Original: Fish Division
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Inst. for Fish. Res.
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April 26, 1955

Report No. 1446

FOOD HABITS OF THE BURBOT (LOTA LOTA LACUSTRIS) IN THE WHITE RIVER, A MICHIGAN TROUT STREAM[1]

By

Alfred M. Beeton

Abstract

A fish inventory of the White River system made in the late spring and summer of 1952, and subsequent collections made during the summer of 1953 and February, 1954, indicate that the burbot is one of the abundant species in this watershed. All collections were made by using a 230-volt, D-C shocker. Analyses of stomach contents were made on 196 of the burbot--176 from the summer collections and 20 from the winter collections. Within the two seasonal groups, analysis was based on four length classes of burbot: 2.0"-3.9", 4.0"-6.9", 7.0"9.9", and 10.0"-12.9". The relative importance of various food items in the winter and summer diets, for each of these size groups, was determined through numerical count of species and individuals, and by determination of volume through displacement of 80 percent alcohol in a graduated centrifuge tube.

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[1] A joint contribution from the Institute for Fisheries Research, and the Zoology Department of the University of Michigan. A condensed version of the paper has been submitted for publication in the journal Copeia.

The food habits of the burbot from the White River and its tributaries were similar in winter and summer, and compared closely to published data on the food habits of burbot inhabiting lakes. During both seasons the smaller burbot fed more on gammarids and insects, while the larger burbot fed more on crayfish and fish in the summer and on gammarids and fish in the winter. The burbot under 7" rarely contained fish; of the 49 burbot which were 7"-9" in length, 11 contained fish; and all 6 of the burbot 10"-12" long contained fish. The fish eaten by burbot most frequently were blacknose dace and rainbow trout followed by a variety of other species. As burbot increase in length, there is a shift in their diet from smaller to larger food items, and it is concluded that the size of food particle is one of the most important factors which determines what items are eaten.

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Alfred M. Beeton[2]

The fish on which this study was conducted were collected during the summers of 1952 and 1953 and during February, 1954, in the White River watershed. A fairly large population of burbot is present in this watershed, being permanent residents in the upper reaches of the river and possibly migrants (from Lake Michigan) in the lower regions. The main stream and most of the tributaries are considered to be marginal trout waters (Schultz, 1953). This watershed (situated in western Michigan) encompasses the major portion of Oceana County and extends into Newaygo and Muskegon counties. The river proper empties into White Lake, which in turn is connected to Lake Michigan.

The food habits of burbot in lakes has been studied extensively (Clemens, 1950; Cooper and Fuller, 1945; Van Oosten and Deason, 1938; and Bjorn, 1939), but very little information is available on food of burbot in streams. Also, almost all of the previous work has been concerned with burbot of larger sizes, although Clemens (1950) examined 23 stomachs of small burbot and found that gammarids and mayflies constitute a staple portion of their diet.

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[1] A joint contribution from the Institute for Fisheries Research, and the Zoology Department of the University of Michigan. A condensed version of the paper has been submitted for publication in the journal Copeia.

[2] Mr. Beeton has been employed as an assistant on a summertime stream survey party with the Institute; he is now a graduate student in the Zoology Department of the University of Michigan.

The present paper is concerned with all sizes of burbot (2" to 13") occurring in the White River, and with food habits of the fish in the stream environment.

A fish inventory of the White River system was recently conducted by an Institute field party, with Mr. Edward E. Schultz as party leader and the author as one of the two assistants. The present samples of burbot were part of the fish collections obtained.

I should like to express my gratitude to Dr. A. S. Hazzard, Dr. G. P. Cooper, and Mr. Schultz, of the Institute for Fisheries Research, Michigan Department of Conservation, for making this study possible and for permission to use the data on distribution of burbot. Also, I am indebted to Dr. David C. Chandler, of the University of Michigan, for his cooperation and advice.

Methods

The fish collections were made with the use of a 230-volt, 11-amp, D-C shocker. The main stream and the larger tributaries were shocked by placing the generator in a small, flat-bottom boat with a metal strip on the bottom for the negative electrode. Two positive electrodes were used, each attached to a 20-foot extension cord.

In small streams, where a boat could not be used, the shocker was placed on the stream bank. A large piece of copper screen served as the negative electrode. The positive electrode was attached to a 200-foot extension cord. This made it possible to sample 400 feet of stream by working downstream and upstream from the generator.

The stomach analysis incorporates numerical count of species and individuals, and determination of the volume of each group of organisms through displacement of 80 percent alcohol in a graduated centrifuge tube. The 80 percent alcohol was employed in preference to water to increase the accuracy--

it is a characteristic of the burbot to be extremely oily and this interferes with the formation of a typical meniscus when water is used.

Distribution of burbot in the White River watershed

Ninety-eight fish collections were made throughout the watershed, giving a good sample of the fish fauna. Ninety-two of these were made during the summer of 1952; two collections were made during the summer of 1953; and four were made during February of 1954. Burbot were taken at 44 of the 98 stations. These 44 locality records for burbot indicate that the species occurs throughout the main river from its mouth up to the dam at White Cloud, and in lower tributaries (those entering the main river below White Cloud) up to impassable dams. Tributaries containing burbot include Silver, Sand, Cleveland and Mena creeks and the North Branch. Two collections above Silver Creek dam, four above Rochdale on Sand Creek, eight above Ferry on the North Branch, two above the dam on Mena Creek, and ten above White Cloud indicate that these dams have been, and are, effective barriers against any further upstream spread of the burbot. Burbot were found below these dams, but not above them (Table 1). A large dam is situated on the main stream at Hesperia, part way between the mouth of the river and the White Cloud dam. Ten collections, made at widely separated points between Hesperia and White Cloud, contained burbot. The population of burbot above the (impassable) Hesperia dam presumably is a resident one--i.e., not migratory from Lake Michigan. It is not known whether the population below Hesperia is made up of permanent residents, or of migrants from Lake Michigan, or a mixture of two stocks. Burbot are known to migrate from the Great Lakes up other Michigan streams to spawn.

The burbot seems to be able to withstand the adverse conditions of marginal trout streams considerably better than trout. Out of 19 collections made on the main stream, which is considered submarginal trout water (Schultz,

Table 1.--Data for the various dams[1] on the White River and tributaries

Stream	Name of dam	Height (feet)	When built (year)	Fish collections above dam	
				Total	Number with burbot
Silver Creek	?	7.0	1950	2	0
Sand Creek	Rochdale	10.0	1913	4	0
Cleveland Cr.	Lake Wolverine	16.0	?	0	...
N. Br. White R.	Ferry	...[2]	1871	8	0
White R.	Hesperia	10.0	1870	24	10
Mena Creek	?	8.0	?	2	0
White R.	White Cloud	17.0	1870	10	0

[1] Burbot were collected a short distance downstream from each dam.

[2] The dam at Ferry was not functioning at time of collections. Flow over the spillway had a drop of only about 2 feet, and was possibly passable to burbot going upstream.

1953), only 3 contained trout while burbot occurred in 16. Burbot are found in the lower sections of practically all of those tributary streams entering below White Cloud, many of which are fairly good trout streams in their upper reaches. As these streams become shallower and colder towards their source, burbot occur less frequently and trout are more abundant. An excellent example of this is Carlton Creek. A collection made near the mouth of Carlton Creek contained 90 burbot and 48 brook trout; one mile further upstream, 32 burbot, 64 brook trout, and 2 rainbow trout were collected; four miles further upstream, 7 brook trout and 1 burbot were taken; while in the headwaters only brook trout were collected.

The collection records for the White River survey indicate that the burbot is one of the major constituents of the fish population. During the summer of 1952, 1,770 brook trout, 679 burbot, 258 brown trout, and 69 rainbow trout were collected.

Specific habitat of the burbot in streams

Burbot taken in our collections were invariably found in sections of the stream having a great deal of bottom litter. They were especially abundant in sections of stream where dark silty bottom was found in conjunction with submerged logs, stumps, and other debris. All size groups of burbot were found around this same cover, i.e., small fish had the same preferences as large fish. Although burbot were taken from deep holes, they were not so abundant in this habitat as in shallower areas. They appear to be able to tolerate slightly warmer water than brown trout, as they were captured in parts of the main stream where water temperatures of 80° F. were recorded. The largest collections of burbot were made in streams approximately 15 feet wide, and having an average depth of 4 inches, a dark bottom, plenty of cover, and a water temperature around 65° F. Burbot may spawn in shallow water in streams (Olson, 1946), or in deep holes in rivers (Bjorn, 1939).

Burbot examined

The fish survey (collections at 92 stations) of the White River, reported on by Schultz in I. F. R. Report No. 1378, was made during the summer of 1952. The locations of these stations are given on a map with Schultz's report. For the present food habits study, burbot in the following 1952 collections were studied:

Sta. No.	Stream	Date	Number of burbot examined
19	E. Br. Heald Cr.	May 16	4
35	Skeel Cr.	June 2	34
64	Carlton Cr.	July 9	90
75	N. Br. White R.	July 29	17
76	N. Br. White R.	July 30	5
78	White R.	July 31	10
89	White R.	Aug. 19	3

The food habits study also included burbot collected during 1953 and 1954 at the following 1952 stations (collections repeated at these sites):

Sta. No.	Stream	Date	Number of burbot examined
51	Cushman Cr.	Aug. 19, 1953	8
6	White R.	Feb. 13, 1954	1
64	Carlton Cr.	Feb. 14, 1954	18
67	Newman Cr.	Aug. 20, 1953	5
New sta.	White R. (T14N, R14W, Sec. 25)	Feb. 14, 1954	1

Thus, the 196 burbot used for the present study were from 11 stations scattered throughout that part of the White River drainage (main river and tributaries) where the burbot occurs.

Food habits

It is reasonable to consider each successive stage in the life history of an organism as a separate entity, because the several stages may have widely varying relationships with the environment. This is obvious for dipterous insects, as an example, where there is a cycle of egg, larva, pupa, and adult. It is less obvious for fish, but nonetheless true. Following this line of thought, we cannot speak of a species of fish as having certain food preferences, but we are forced to think in terms of various size classes and the individual food preferences of these size classes. Relating this to the food-web concept, Allee et al. (1949) stated: "Animals of the same species may feed on different meshes at different parts of their life cycle."

Burbot from the White River were separated into size groups, on the assumption that food preferences would depend upon the relationship of size of burbot to size of food particle. Four size groups of burbot were set up, based on a length-frequency graph for all specimens in the collections examined: 2.0"-3.9", 4.0"-6.9", 7.0"-9.9", and 10.0"-12.9". Although these size groups may correspond in some cases to age groups, this was not intentional; age determinations on the burbot were not made, and no attempt was made to correlate food preferences with age.

Setting up these size groups is important for several reasons: (1) to determine, firstly, if food preferences are related to size of fish; if so, (2) to determine what the small burbot eat, since there is little published information on food of burbot under 9" in length; and (3) to have data for the 10.0"-12.9" group for comparison with data which other workers have published.

A total of 196 stomachs were examined, 176 from burbot collected from May to August (Table 2) and 20 collected in February (Table 3). Of twenty-five of the former and two of the latter, the stomachs were empty (void). The percentages of void stomachs amounted to 14.2 percent and 10.0 percent, respectively.

These percentages of void stomachs are somewhat lower than those noted by Clemens (1950), and Van Oosten and Deason (1938). They reported 40.0-50.0 percent and 16 percent of the stomachs empty. The difference is probably explainable in that the stomachs used in the present analysis were taken from fish collected with a D-C shocker and preserved in formalin immediately after capture; while those used in the other studies were taken from burbot caught with nets, with some time lag between collection and preservation of stomachs. Van Oosten and Deason (1938) stated that the fish were left in the nets from two to ten days, and Clemens (1950) obtained the majority of his burbot stomachs from commercial fishermen. It is likely that many of the smaller invertebrates would have been completely digested before the stomachs were examined. This may be one of the reasons why more insects were not found by Van Oosten and Deason; insects occurred in only 0.2 percent of the stomachs examined by them. Also, Lagler and Applegate (1942) found that fish collected by means of a trap do not offer an adequate record of the food habits. This conclusion should apply to any means of collecting whereby the fish are not preserved almost immediately after capture.

Food preferences during summer

The 176 stomachs of fish collected during summer (May 20 to Aug. 20) contained a total food volume of 46.83 ml. The analyses of stomach contents for the four size groups of *Lota* are summarized in Table 2 and Figures 1 and 2. For burbot under 7 inches, the crustacean, *Gammarus fasciatus*, and aquatic insect larva, especially mayfly nymphs and *Hydropsyche* larva, were eaten more frequently, and these food types also comprised the greater percentage of the

Table 2.--Stomach contents of Lota lota lacustris, White River watershed, in late spring and summer. Figures are volume percentage of each type of food, and frequency-of-occurrence percentage for each type of food in stomachs containing food. Tr. = trace

Length of burbot	2.0"-3.9"		4.0"-6.9"		7.0"-9.9"		10.0"-12.9"	
Total volume of food (ml.)	2.58		11.51		26.29		6.45	
Number stomachs with food	35		68		43		5	
Number void	2		8		15		0	
Food items L = larva N = nymphs A = adults	Vol. %	Freq. %	Vol. %	Freq. %	Vol. %	Freq. %	Vol. %	Freq. %
Annelida	3.1	2.9	2.2	1.5	23.7	9.3	...	...
Malacostraca	32.2	91.4	27.4	57.4	32.0	69.8	22.5	40.0
Gammarus fasciatus	30.6	91.4	16.9	47.1	2.2	30.2	...	...
Cambarus sp.	1.6	8.6	10.3	14.7	29.7	46.9	22.5	40.0
Isopod	...	...	0.2	1.5	0.1	2.3	...	...
Aquatic insects								
Ephemeroptera	16.3	62.8	12.4	55.9	3.2	41.9	Tr.	20.0
Heptageniidae (N)	2.3	14.3	0.8	13.2	0.1	2.3	Tr.	...
Heptageniidae (A)	...	...	0.1	1.5	...	...	...	...

Ephemerella sp. (N)........	1.2	5.7	1.1	7.4	...	...	...	...
Baetidae (N)...............	1.2	8.6	0.4	5.9	0.3	4.7	...	...
Undetermined (N)...........	11.6	42.9	6.8	42.6	2.8	37.2	Tr.	20.0
Undetermined (A)...........	...	...	0.4	1.5	...	...	...	...
Ameletus sp. (N)...........	...	...	0.6	5.9	...	...	...	...
Hexagenia sp. (N)..........	...	...	2.2	1.5	...	...	...	...
Odonata....................	...	...	...	...	1.9	7.0	...	...
Agrion sp. (N).............	...	...	4.4	7.4	Tr.	2.3	...	...
Anisoptera (N).............	...	...	...	...	1.9	4.7	...	...
Plecoptera.................	...	...	1.5	8.9	...	...	...	...
Undetermined (N)...........	...	...	1.2	5.9	...	...	...	...
Peltoperla sp. (N).........	...	...	0.1	1.5	...	...	...	...
Acroneuria sp. (N).........	...	...	0.2	1.5	...	...	...	...
Hemiptera..................	...	...	...	...	1.1	2.3	...	...
Notonecta sp..............	...	...	...	...	0.1	2.3	...	...
Coleoptera.................	1.7	2.9	0.5	2.9	0.1	4.7	0.5	20.0
Undetermined (A)...........	1.7	2.9	...	...	Tr.	2.3	0.5	20.0
Undetermined (N)...........	...	...	0.5	2.9	0.1	2.3	Tr.	20.0
Trichoptera................	5.0	37.1	24.9	75.0	6.2	58.1	Tr.	20.0
Hydropsyche (L)............	2.3	20.0	21.2	66.2	4.9	41.9	...	...
Undetermined (L)...........	2.3	14.3	2.7	10.3	0.9	14.0	Tr.	20.0
Undetermined (A)...........	0.4	2.9	...	...	...	...	...	...
Brachycentrus sp. (L)......	Tr.	2.9	0.9	13.2	0.4	20.9	...	...
Limnephilidae (L)..........	...	...	0.1	1.5	...	...	...	...

Diptera	4.6	65.7	0.8	26.5	3.3	27.9	0.3	40.0
Tendipes sp. (L)	0.8	22.9	0.2	13.2	0.2	9.3	Tr.	40.0
Pentaneura sp. (L)	Tr.	2.9	0.2	7.4	Tr.	4.7	...	...
Other Tendipedidae (L)	1.5	22.9	Tr.	2.9	0.1	4.7	...	...
Tipulidae (L)	...	...	...	...	2.9	4.7	...	...
Simulium (L)	1.9	28.5	0.3	8.8	0.1	11.6	0.3	20.0
Simulium (P)	Tr.	2.9	...	...	...	...	...	...
Chaoborinae (L)	Tr.	5.7	...	...	...	...	...	...
Undetermined Diptera	0.4	5.7	0.1	1.5	Tr.	4.7	Tr.	20.0
Terrestrial insects								
Cicadia	...	...	...	...	0.1	2.3	...	...
Araneae	...	...	0.2	1.5	...	...	...	...
Fish	3.9	2.9	1.4	4.4	12.9	23.2	72.1	100.0
Cottus bairdi	3.9	2.9	...	...	...	...	...	...
Undetermined fish remains	...	...	1.0	2.9	0.7	16.2	Tr.	40.0
Brown trout	...	...	0.4	1.5	0.8	2.3	...	...
Rainbow trout	...	...	...	...	...	...	32.6	20.0
Burbot	...	...	...	...	9.3	2.3	Tr.	20.0
Blacknose dace	...	...	...	...	0.8	2.3	39.5	40.0
Pearl dace	...	...	...	...	0.4	2.3	...	...
Johnny darter	...	...	...	...	0.9	2.3	...	...
Plant debris	0.7	...	1.9	...	2.6	...	0.9	...
Animal debris	16.7	...	9.7	...	7.5	...	3.7	...
Insect remains	9.7	...	11.6	...	4.1	...	...	...
Inorganic debris	6.1	...	1.1	...	1.3	...	Tr.	...

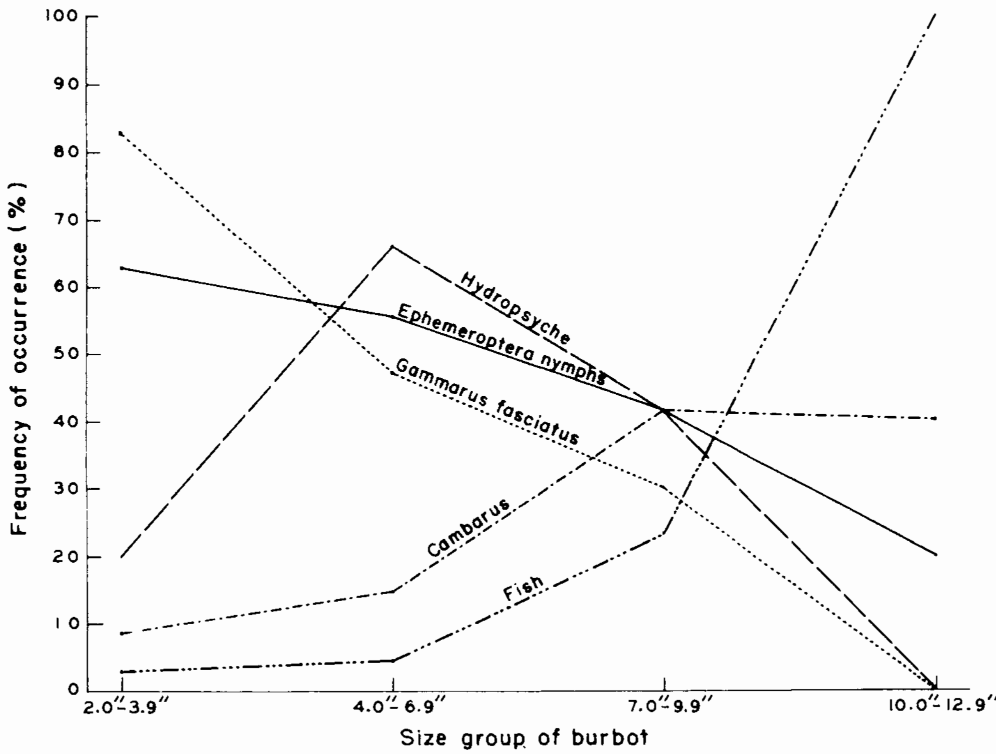
Table 3.--Stomach contents of Lota lota lacustris, White River watershed, in winter. Figures are volume percentage of each type of food, and frequency-of-occurrence percentage for each type of food in stomachs containing food. Tr. = trace

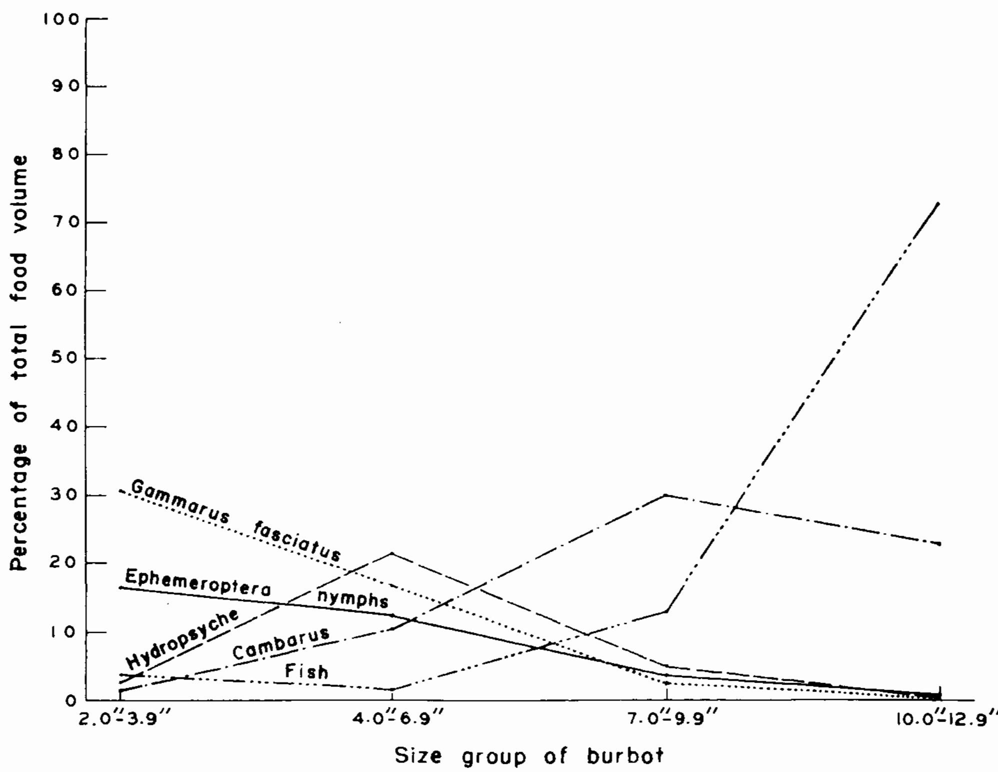
Length of burbot	4.0"-6.9"		7.0"-9.9"		10.0"-12.9"	
Total volume of food (ml.)	2.9		6.74		4.4	
Number stomachs with food	11		6		1	
Number void	2		0		0	
Food items L = larva N = nymph	Vol. %	Freq. %	Vol. %	Freq. %	Vol. %	Freq. %
Malacostraca						
Gammarus fasciatus	23.1	81.8	77.2	83.3	1.1	100.0
Aquatic insects						
Ephemeroptera	24.5	100.0	7.0	83.3	...	...
Blasturus sp. (N)	1.4	18.2	...	...	...	...
Ephemerella sp. (N)	12.4	54.5	2.1	16.7	...	...
Heptageniidae (N)	0.7	18.2	...	...	...	...
Baetidae (N)	3.4	9.1	0.7	16.7	...	...
Undetermined (N)	6.6	81.8	4.2	66.7	...	...
Plecoptera (N)	9.7	72.7	1.8	66.7	...	...
Taeniopteryx sp. (N)	9.7	72.7	1.6	50.0	...	...
Undetermined (N)	...	...	0.2	16.7	...	...
Trichoptera	6.5	45.5	0.1	16.7	...	...
Limnephilidae (L)	2.7	9.1	...	...	...	...
Hydropsyche sp. (L)	3.8	36.4	0.1	16.7	...	...
Brachycentrus sp. (L)	...	...	Tr.	16.7	...	...
Undetermined (L)	Tr.	9.1	...	...	...	...
Diptera	0.7	27.3	0.1	16.7	...	...
Tendipes sp. (L)	0.4	18.2	...	...	...	...
Pentaneura sp. (L)	0.3	9.1	0.1	16.7	...	...
Undetermined (L)	Tr.	9.1	...	...	...	...
Fish						
Cyprinodontidae	...	...	...	...	98.9	100.0
Organic debris						
Plant	0.7	...	0.7	...	...	...
Animal	34.8	...	13.1	...	...	...
Inorganic debris	...	...	Tr.[1]	...	...	...

[1] A fish hook.

Figure 1.--Frequency-of-occurrence of food items in stomachs of burbot collected in summer, related to size (length in inches) of consumer.

Figure 2.--Percentage of total food volume of various food items in stomachs of burbot, collected in summer, related to size (length in inches) of consumer.


100
90
80
70
60
50
40
30
20
10
0
Frequency of occurrence (%)
Hydropsyche
Ephemeroptera nymphs
Gammarus fasciatus
Cambarus
Fish
2.0"-3.9"
4.0"-6.9"
7.0"-9.9"
10.0"-12.9"
Size group of burbot


100
90
80
70
60
50
40
30
20
10
0
Percentage of total food volume
Gammarus fasciatus
Ephemeroptera nymphs
Hydropsyche
Cambarus
Fish
2.0"-3.9"
4.0"-6.9"
7.0"-9.9"
10.0"-12.9"
Size group of burbot

food by volume. Among burbot over 7 inches, Gammarus and insect larvae were of less importance, while crayfish (Cambarus) and fish occurred more frequently. Crayfish were the most important food for 7.0"-9.9" fish. Fish were definitely the most important food of burbot over 10.0", with blacknose dace and rainbow trout being eaten more frequently than other fish. These data show that there is a shift in the diet of burbot, with a positive correlation between size of the food and size of the consumer. As the burbot increase in length, two diet shifts occur. First, there is a shift from gammarids and aquatic insects to crayfish and aquatic insects, and then a shift to crayfish and fish.

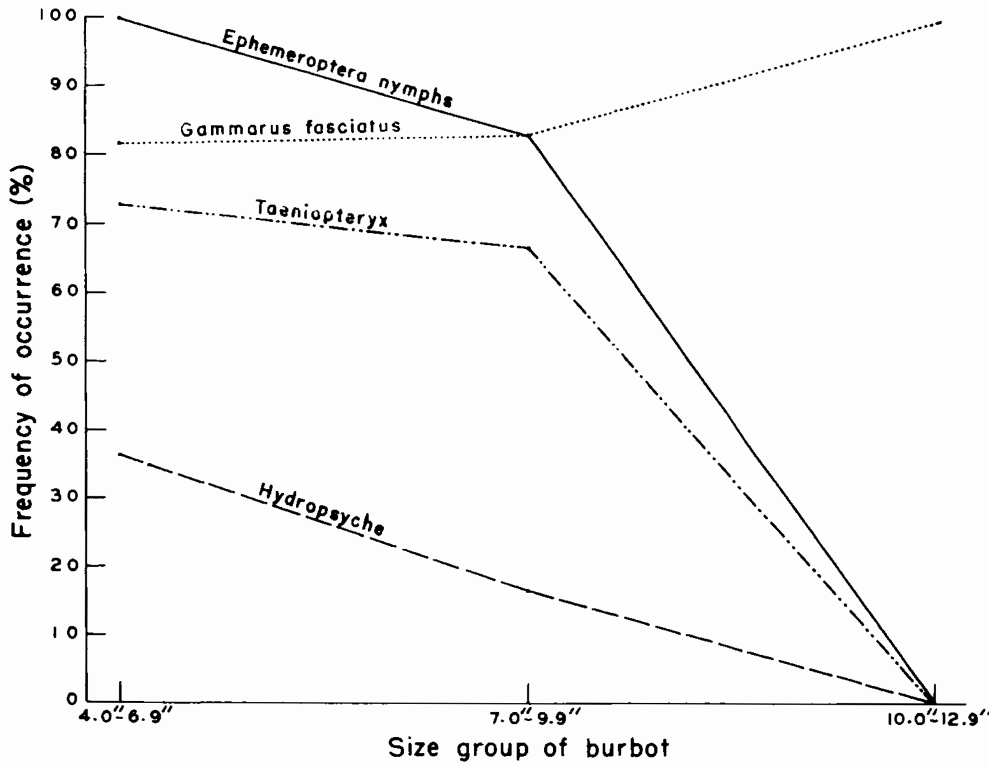
Food habits in the winter

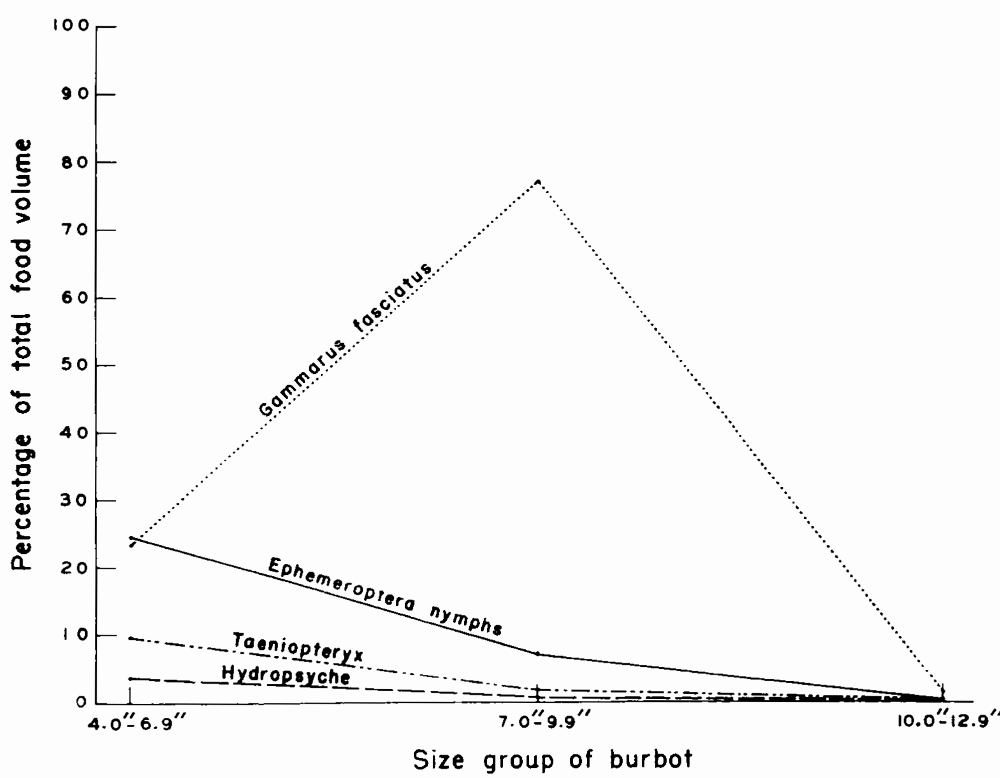
The winter sample (only 20 stomachs) is small. However, the analysis does show a trend. Of the 20 stomachs examined, 2 (or 10.0 percent) were empty. Clemens (1950) also found that the percentage of void stomachs was less in the winter months. This is undoubtedly because of reduced metabolism during the winter--i.e., any food eaten is retained in the stomach for a longer period.

The 18 winter stomachs contained a total of 14.04 ml. of food. There were no burbot in the 2.0"-3.9" group; by winter, presumably the smaller fish had attained a length of at least 4.0". The stomach contents are summarized in Table 3 and Figures 3 and 4. Mayfly nymphs, Gammarus fasciatus, and Hydropsyche larva were the important constituents of the winter diet, both volumetrically and according to frequency of occurrence, for burbot from 4.0" to 6.9". A plecopteran nymph, Taeniopteryx, was an important item in the winter, although it did not occur in the summer diet. Only one burbot in the 10-inch class was collected; its stomach contained fish remains.

Figure 3.--Frequency-of-occurrence of food items in stomachs of burbot, collected in winter, related to size (length in inches) of consumer.

Figure 4.--Percentage of total food volume of various food items in stomachs of burbot, collected in winter, related to size (length in inches) of consumer.


Ephemeroptera nymphs
Gammarus fasciatus
Taeniopteryx
Hydropsyche
Frequency of occurrence (%)
100
90
80
70
60
50
40
30
20
10
0
4.0"-6.9"
7.0"-9.9"
10.0"-12.9"
Size group of burbot


Gammarus fasciatus
Ephemeroptera nymphs
Taeniopteryx
Hydropsyche
Percentage of total food volume
100
90
80
70
60
50
40
30
20
10
0
4.0"-6.9"
7.0"-9.9"
10.0"-12.9"
Size group of burbot

Comparison of the winter and summer food habits

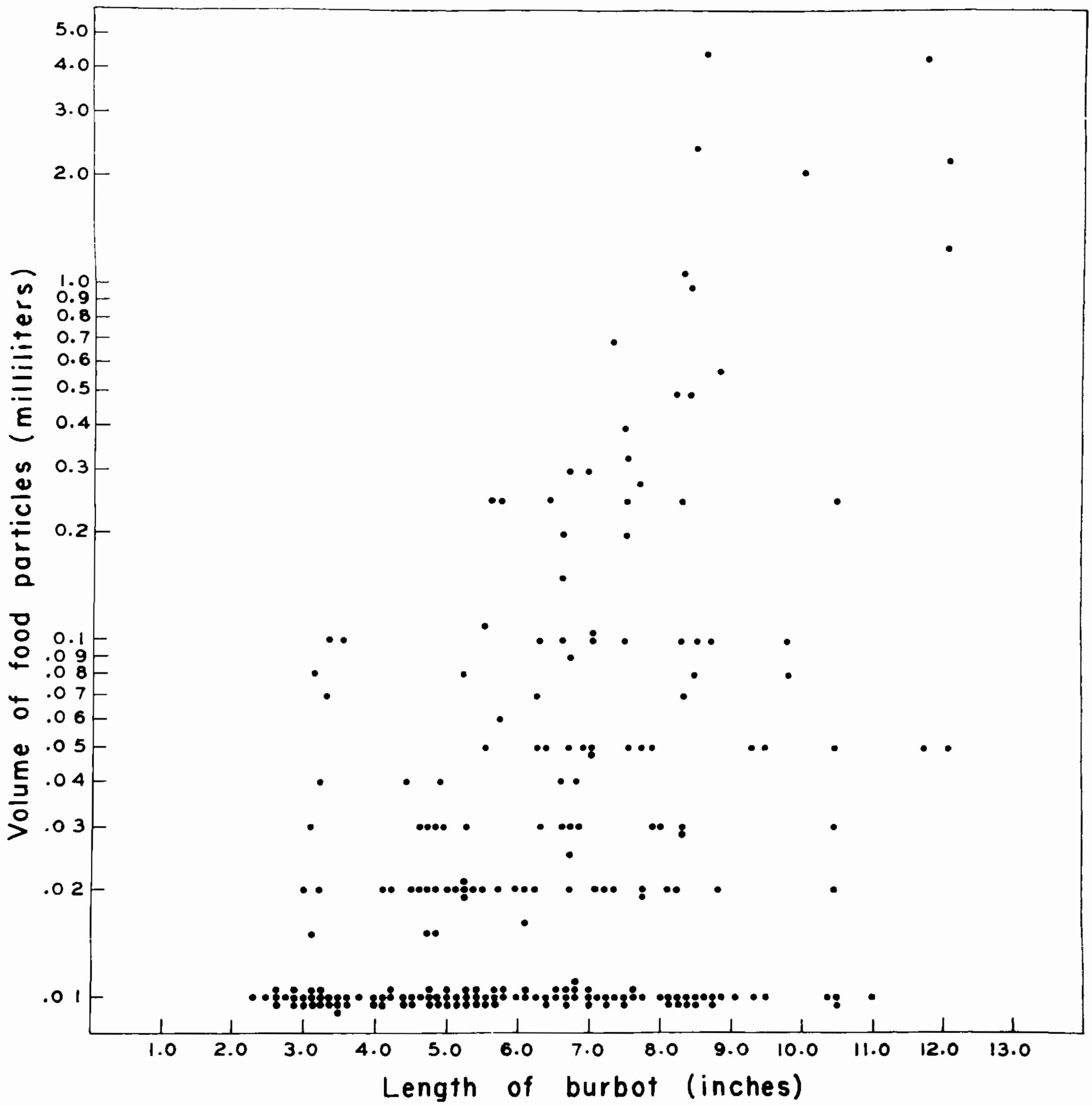
The diet of burbot in the White River watershed was much the same in winter as in summer. In both seasons the smaller burbot fed more on gammarids and insects, while the larger burbot fed more on crayfish and fish. The main difference between the summer and winter diets was that 7.0"-9.9" burbot fed more on crayfish during the summer and more on gammarids during the winter. Possibly the increased consumption of gammarids during winter occurred because of the unavailability of crayfish.

Relationship of food size to burbot size

The data indicate that there is a shift in the diet of burbot, which points to a correlation between food size and size of the consumer. As burbot increase in length, there is a shift in the diet from small food to medium-size food to large food items (from insects to gammarids to crayfish to fish). Odum (1953) stated: "Size of food is one of the main reasons underlying the existence of food chains, ... This is because there are usually rather definite upper and lower limits to the size of food that can efficiently support a given animal type."

The correlation between food size and consumer size, for White River burbot, is shown in Figure 5. The volume of individual food particle was plotted against the length of fish eating the food particle. The correlation is generally good, although it is reduced somewhat by the fact that larger burbot contained both large and small food items. Smyly (1952) in his study of perch fry, and Daiber (1952) in his study of the fresh-water drum, found a similar correlation. The correlation between food-size and consumer-size is probably related to the amount of effort exerted by the fish in securing its food and the efficiency of food utilization. Cooper (1941) suggested that the number of food organisms consumed is a better index of the amount of

Figure 5.--Volume of individual food particles, in stomachs of burbot, plotted against the size (length in inches) of consumer.


5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
Volume of food particles (milliliters)
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
Length of burbot (inches)

effort on the part of the fish in seeking and capturing its food; while the volume of food is presumably a better index of the amount of benefit which the fish obtains from it.

Comparison of the food habits of burbot occurring in streams and lakes

Clemens (1950), Dymond (1928), and Van Oosten and Deason (1938) made food habit studies of the burbot occurring in the Great Lakes. Bjorn (1939) and Cooper and Fuller (1945) studied the food habits of burbot in some smaller lakes. There is general agreement that fish comprise the major food of larger burbot in lake environments, especially in the Great Lakes. This may be because burbot reach a larger size in the Great Lakes. Of the invertebrates eaten, the crustaceans were the most important. Clemens (1950) and Bjorn (1939) found that amphipods were eaten more frequently, while Van Oosten and Deason (1938) found that *Mysis* and *Pontoporeia* were very important in the diet.

The preceding data do not disagree to an important extent with the data compiled for the large-size burbot from the White River. It is reasonable to assume that *Gammarus* and small crayfish in the White River would take the place of *Mysis* and *Pontoporeia* in the Great Lakes.

Small burbot in Lake Erie eat *Gammarus* and mayflies (Clemens, 1950). These were also the major items in the diet of the small-sized burbot from the White River.

Conclusions

(1) The burbot is an important part of the fish fauna of the White River, a submarginal trout stream.

(2) In the White River system, during late spring and summer, gammarids, mayfly nymphs, and *Hydropsyche* larva are the most important foods for small-sized burbot, while fish and crayfish are the important food items for large-sized burbot.

(3) In winter, gammarids, mayfly nymphs, and a plecopteran nymph are the main constituents of the diet for small burbot, and fish and gammarids are the main foods of large burbot.

(4) Feeding habits of burbot change with size, and there is a positive correlation between size of food item and size of consumer.

(5) More work needs to be done on the food habits of small burbot, because previous work has been concerned almost entirely with fish over 9.0" in length.

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