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Education - Game
R. S. Marks
E. L. Cooper
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Institute for Fisheries Research

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March 1, 1951
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The coefficient of condition of brook, brown, and rainbow trout in the Pigeon River, Otsego County, Michigan[1]

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[1] Contribution from the Michigan Institute for Fisheries Research

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ABSTRACT

Length and weight data from several thousand brook, brown, and rainbow trout, both hatchery and native, from the Pigeon River were utilized in a study of changes in condition due to different factors. The coefficient of condition of native trout in the stream increased rapidly to a peak in June and declined thereafter to the winter low; the loss in condition in July and August was accompanied by a rise in maximum water temperatures generally above 70° F.

Changes in condition of hatchery trout following planting varied with species and with the different plantings. Brook trout at the time of planting

were in a higher condition than browns or rainbows and also decreased the most after planting. Losses in condition after the first week in the stream were slight with the rainbow losing somewhat more than brooks or browns. No difference in condition of recovered hatchery trout could be traced to differences in planting method or differences in marking the trout. Also, no effect on the condition of the native trout could be demonstrated as being caused by planting large numbers of hatchery trout.

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Introduction

The Pigeon River is located in the north-central portion of the lower peninsula of Michigan. It flows for about sixty miles in a northerly direction through wooded terrain to empty indirectly into Lake Huron. Approximately half way upstream from the mouth, a five-mile portion of the river has been set aside as a trout research area. From April, 1949 to October, 1950, data on the length and weight of both hatchery trout and naturally spawned trout have been obtained in conjunction with other studies in progress. The present paper deals with the change in condition of the hatchery fish following planting and a comparison of these data with the condition of native fish.

The coefficient of conditions (R) as used in this study was calculated for each fish based on the formula:

$$R = \frac{W \times 10}{L^3}$$

where W = Weight in grams,

and L = Total length in inches.

The conversion factor for use between the English C (total length in inches, weight in grams) is as follows:

$$R \times 22.038 = C.$$

Conversion factors between R and K (standard length in millimeters and weight in grams) are not given because of the curvilinear relationship existing between standard length and total length in brook trout in Michigan. According to data taken from 1957 brook trout ranging in standard length from 40 millimeters to 360 millimeters, this relationship was established as follows:

Total length = 0.141 standard length 0.964, or

Log. total length = 0.15037 + 0.964 x log. standard length.

The relationship between R and K must be calculated for each fish, from the data given above.

The selection of units of measurement is largely one of convenience. Measuring boards used are calibrated in inches and tenths of inches. The Chatillon dietary scales used in weighing the fish are calibrated in grams. With the small size of the fish generally encountered in our work the gram seems to be the most appropriate unit of weight, although a scale graduated in hundredths of a pound would be equally as good.

The problems involved in the standardization of fish measurements and the corresponding calculation of Condition factors has been well summarized by Hile (1948). Until such standardization is adopted by fishery investigators in general, a comparison of coefficients of condition between different workers will remain difficult. When the relationship between different fish measurements such as standard length and total length is non-linear, even trends in the change of condition with an increase in size may be reversed by the selection of different length measurements (compare C and K of largemouth black bass cited by Beckman, 1948). Factors for conversion of standard, fork and total lengths of fish, when given, are useful in the computation of comparable data, but authors do not always agree with one another as to the coefficients, even for the same species of fish. For example, compare the conversion factors between standard and total lengths for both brook and brown trout given by Carlander and Smith (1945) with those published by New York State Hatcheries (Mimeo. table). These coefficients, as well as those for many other species, have been recently compiled by Carlander (1950).

The apparent confusion in the methodology of computing condition factors of fish does not invalidate a study of the changes of conditions due to season, sex and other factors when the same index of condition is used. Authenticated changes in condition of fish of a general nature should be comparable even though the actual values for the coefficients differ because of different units of measurement used. However, slight differences in these condition factors should be viewed with skepticism until their nature is fully understood and their validity established through repeated observations.

Sources of Variation in Condition Factor

The interpretation of differences in the coefficient of condition among groups of fish depends to a large extent upon the recognition of the sources and extent of variation. Such a variation is shown among different species of trout reared at separate hatcheries and also from samples of wild brook and brown trout taken from the Pigeon River (Table 1). Small numbers of fish therefore may not be representative of the condition of the group from which they came, due to improper or inadequate sampling methods. The use of statistical measures of central tendency and their accompanying measures of reliability is recommended for studies dealing with coefficients condition.

Another source of variation found in many species of fish is a normal change in the condition factor as the fish increases in size. This change in condition is associated with a change in form of the fish as it increases in size, and is directly reflected in the length-weight relationship. If form and specific gravity remained constant as the fish grows in length, the length-weight relationship would be expressed by the formula:

$W = CL^3$, the well known cube law.

Since the length-weight relationship of most species of fish has been found to differ slightly from the cube law, the more general formula:

$$W = CL^n$$

has been used to express this relationship. Because the coefficient of condition is based on the cube law, values of n in the more general formula indicate the direction and degree of change of the coefficient of condition of a species of fish with an increase in size. For some fish, such as the bluegill and yellow perch, the condition factor increases slightly as the fish grow in length (Beckman, *op. cit.*). For both the brook and brown trout populations in the Pigeon River this trend is reversed; the fish become relatively lighter as they increase in length. This change may easily be seen by an examination of the length-weight relationship of the two species (Fig. 1 and 2). However, variations in conditions of this nature are usually slight and do not invalidate the comparison of the coefficient of condition of fish of different sizes to any extent.

A marked seasonal change in condition was observed for both native brook and brown trout in the Pigeon River. In this stream, native rainbow trout at the present time are too rare to afford opportunity for comparative study. Collections were made with an electric shocker in all months of the year except January and February, at which time ice conditions made fish-collecting impossible. For both brook and brown trout the coefficient of condition was low during winter and early spring, rose rapidly to a peak in June and subsequently declined rather uniformly to the winter low (Figure 3). Brown trout apparently do not fluctuate so much in condition throughout the year as brook trout in the same stream. Both species exhibit a drop in condition in the late fall which probably is coincident with spawning, although the coefficient of condition immediately prior to spawning is less than the peak condition in June.

The condition of the native fish caught by anglers during the trout season (Figure 4) follows very closely the trend just described for collections made with the electric shocker. To what extent the drop in condition in July and August is due to a rise in water temperature to a point generally considered too warm for trout is largely unknown. Although water temperatures decreased again in late August and September, the coefficient of condition of the fish continued to decline.

In an earlier study of the brook trout in streams of New York (Hazzard, 1932) it was indicated that the fish were heaviest at the spawning season, losing weight thereafter and not recovering condition until after several weeks of feeding in the spring. A summary of seasonal changes in condition of the brook trout in Hunt Creek, Michigan (Shetter, unpublished) revealed that the peak of condition was reached during May. There was a decline in condition factor during July and August and an increase again during September and October to nearly the same condition as in May. A seasonal decline in the condition of the fish before the spawning season was observed for the whitefish of Lake Erie (VanOosten and Hile, 1949) and for the kiyi of Lake Michigan (Deason and Hile, 1947). More information on the seasonal changes in condition of trout in different localities is desirable. Also, information is needed concerning such factors as food supply, water temperatures, growth rate, and population density as to their effects on the condition of fish.

Variation in condition of hatchery fish

Extensive plantings of hatchery-reared brook, brown and rainbow trout were made in the Pigeon River during the open trout seasons of 1949 and 1950 (Table 2). Recoveries from a little more than 40 percent of these trout furnished data on the changes in condition following planting. A permit system of angling required fishermen to present their catch at a checking station where each hatchery fish recovered was measured and weighed. Individual records were assured by marking each fish with a jaw-tag before planting. For a few plantings in 1950, half of each planting was fin-clipped, the other half jaw-tagged.

Brook trout were somewhat heavier at the time of marking than either the browns or rainbows (Tables 2 and 3). The difference in condition was probably due to their origin from different rearing stations rather than a difference *per se* between the species, since native brook and brown trout from the Pigeon River are nearly identical as to condition at any given time of the year (Table 4). Oden Hatchery derives its water supply from numerous springs; the temperature seldom rising above 50° to 55° F.

The Wolverine Rearing Station gets its water from the Sturgeon River where water temperatures frequently go above 70 degrees during the summer.

The hatchery brook trout were considerably heavier at the time of marking than the native brook trout, but very quickly lost condition (Table 3). The hatchery brown and rainbow trout changed very little after marking. It is believed that much of the initial loss in condition of brook trout occurred during the one- to two-day period of enforced fasting caused by retaining them in live cages before planting. This observation is substantiated by the data in Table 3. Notice that the condition of the brook trout recovered the same day as they were planted was considerably less than when marked and that little or no further loss occurred during subsequent days in the stream. No such loss was observed in the brown and rainbow trout, however, they usually were marked after the brook trout and their period in live cages was less.

Changes in condition subsequent to the first week following planting were slight for all species (Table 3). Apparently the hatchery fish were able to adjust themselves to stream conditions and compete successfully with the native fish for food. These observations are apparently contradictory to the conclusions of Klak (1941) as a result of similar studies made in Virginia.

Most of the plantings of hatchery trout were numerous enough to more than double the population of legal-sized fish in the stream at least temporarily. The experimental area of the Pigeon River has been divided into four fishing sections, designated as A, B, C, and D. The plantings were made in the two center sections and judging from the fish that were recaptured either by angling or by the electric shocker, the hatchery trout did not move to a great extent from the vicinity in which they were planted. Despite this sudden increase in competition for food and space no corresponding decrease in the condition of wild fish was observed; the condition of the wild fish taken in Sections A and D was the same as those taken in Sections B and C (Table 4). This suggests that the supply of food in the stream was more than adequate for the native population alone.

Seasonal changes in condition of hatchery trout, corresponding to those for native populations in the Pigeon River, were not observed except perhaps as the slight loss in condition of the hatchery trout recovered after a long interval could be interpreted as a seasonal decline. The wild trout caught by anglers showed a decline in condition as the season progressed past June. The bulk of the hatchery trout recaptured following an interval of more than one week after planting were taken in the latter part of the season. The loss observed for these fish might be interpreted, therefore, as being similar to that observed for the wild trout.

A comparison of hatchery fish at different times of the season reveals that, in general, their condition remains relatively high from April to August, based on data from the fish planted in the Pigeon River (Table 2). Although the brook trout planted in June, 1950 were in poor condition compared with the other brook trout planted, they were about average for all the native trout caught by anglers from the Pigeon River. They also did not lose in condition nearly so much as did the other hatchery brook trout.

During both seasons of stocking, the hatchery plantings were equally divided between "spot" type and "scatter" type to determine the relative merits of the two methods. Recoveries from these groups were about equal and were tallied separately. No difference could be seen in the average condition at recovery of the fish planted by the two methods (Table 5), although one might expect that the increased competition for food and space for the spot-planted trout would result in a lower condition factor for such fish.

During 1950, because of a temporary shortage of tags for marking hatchery trout, half of each planting made in June and August were fin-clipped; the other half were jaw-tagged. At the time of marking, alternate groups of fish were taken at random from the hatchery stock to insure no bias, in the selection of fish to be either jaw-tagged or fin-clipped, that might affect the average size of the fish or their condition. Also, equal numbers of tagged and fin-clipped trout were combined in the hatchery holding tanks and planted as a unit, either as a spot plant or as a scatter plant.

From these plantings, fin-clipped trout were much more numerous among the hatchery fish recovered by anglers than were the tagged trout; this was true for both brook trout and rainbow trout in four different plantings in June and for the brook trout in one of two plantings in August. However, the condition factor of the recovered trout was not different between fish that had been fin-clipped and those that had been jaw-tagged (Table 6).

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INSTITUTE FOR FISHERIES RESEARCH

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Table 1. Variation in condition of hatchery trout from Oden Hatchery and Wolverine Rearing Ponds, and of wild brook and brown trout from the Pigeon River, Michigan

Species	Locality and date	Number of fish in sample	Size range in inches	Coefficient of condition (R)			
				Range	Mean	Standard deviation	Standard error of mean
Brook	Oden Hatchery April 27, 1949	100	6.8-9.9	1.43-2.01	1.72	0.12	0.012
Brown	Wolverine Rearing Ponds April 27, 1949	100	8.1-12.5	1.29-1.92	1.56	0.13	0.013
Rainbow	Wolverine Rearing Ponds April 27, 1949	100	6.8-12.8	1.12-1.96	1.61	0.15	0.015
Brook (native fish)	Pigeon River May 13-June 21, 1949	100	6.9-10.5	1.40-2.11	1.65	0.15	0.015
Brown (native fish)	Pigeon River May 1-August 2, 1949	100	6.9-18.5	1.22-2.01	1.62	0.14	0.014

Table 2. Hatchery trout planted in 2.3 miles of the Pigeon River*/ during the seasons of 1949 and 1950 Brook trout were from the Oden Hatchery; brown and rainbow trout were from the Wolverine Rearing Ponds.

Date of planting	Brook trout Number	Brook trout Size range in inches	Brook trout Coefficient of condition (R)	Brown trout Number	Brown trout Size range in inches	Brown trout Coefficient of condition (R)	Rainbow trout Number	Rainbow trout Size range in inches	Rainbow trout Coefficient of condition (R)
April 28, 1949	300	6.8-10.2	1.73	300	7.5-12.5	1.58	300	7.2-14.6	1.65
May 25, 1949	300	6.9- 9.3	1.80	300	7.0-10.7	1.52	300	7.4-12.6	1.66
June 29, 1949	300	7.2-11.0	1.86	300	7.1-13.2	1.60	300	7.0- 9.9	1.58
July 27, 1949	300	7.0-10.6	1.94	300	7.1-11.1	1.69	300	7.0-10.5	1.63
August 17, 1949	300	7.0-10.8	1.87	300	7.5-11.7	1.66	300	7.0-11.8	1.60
1949 total planted	1,500	...	...	1,500	..	..	1,500	...	...
Percent of recovery in 1949	40.0	...	...	25.6	...	..	44.7	...	...
Percent of recovery in 1950	0.0	...	..	2.2	...	...	2.3	...	...
April 26, 1950	1,000	7.0-11.1	1.90	...	...	...	1,000	7.0-11.5	1.58
June 1, 1950	1,000	6.9-11.1	1.60	. .	.	...	1,000	7.0-10.2	1.52
August 8, 1950	500	7.0-11.0	1.78	...	...	. .	...	...	...
1950 total planted	2,500	...	...	...	...	...	2,000	...	...
Percent of recovery in 1950	47.4	...	...	...	...	...	52.5	...	...

*/ Minimum legal size on trout in this stream is 7 inches.

Table 3. Changes in condition of hatchery trout following planting in the Pigeon River, Michigan during 1949. All data from individual tagged fish. In parentheses is given the standard error of the mean for that sample.

Time of Sampling	Brook trout			Brown trout			Rainbow trout		
		Mean condition factor (R)			Mean condition factor (R)			Mean condition factor (R)	
	Number	When marked	At recovery	Number	When marked	At recovery	Number	When marked	At recovery
Random sample of entire planting; 100 from each of 5 plantings of 300. Condition at time of marking.	500	1.81 (0.007)	...	500	1.59 (0.006)	...	500	1.61 (0.006)	...
Fish recovered by anglers the same day they were planted	61	1.78	1.66	14	1.66	1.65	40	1.60	1.55
Fish recovered the second day	41	1.75	1.63	18	1.63	1.57	22	1.61	1.52
Fish recovered the third day	24	1.77	1.61	6	1.60	1.55	17	1.63	1.54
Fish recovered the fourth day	48	1.81	1.64	18	1.61	1.54	40	1.57	1.49
Fish recovered the fifth day	54	1.77	1.65	18	1.64	1.58	39	1.61	1.58
Fish recovered the sixth day	19	1.82	1.61	10	1.70	1.56	16	1.50	1.48
Fish recovered the seventh day	32	1.62	1.65	8	1.62	1.61	17	1.64	1.61
Total of all fish recovered first seven days.	279	1.79	1.64 (0.008)	92	1.64	1.54 (0.015)	191	1.59	1.57 (0.009)
Total of all fish recovered after seven days of the season (1949)	223	1.80	1.58 (0.009)	241	1.63	1.51 (0.010)	350	1.57	1.48 (0.009)
Total of all fish recovered during the following fishing season (1950)	0	...	..	25	1.65	1.50	31	1.56	1.49

Table 4. Coefficient of condition (R) of native brook trout and brown trout caught by anglers in the Pigeon River during 1949 and 1950. Fishing sections B and C were stocked with hatchery trout, sections A and D were not.

Species	Fishing section	Number of fish in sample	Average length in inches	Coefficient of condition (R)
Brook trout	A	163	7.7	1.59
	D	524	7.6	1.63
	A + D	687	7.6	1.62
	B	251	7.8	1.64
	C	452	7.6	1.64
	B + C	703	7.7	1.64
Brown trout	A	39	8.4	1.61
	D	86	9.0	1.59
	A + D	125	8.8	1.60
	B	131	8.6	1.62
	C	129	8.4	1.61
	B + C	260	8.5	1.61

Table 5. Comparison of the coefficient of condition (R) at time of recovery between spot-planted and scatter-planted hatchery trout in the Pigeon River, Michigan. Numbers in parentheses are size of samples upon which calculations are based.

Date of Planting	Brook trout		Brown trout		Rainbow trout	
	Spot	Scatter	Spot	Scatter	Spot	Scatter
April 28, 1949	1.63 (90)	1.64 (75)	1.61 (59)	1.61 (108)	1.61 (91)	1.59 (76)
May 25, 1949	1.58 (68)	1.57 (45)	1.45 (55)	1.46 (39)	1.51 (89)	1.52 (75)
June 29, 1949	1.56 (15)	1.59 (18)	1.43 (31)	1.38 (22)	1.37 (35)	1.36 (21)
July 27, 1949	1.57 (30)	1.53 (18)	1.50 (21)	1.44 (7)	1.39 (46)	1.39 (24)
August 17, 1949	1.66 (78)	1.60 (74)	1.59 (37)	1.60 (8)	1.57 (54)	1.53 (30)
April 26, 1950	1.60 (160)	1.56 (145)	...	...	1.55 (162)	1.55 (130)
June 1, 1950	1.51 (121)	1.50 (93)	...	...	1.48 (120)	1.46 (96)
Total	1.59 (562)	1.57 (468)	1.52 (203)	1.54 (184)	1.52 (597)	1.51 (452)

Table 6. A comparison of the average coefficient of condition of tagged and fin-clipped brook and rainbow hatchery trout recovered by anglers in the Pigeon River.

Date	Species	Number planted	Condition at planting	Number recovered		Condition at recovery	
				Tagged	Fin-clipped	Tagged	Fin-clipped
June 1, 1950	Brook	250	1.60	123		1.51	
	Brook	250	1.60		173		1.51
	Brook	250	1.60	96		1.49	
	Brook	250	1.60		146		1.54
	Total	500	1.60	219		1.50	
		500	1.60		319		1.52
June 1, 1950	Rainbow	250	1.52	159		1.45	
	Rainbow	250	1.52		190		1.47
	Rainbow	250	1.52	129		1.45	
	Rainbow	250	1.52		201		1.47
	Total	500	1.52	288		1.45	
		500	1.52		391		1.47
August 7, 1950	Brook	125	1.81	76		1.65	
	Brook	125	1.81		76		1.62
	Brook	125	1.81	71		1.66	
	Brook	125	1.81		96		1.67
	Total	250	1.81	147		1.65	
		250	1.81		172		1.64

Figure 1. Length-weight relationship of native brown trout in the Pigeon River. Electric shocker and angler collections, April, 1949 to June, 1950. Line fitted mathematically from data on 1,003 specimens.

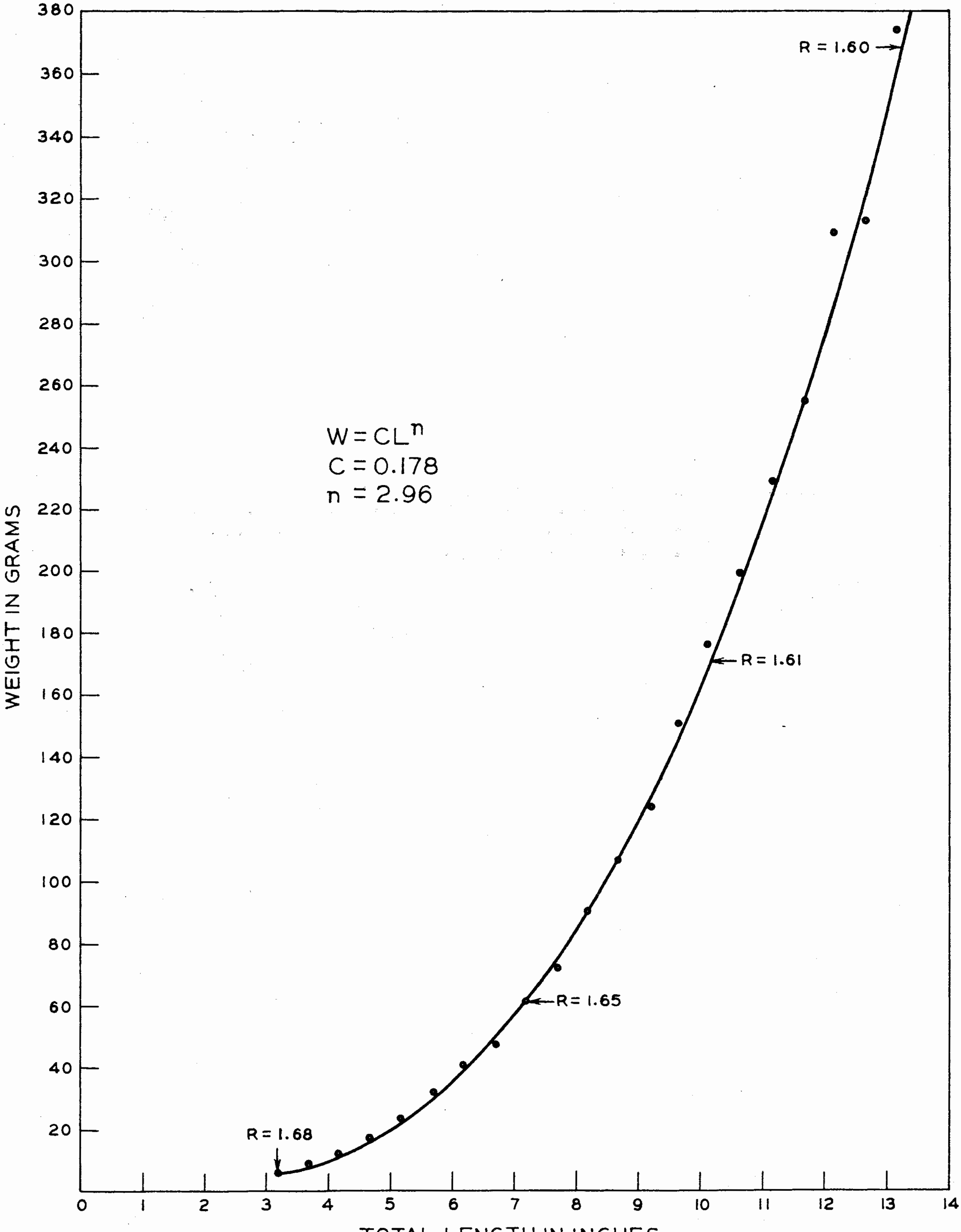
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
WEIGHT IN GRAMS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
TOTAL LENGTH IN INCHES
W = CL^n
C = 0.178
n = 2.96
R = 1.60
R = 1.61
R = 1.65
R = 1.68

Figure 1.

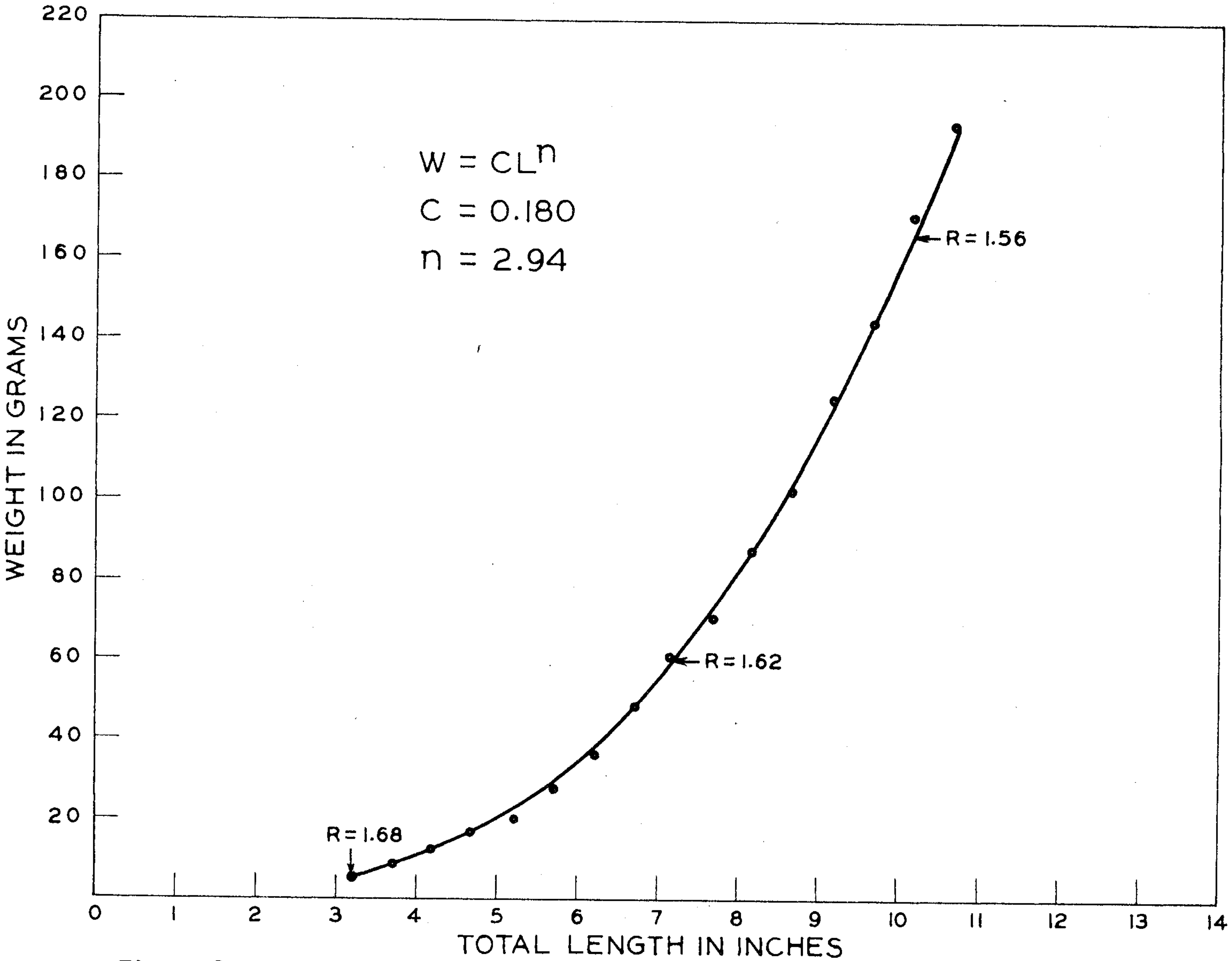

Figure 2. Length weight relationship of native brook trout in the Pigeon River. Electric shocker and angler collections, April, 1949 to June, 1950. Line fitted mathematically from data on 1,997 specimens.

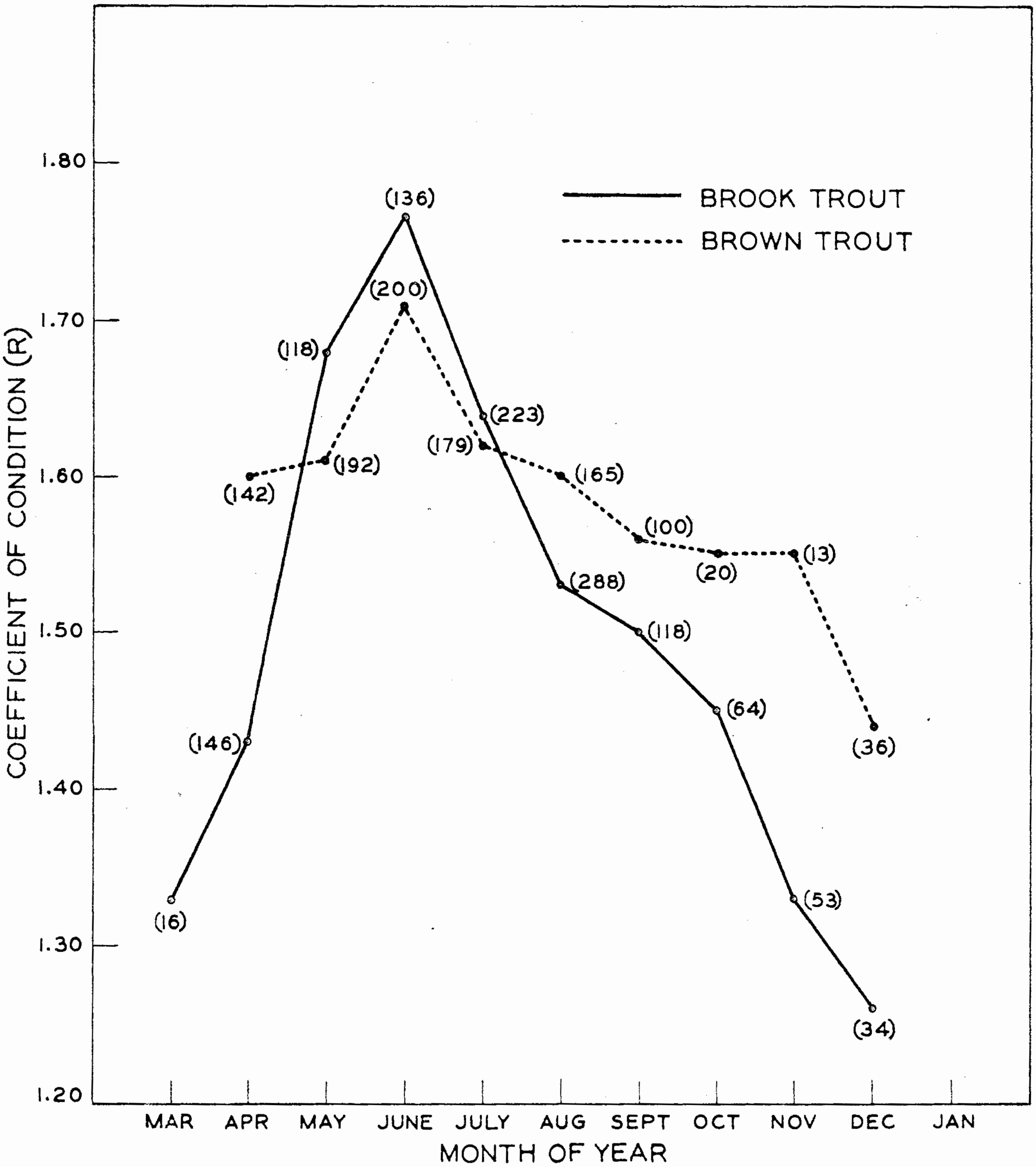

Figure 3. Seasonal variation in condition (R) of native brook trout and native brown trout in the Pigeon River. In parentheses is given the number of specimens upon which the average condition factor is based. Brown trout collected by electric shocker and anglers, brook trout from electric shocker collections, only; data for 1949 and 1950 combined.

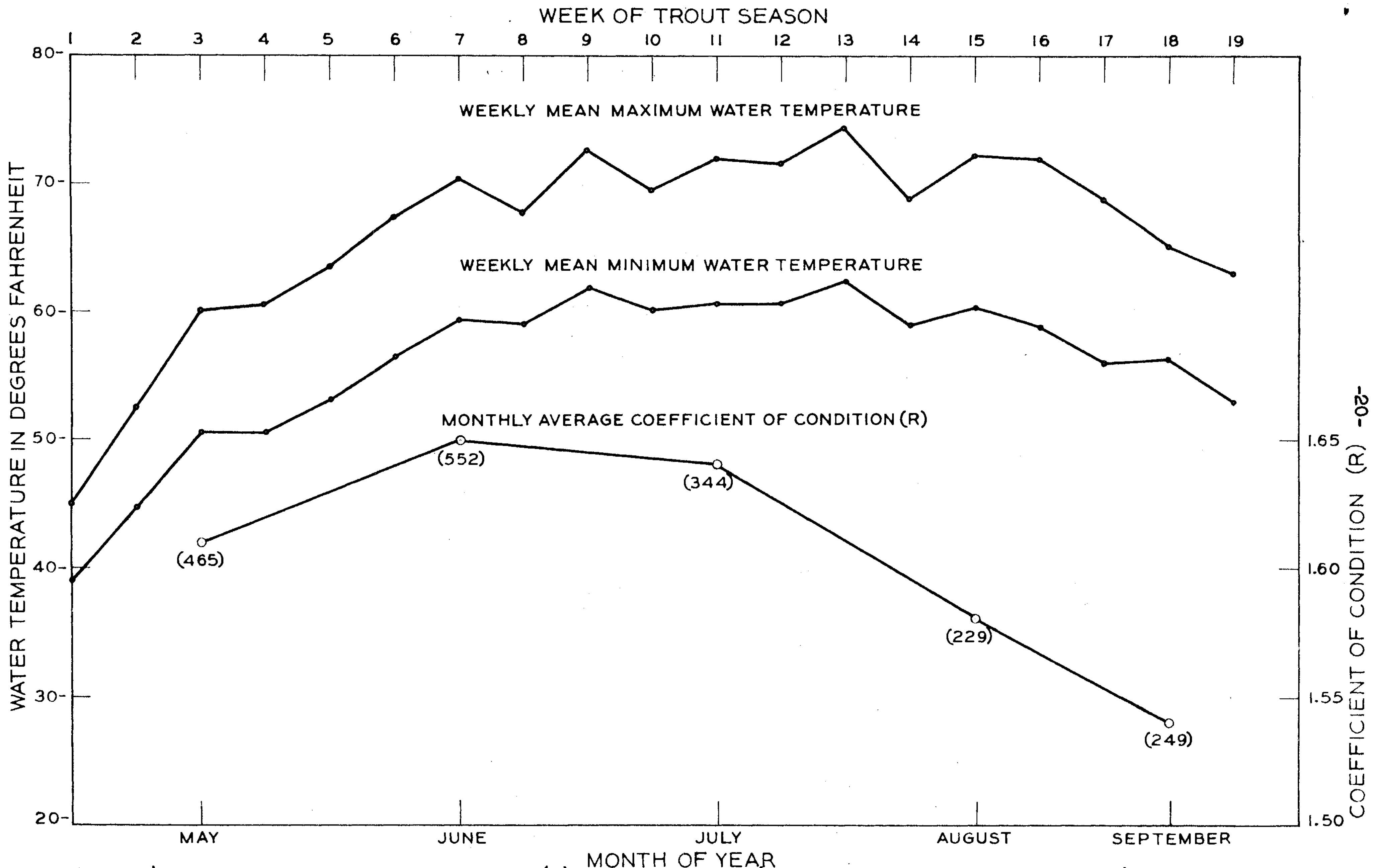

Figure 4. Seasonal variation in condition (R) of native trout (brook, brown and rainbow combined) caught by anglers in the Pigeon River during the 1949 and 1950 trout seasons compared with stream water temperatures.