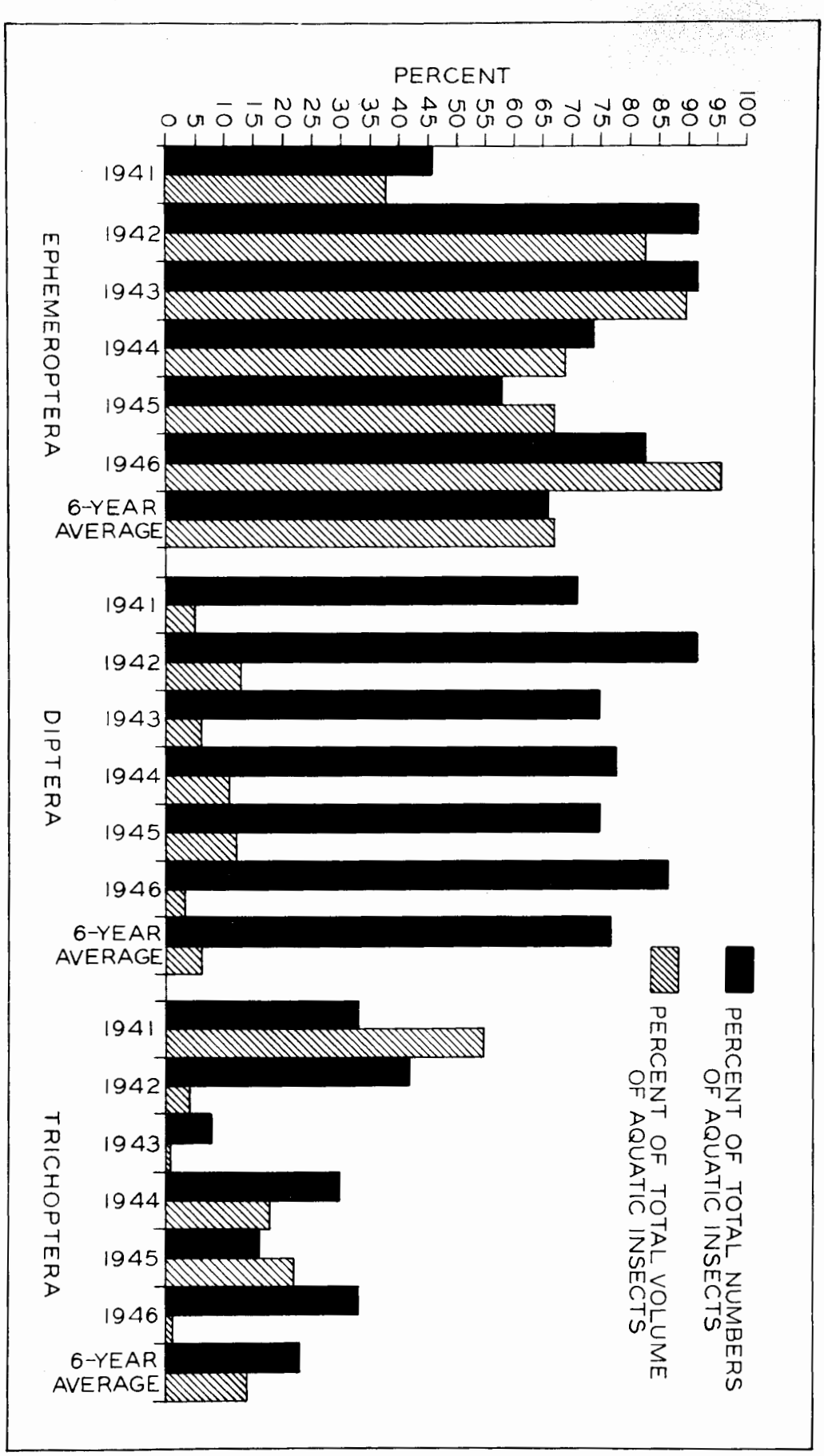
the other a "fingernail" clam.

A comparison of Table 4 with Table 2 reveals that of the 31 species of fishes known to occur in the lake, 17 were found in the stomachs, including the unidentified salmonid. Scales of four others, the cisco, common sucker, mud minnow and Iowa darter, appeared in one stomach each but have been omitted from the tabulation in the belief that they were probably accidentally ingested with bottom material and did not represent fish eaten. Every species of cyprinid known to inhabit the lake was represented in the diet. The mimic shiner, Notropis v. volucellus, led all species of fish in frequency of occurrence and greatest number per individual stomach, but was surpassed volumetrically by the less frequently occurring yellow perch. It is noteworthy that trout of the smaller size group fed scarcely at all on game or pan fishes.

One important question answered by Table 4 is that concerning the possible influence of the rainbow trout in reducing the cisco population of Birch Lake. It is obvious that there are no grounds for apprehension on this score. The rainbows are not predatory on the cisco; and since it has been shown in Table 3 that they are not heavy plankton feeders, it seems unlikely that the two species are in conflict. So far as feeding habits are concerned, the two species should be able to thrive and each provide a satisfactory fishery.

A wide variety of aquatic insects appeared in the stomachs of trout of both size classes, as is shown by Table 5. Three orders, Ephemeroptera, Trichoptera and Diptera, far outweighed all others in frequency of occurrence, number of individuals eaten, and percent of total volume (Figure 2). Chironomid midge larvae and pupae, the most frequently occurring single insect group, included Polypedilum nubeculosum, Tanypus stellafus, Tanytaosus jucundus dimorphus, Chironomus plumosus, lobiferus,


PERCENT
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70
75
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95
100
EPHEMEROPTERA
1941
1942
1943
1944
1945
1946
6-YEAR AVERAGE
DIPTERA
1941
1942
1943
1944
1945
1946
6-YEAR AVERAGE
TRICHOPTERA
1941
1942
1943
1944
1945
1946
6-YEAR AVERAGE
PERCENT OF TOTAL NUMBERS OF AQUATIC INSECTS
PERCENT OF TOTAL VOLUME OF AQUATIC INSECTS

Table 5.--Fluctuations in annual occurrence of species of aquatic insects[1] in rainbow trout stomachs from Birch Lake, Michigan

Species	Years[2] in which species occurred	Species	Years in which species occurred
Ephemeroptera (Mayflies)	1-6	Trichoptera (Caddisflies)	1-6
Ephemera simulans	4,6	Hydroptilidae	1-6
Hexagenia occulta	1-6	*Oxyethira* sp.	4,5
Baetinae	4,5	*Banksiola selina*	5,6
Callibaetis sp.	6	*Phryganea* sp.	1,2,4-6
Ephemerella temporalis	6	Limnephilidae	6
		Leptocella exquisita	1,2,4
Odonata (Dragonflies & damselflies)	1-2,4-6	*Leptocella albida*	4-6
Coenagrioninae	2,4,5	*Oecetis* sp.	4
Enallagma spp.	1,4-6	*Oecetis eddlestoni*	2
Amphiagrion saucium	4	*Triaenodes tarda*	2
Neogomphoides obscura	5	*Triaenodes injusta*	4
Stylurus sp.	5	*Mystacides* sp.	1,5
Epicordulia princeps	5	*Mystacides sepulchralis*	4,6
Tetragoneuria simulans	4,5	*Brachycentrus* sp.	4,5
Libellula spp.	1,4,5		
Plathemis lydia	5	Diptera (True flies)	1-6
		Tipula abdominalis	4,5
Neuroptera (Alder flies)	1,3-6	Chironomidae	1-6
Sialis infumata	1,3-6	Ceratopogonidae	1,4-6
		Culex sp.	1,5
Plecoptera (Stoneflies)	1	*Chaoborus punctipennis*	5
Isoperla sp.	1	*Simulium venustum*	3
Hemiptera (Water bugs)	3-6		
Arctocorisa sp.	3-6		
Notonecta undulata	5,6		
Belostoma flumineum	6		
Coleoptera (Water beetles)	5		
Haliplus sp.	5		
Dytiscidae	5		
Gyrinidae	5		
Hydrophilidae	5		
Dryopidae	5		
Donacia sp.	5		

[1] All forms listed were taken in immature stages except the following: *Ephemera simulans*, both nymphs and subimagoes; *Haliplus* sp. and *Donacia* sp., pupae and adults; Hydroptilidae, larvae, pupae and adults; *Tipula abdominalis* and *Culex* sp., both larvae and adults.

[2] The years 1941 - 1946 are represented by the numbers 1 - 6.

and modestus. Many species of caddis larvae and pupae were eaten. A species of Phryganea near cinerea dominated, followed by two species of Leptocella and an undetermined Hydroptilid. Two burrowing mayflies, Hexagenia occulta and Ephemera simulans, were the most important element of the ephemeropteran portion of the diet, which accounted for over three-quarters of the total volume of aquatic insects. Of particular interest was the fact that Hexagenia, represented only by nymphs, occurred in stomachs throughout the entire seasonal span covered by the collections, whereas the Ephemera was represented by nymphs and subimagoes occurring together in stomachs over a very short period of time in late May and was obviously utilized by the rainbows only during its emergence period. It is surprising that two species whose nymphs presumably possess very similar habits should exhibit such a wide disparity in the trout diet.

Other peculiarities in occurrence of aquatic insects are displayed by the aquatic Coleoptera, represented by six families but found in stomachs collected in 1945 only; by blackfly (Simulium) larvae; and a stonefly, Isoperla sp. The two last-named forms, represented by only a few individuals, would not be expected in typical lake environments, and may represent a foray into the region adjacent to the outlet stream (which was screened to prevent escape of fish from the lake) by the trout eating them. Although aquatic Hemiptera have often been considered unpalatable to fish owing to their noticeable odor and the stinging potentialities of certain familes, notably the notonectids, representatives of this order were of steady though not abundant occurrence in the stomachs.

It has not been considered profitable to tabulate the terrestrial insect portion of the diet by taxonomic categories. However, it should

be noted that land insects appeared very infrequently throughout the summer but were eaten in great quantity during October and early November.

In addition to collecting rainbow trout stomachs, the creel census clerks covering Birch Lake obtained stomachs from 25 lake trout (Cristivomer n. namaycush), the contents of which are analyzed in Table 6. On the basis of this limited series of specimens, it would appear that the lake trout are more strongly piscivorous than the rainbows, but feed upon aquatic insects frequently enough to be rated as direct competitors of the rainbows for both insect and fish food organisms. There were no indications that ciscoes, large or small, entered the lake trout's diet. Two lake trout had eaten adult June beetles, and another a large hawk-moth larva, evidence that even these lovers of deep water may now and then take surface food.

The composition of the rainbow trout diet is such as to deserve consideration when management of the Birch Lake fishery is being planned. The suitability of the environment for rainbows is apparent from the catholicity of their feeding habits. They are able to utilize inhabitants of the shallow littoral zone, such as a majority of the immature stages of aquatic insects; the bottom fauna of the deeper zones, as evidenced by nymphs of Hexagenia which occur in fair numbers to a depth of 60 feet, and immature chironomids which are abundant even at the lake's greatest depth; and organisms of the open water, such as forage fishes and plankton. Since terrestrial insects and flying stages of aquatic insects were consumed most sparingly except for a few days during the heavy emergence of Ephemera simulans in late May and during October when the great bulk of terrestrial insects appeared in the diet, it is obvious that fly fishermen will be able to expect a fair measure of success only

Table 6.--Contents of 25 stomachs of lake trout taken from Birch Lake, Michigan, 1941 - 1946. (L = larva, P = pupa, N = nymph, A = adult).

Food Items	Number of species	Percent of stomachs containing organisms	Number of organisms in stomachs containing them		Percent of total volume
			Maximum	Average	
Annelida	1	4	1	1.0	trace
Hirudinea (Leeches)	1	4	1	1.0	trace
Aquatic Insects	8	80	19	6.5	11
Ephemeroptera (Hexagenia occulta,N)	1	76	11	3.7	9
Odonata (Enallagma sp.,N)	1	4	1	1.0	trace
Neuroptera (Sialis infumata,L)	1	20	2	1.2	trace
Hemiptera (Arctocorisa sp.,A)	1	4	1	1.0	trace
Trichoptera (Phryganea sp.,L)	1	8	1	1.0	1
Diptera (Chironomidae, L and P)	3	48	8	3.7	1
Water mites	1	16	9	4.3	trace
Hydracarina	1	16	9	4.3	trace
Terrestrial Insects	3	8	2	1.5	2
Coleoptera (Phyllophaga spp. A)	2	8	1	1.0	1
Lepidoptera (Sphingidae, L)	1	4	1	1.0	1
Fish	16	76	12	2.6	83
Cyprinidae (undentifiable)	3	16	7	3.0	7
Notemigonus crysoleucas auratus	1	4	1	1.0	3
Notropis spp.	2	8	3	2.5	4
Notropis cornutus chrysocephalus	1	4	1	1.0	1
Notropis heterodon	1	4	1	1.0	2
Notropis v. volucellus	1	8	4	2.5	3
Hyborhynchus notatus	1	4	1	1.0	4
Fundulus diaphanus	1	4	5	1.0	12
Perca flavescens	1	4	1	1.0	17
Centrarchidae	1	4	1	1.0	trace
Lepomis m. macrochirus	1	8	2	2.0	19
Pungitius pungitius	1	20	2	1.4	2
Cottus sp.	1	4	1	1.0	1
Fish remains	...	40	4	1.8	8
Algae	...	4	...	...	trace
Higher plants	...	4	...	...	trace
Animal debris	...	...	...	...	4
Totals	29	...	...	...	100

when special regulations permit them to fish for rainbows during the spring and fall months. High surface water temperatures which exist during summer seem to discourage rainbows from surface feeding except when their attention is attracted by the mass emergence of E. simulans just mentioned, and even this insect was represented in stomachs by many more nymphs than subimagoes, an indication that feeding was heaviest while the nymphs were rising from the bottom to the surface preparatory to transforming. Anglers seeking to take rainbows during the summer months must expect to use baits fished at depths where water temperatures have sunk to a point tolerable to the species, generally 15 feet or more below the surface.

Neither the rainbow nor the lake trout appears to be significantly predatory on the cisco or on any of the game fishes in the lake, nor does either compete with the cisco for food to an important degree. Neither trout species, therefore, is by its presence jeopardizing the cisco population. But the two trouts are themselves competing for the same food organisms, a factor which should be kept in mind when stocking either species. Yellow perch and the various centrarchids played such a small part in the diet of the trouts that it is apparent their populations are not at present being significantly reduced by trout predation. Although yellow perch made up one-fifth of the volume of all fish consumed by the rainbow trout, they appeared in only 3 percent of the stomachs; centrarchids, making up 14 percent of the total fish volume, were contained in only 7 percent of the stomachs. Numerically, only

90[4] centrarchids and 11[5] perch were found in the 322 stomachs. During

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[4] Centrarchids included 3 largemouth bass, 2 - 4-1/2 inches long; 6 bluegills, 3/4 - 5 inches long; 1 green sunfish, 4-7/8 inches long; and 16 Lepomis sp; 1/2 - 1 inch in length.

[5] Five of the perch ranged from 3-1/4 - 4-1/2 inches in length.

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the warmer months of the year the salmonids and centrarchids probably seldom occupy the same levels of the lake; but if further reductions in the centrarchid and perch populations are desired, an increased trout-stocking program might force the trout to feed more extensively on young bass, bluegills, sunfish and perch during the colder months.

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Summary and Conclusions

1. Analyses of stomach contents of 322 rainbow trout and 25 lake trout collected from Birch Lake, Cass County, Michigan, over a 6-year period, are presented.

2. The most important elements in the diet of the two species of trout were aquatic insects and fishes, especially forage fish.

3. There were no indications that either the rainbow or lake trout fed upon ciscoes or competed with them for food, hence it is concluded that the presence of these trout in Birch Lake is not jeopardizing the resident cisco population.

4. Neither species of trout fed extensively on perch or centrarchids and did not serve as a check on the populations of these species during the period covered by the study.

5. The rainbow and lake trout compete directly with each other for fish and aquatic insect dietary components.

6. Birch Lake rainbow trout fed on surface organisms to a significant extent only during the brief period in late May when the burrowing mayfly Ephemera simulans was emerging, and again in October and early November when large numbers and many species of terrestrial insects appeared in the stomachs. It is therefore concluded that fly fishing can be expected to meet with success only so long as regulations permit angling for rainbows during spring and fall months.

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