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Report No. 1363

A PRELIMINARY STUDY OF THE RELATIONSHIP BETWEEN STOMACH CONTENTS AND COEFFICIENT OF CONDITION OF BROOK TROUT (SALVELINUS FONTINALIS) IN THE PIGEON RIVER, OTSEGO COUNTY, MICHIGAN

By

Norman G. Benson

Abstract

The relationship between volume of stomach contents and coefficient of condition was determined for 420 specimens of wild brook trout from the Pigeon River, Otsego County, Michigan. All fish were caught by anglers and checked by trained personnel during the season of 1952 (April 26 to September 14). In a previous study on this stream, Dr. E. L. Cooper demonstrated that much of the annual growth increment for brook trout was added during the months of May and June. The rate of growth decreased after these latter months to a minimum in mid-winter. In this investigation data on coefficient of condition and volume of stomach contents were averaged for two-week periods. Both condition and stomach contents were highest during the months of May and June and decreased thereafter during the angling season. The data suggested that there was a close relationship between periodicity of growth,

coefficient of condition, and mean volume of stomach contents. There was also evidence that condition at any one time was dependent on food consumed at a slightly earlier period.

The types of food eaten by trout during the period of most-rapid growth and best condition must be important from the standpoint of growth. Mayflies, caddis flies, and crayfish were the most common organisms present in the stomachs.

The temperatures were in the range of 55 to 66 degrees F. when the trout were in the best condition and had the greatest volume of food in their stomachs. This temperature range has been found to be optimum for feeding and activity of brook trout, from both laboratory and field studies. It is suggested, therefore, that the growth rate must be dependent on optimum temperatures, and the food available when the temperatures are in the optimum range.

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The factors responsible for rate of growth are of primary importance in the management of trout. At the Pigeon River Trout Research Area, Otsego County, Michigan, the rate of growth and periodicity of growth of brook trout were investigated by Cooper (1953, and, in press). It was shown that most of the growth increment was added during the months of May and June. After this period, the growth rate decreased until winter when very little or no growth was added. During the period of most rapid growth, the coefficient of condition was also at its maximum. The condition decreased gradually thereafter and reached a minimum in late winter in a manner similar to that of growth rate. It was suggested, therefore, that there was a correlation between rate of growth and condition. The possibility that food supply was a salient factor in determining the condition and rate of growth was also suggested. Other workers have likewise noted a close relationship between

condition and rate of growth in fishes (Brown, 1946; Stroud, 1949; Hansen, 1951).

The purposes of the present study on brook trout were to investigate the relationships between stomach contents and coefficient of condition, between both the kind and volume of organisms in stomach contents and rate of growth, and between stream temperatures and coefficient of condition.

Methods

This investigation was based on 420 specimens of wild brook trout that were caught by anglers during the season of 1952 (April 26 to September 14) on the Pigeon River Trout Research Area. A permit system of angling was used, and all angler-caught fish were examined by trained personnel. Lengths, weights, scale samples, and stomachs were collected from most of the fish. The coefficient of condition, R (Cooper and Benson, 1951), was computed for each fish. Each stomach was first preserved in 10 percent formalin and later transferred to 70 percent alcohol. Later, the contents of each stomach were separated into general groups and measured volumetrically by displacement. The data were grouped into two-week periods except for the last sixteen days of the season. Continuous temperature data were collected by a recording thermometer located approximately in the center of the experimental area.

In an earlier study, Cooper (In press) demonstrated that the use of angler-caught fish caused much bias in the analysis of periodicity of growth. He showed that, throughout the season, anglers remove the most-rapidly growing fish; and that, therefore, it was not possible to clearly demonstrate periodicity of growth

with angler-caught fish in this stream. In view of this earlier study, I did not study periodicity of growth.

Results

Coefficient of condition. The coefficient of condition of brook trout was greatest during the months of May and June and declined generally thereafter (Figure 1). It was low, however, during the first two weeks of the angling season. Similar findings on the Pigeon River brook trout have already been reported (Cooper and Benson, 1951; Cooper, 1953).

Stomach contents. For the several two-week periods, the mean volume of the contents of the trout stomachs showed great variation (Table 1). This variation was due to several facts: (1) specimens were caught at different times of the day, (2) the type of food eaten varied greatly in volume, and (3) the size of the individual fish varied. It was not possible to determine accurately the time of day when the individual fish were caught. Single food organisms such as crayfish or small fish gave larger volumes than did a large number (100 to 200) of minute animals such as mayfly nymphs or caddis larvae. Although the majority (86%) of the trout studied were under nine inches there was, as expected, a greater volume of food in the larger fish (Table 2).

Due to these afore-mentioned facts, there was an insignificant correlation ($r=0.03$) between volume of food in stomachs and coefficient of condition when the data for individual fish were treated separately. When the data were averaged for all fish in each period, there was a high correlation ($r=0.84$) between volume of food and condition among these mean values for the several periods.

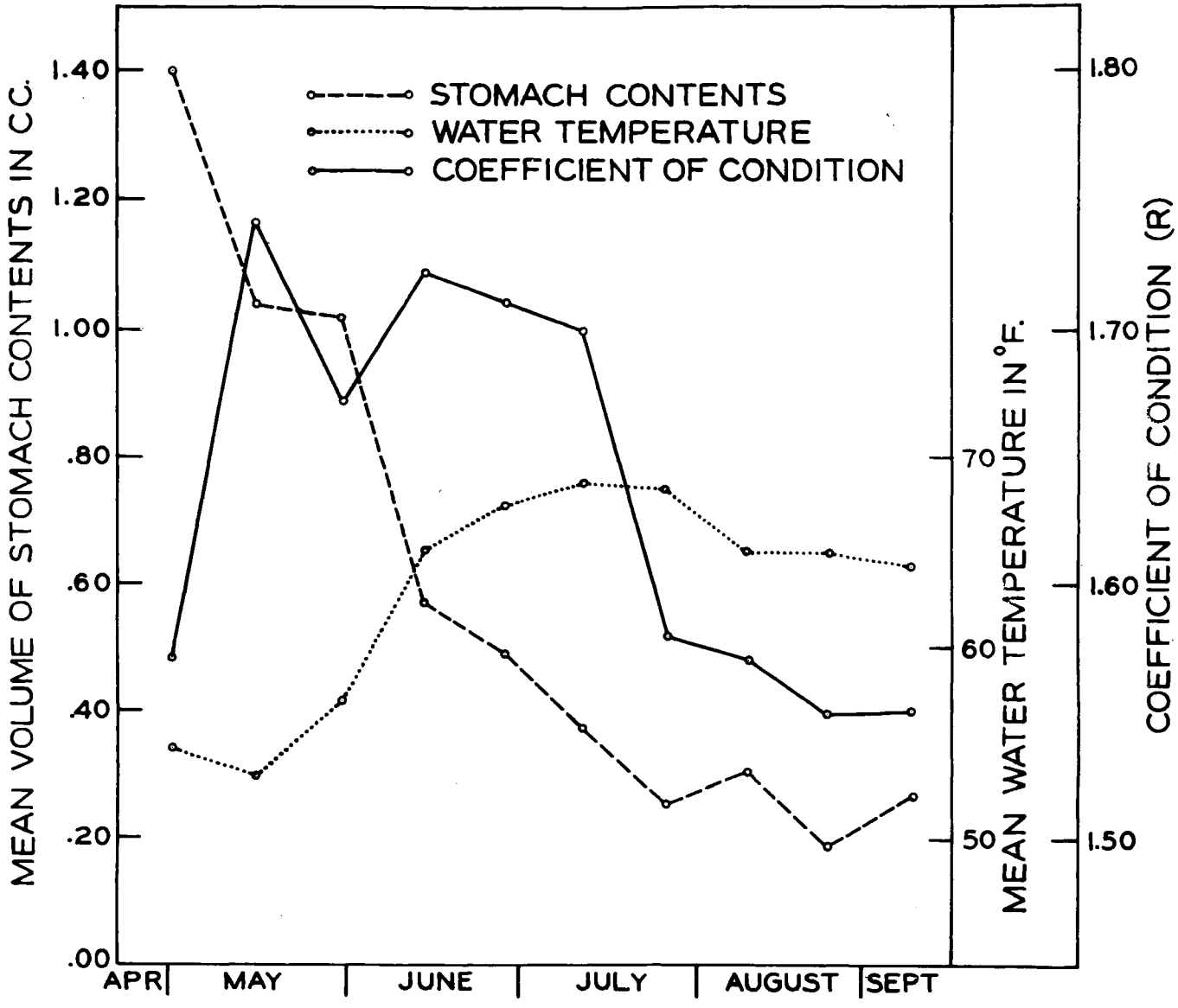

Figure 1. Mean stomach contents by volume (cc.), and mean coefficient of condition (R), for brook trout in Pigeon River, Otsego County, Michigan, by two-week periods. Mean water temperatures also presented in degrees Fahrenheit.

Table 1. Mean volumes in cc. and percentages of stomach contents of 420 brook trout by two-week periods during the angling season of 1952, Pigeon River, Otsego County, Michigan. Organisms in stomachs are listed by major taxonomic groups.

Period (1952)	Number of fish	Taxonomic group										Mean total volume per fish	Standar error o mean vol
		Annelida	Crayfish	Orthoptera	Ephemeroptera	Odonata	Megaloptera	Trichoptera	Diptera	Fish	Miscellaneous*	Unidentified remains		
April 26-May 9														
Volume	46	.086	.217	0	.212	.027	.055	.170	.046	.033	.131	.423	1.400	.180
Percent		6.1	15.5	0	15.1	1.9	3.9	12.1	3.3	2.4	9.4	30.2		
May 10-May 23														
Volume	32	.136	.064	0	.247	.029	.016	.031	.016	0	.036	.466	1.041	.166
Percent		13.1	6.1	0	23.7	2.8	1.5	3.0	1.5	0	3.5	44.8		
May 24-June 6														
Volume	54	.069	.406	0	.073	.022	.006	.056	.017	0	.073	.299	1.021	.169
Percent		6.8	39.8	0	7.1	2.2	0.6	5.5	1.7	0	7.1	29.2		
June 7-June 20														
Volume	26	0	.085	0	.053	.004	.038	.009	.010	.071	.089	.212	.571	.116
Percent		0	14.9	0	9.3	0.7	6.7	1.6	1.7	12.4	15.6	37.1		
June 21-July 4														
Volume	62	.033	.024	.076	.010	.163	.005	.002	.014	.024	.030	.104	.485	.081
Percent		6.8	4.9	15.7	2.1	33.6	1.0	0.4	2.9	4.9	6.2	21.4		
July 5-July 18														
Volume	37	0	.030	.062	.003	.081	.005	T	.015	.014	.017	.149	.376	.054
Percent		0	8.0	16.5	0.8	21.5	1.3	T	4.0	3.7	4.5	39.7		
July 19-Aug. 1														
Volume	19	.003	.001	.037	.010	.029	0	.007	.046	.016	.044	.066	.259	.048
Percent		1.1	0.4	14.3	3.9	11.2	0	2.7	17.8	6.2	17.0	25.4		
Aug. 2-Aug. 15														
Volume	62	.035	.066	.007	.009	.020	0	.006	.066	0	.027	.068	.304	.054
Percent		11.5	21.7	2.3	3.0	6.6	0	2.0	21.7	0	8.9	22.3		
Aug. 16-Aug. 29														
Volume	25	.008	.032	.010	.008	.044	0	.021	.027	0	0	.043	.193	.046
Percent		4.1	16.5	5.2	4.1	22.8	0	10.9	14.0	0	0	22.3		
Aug. 30-Sept. 14														
Volume	57	.005	.109	.024	.003	.018	.001	.006	.014	0	.048	.050	.278	.071
Percent		1.8	39.2	8.6	1.1	6.5	0.4	2.2	5.0	0	17.3	17.9		

* Includes Mollusca, Plecoptera, Hemiptera, Hymenoptera, Lepidoptera and Arachnida.

Table 2. Variation in mean total volume of stomach contents according to date, and to brook trout, Pigeon River, Otsego County, Michigan

Period (1952)	Total length in inches					
	6.8-7.9		8.0-8.9		9.0-12.9	
	Number of fish	Mean volume	Number of fish	Mean volume	Number of fish	Mean volume
April 26-May 9	32	1.008	9	1.839	5	3.120
May 10-May 23	20	1.160	9	.917	3	.626
May 24-June 6	32	.657	13	1.355	9	1.833
June 7-June 20	16	.745	5	.185	5	.400
June 21-July 4	58	.512	2	.125	2	.625
July 5-July 18	28	.407	6	.338	3	1.660
July 19-Aug. 1	15	.260	3	.333	1	.025
Aug. 2-Aug. 15	46	.304	8	.404	8	.200
Aug. 16-Aug. 29	17	.225	..	...	8	.125
Aug. 30-Sept. 14	33	.215	10	.290	14	.418
Total	297	...	65	...	58	...

The volume of the stomach contents, for all sizes of fish, decreased after June and July in a manner similar to the decrease in coefficient of condition. During the first two weeks of the angling season, however, the condition was relatively much lower than the stomach contents. The latter fact suggests that the condition at any one time depends on the amount of food consumed at a slightly earlier date.

An important aim in a study of this type was to determine what foods are contributing the most to the condition and growth of trout. Since much of the growth is added during the months of May and June, the food consumed during this period would be the most important. Although the mean volume of various foods is important, the percentage of occurrence must also be considered because such food as crayfish will form a large volume and yet occur in few trout and thus may benefit few fish (Table 3).

Mayflies (principally Ephemerella and Rithrogena), crayfish, and caddis flies (largely Glossosoma) were present in the greatest volume during the season of most rapid growth (Table 1). Mayflies and caddis flies occurred in a large percentage of the stomachs and thus benefited more fish than did crayfish (Table 3). Diptera were consistently a small part of the volume of stomach contents, although the volume increased in August when the larger terrestrial adults (e.g., the family Asilidae) became available. Dragonflies occupied a small part of the volume during most of the season, but a large part during the last few weeks of June when both nymphs and adults were found in large numbers. Various fishes (principally Cottus b. bairdi and Rhinichthys a. atratulus) were present in largest volume during the middle of June but occurred in few stomachs.

Table 3. Percentage of occurrence of different types of organisms in stomachs of brook trout, and percentage of empty stomachs

Period (1952)	Number of stomachs	Types of organisms									
		Annelida	Crayfish	Orthoptera	Ephemeroptera	Odonata	Megaloptera	Trichoptera	Diptera	Fish	Stomachs empty
April 26-May 9	46	23.9	15.2	....	89.1	10.5	17.3	78.2	52.5	10.8	....
May 10-May 23	32	21.8	15.6	....	75.0	6.2	3.1	18.9	25.0	....	....
May 24-June 6	54	11.1	35.1	....	50.0	5.5	1.8	42.5	14.8	....	....
June 7-June 20	26	....	15.3	....	46.1	3.8	7.6	26.3	23.0	7.6	....
June 21-July 4	62	3.2	3.2	19.3	24.1	24.1	4.8	11.2	24.1	1.6	9.2
July 5-July 18	37	....	10.8	21.6	21.6	24.3	2.7	10.8	16.2	5.4	21.6
July 19-Aug. 1	19	5.2	5.2	10.5	31.5	15.7	....	31.5	42.1	5.2	10.5
Aug. 2-Aug. 15	62	8.0	14.5	6.4	33.8	8.0	....	19.3	48.3	....	3.2
Aug. 16-Aug. 29	25	4.0	8.0	4.0	24.0	12.0	....	28.0	20.0	....	24.0
Aug. 30-Sept. 14	57	3.5	29.0	5.2	12.2	3.5	1.7	17.5	24.5	....	1.7

Grasshoppers appeared first during the last part of June and constituted an appreciable part of the stomach contents after that time. The importance of earthworms as a natural food cannot be fully evaluated from angler-caught fish because several of those found were believed to be the bait that caught the fish. Other forms, such as Megaloptera, Mollusca, Plecoptera, Hemiptera, Hymenoptera, Lepidoptera, and Arachnida, were never found in large volumes at any period and are not believed to be so important as food for trout as the forms previously mentioned.

Volume of food in trout stomachs was the greatest when the stream temperatures (55 to 66 degrees F.) were the lowest of the angling season (Table 4, Figure 1).

Discussion

Based on bi-weekly averages, the data suggest that there was a close relationship between volume of food in the stomachs of legal-sized trout and coefficient of condition. Both were highest during the months of May and June and decreased thereafter. Since an earlier study (Cooper, 1953) suggested that growth in length occurred mostly when Pigeon River trout were in best condition, i.e., during May and June, we can assume that contents of trout stomachs during these latter months were important as growth foods. During these months, the types of food organisms which I found to be most prevalent in trout stomachs were mayflies, caddis flies and crayfish. Needham (1930) found that mayflies and caddis flies were the principal brook trout foods during the months of May and June in New York state. Frost (1945) found that the mayfly (Ephemerella) was common in the stomachs of rapidly growing trout on the River Liffey, even though it formed a small part of the "moss" fauna.

Table 4. Weekly means of daily maximum, minimum, and average water temperatures (degrees F.) in Pigeon River, Otsego County, Michigan, during the angling season of 1952

Period (1952)	Maximum	Minimum	Average
April 26-May 2	59	52	55
May 3-May 9	57	51	54
May 10-May 16	54	50	52
May 17-May 23	58	53	55
May 24-May 30	60	55	57
May 31-June 6	61	54	57
June 7-June 13	66	60	63
June 14-June 20	70	64	67
June 21-June 27	71	64	67
June 28-July 4	71	65	68
July 5-July 11	73	65	69
July 12-July 18	69	67	68
July 19-July 25	71	66	68
July 26-August 1	72	64	68
August 2-August 8	69	62	65
August 9-August 15	68	62	65
August 16-August 22	68	63	65
August 23-August 29	69	61	65
August 30-September 5	66	61	63
September 6-September 14	69	63	66

She concluded that quality of food organisms could explain variances in growth more easily than could quantity.

Several other workers have considered temperature as an important factor limiting growth. Purkett (1951) found that the growth rate of trout in a Montana stream varied mainly with the temperature and not with coefficient of condition; however, the fish for his study were collected at various times in the angling season, and seasonal change in condition, if it did occur, was not considered. Hazzard (1933) also considered temperature as a limiting factor on growth in high mountain lakes and streams. Cooper (1953) believed that temperature differences did not explain the variation in growth rates between Hunt Creek and the North Branch of the Au Sable River in Michigan. Fry (1951) reviewed both laboratory and field studies on the brook trout and suggested that the best temperature range for activity and growth of brook trout was from 55 to 66 degrees F. In the Pigeon River (Figure 1) the greatest volume of food in the stomachs was present when the water temperatures were within the range cited by Fry. The growth rate of brook trout must be dependent on temperature conditions and on the amount (and possibly kind) of food available when the temperatures are in the optimum range.

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