Prepared for publication in Copeia

Original: Copeia
cc: Fish Division
Education - Game
Institute for
Fisheries Research
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July 3, 1951

Report No. 1290

BODY-SCALE RELATIONSHIP OF THE BROOK TROUT (SALVELINUS FONTINALIS) IN MICHIGAN

By

Edwin L. Cooper

Abstract

The body-scale relationship was examined critically for brook trout populations in four streams and one lake in Michigan. All of these populations exhibited similar body-scale relationship curves which deviated significantly from a straight line. Scales from different portions of the body from the same series of fish exhibited different body-scale relationship curves, as did males compared with females.

Calculations of previous growth history made on a basis of either the direct proportion method, or the direct proportion method plus a correction for the size of the fish at which scales first appear, resulted in considerable error when applied to any of the populations of brook trout examined. For accuracy, the body-scale relationship of the population in question should first be determined before calculations of previous growth history are made.

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The present paper is the second in a series dealing with the growth of the brook trout in Michigan. In the previous publication (Cooper, 1951) the validity of the annulus as a true year-mark was established principally on data from known-age fish. This confirmation of the scale method, generally accepted for most other species of fish, was felt necessary because of the skepticism of earlier published reports on age of brook trout (Kendall and Dence, 1927, 1929; Ricker, 1932; and King, 1942).

Once the validity of the annulus as a year-mark is established, it is possible to compare growth of individual fish or of fish from different localities. The methods of tabulating fish according to age and actual lengths cannot be applied with accuracy unless all fish are taken on or near the same date. Unfortunately, all previous students of growth in brook trout, except Hazzard (1932, 1935) and Shetter and Leonard (1943), have used actual lengths of fish caught at different seasons, usually with no regard for the large variation in age in months within each age group.

A better means of determining rate of growth is by calculating the past growth of fish from scale measurements. Here, lengths and ages are strictly comparable because all calculated lengths are those attained at the end of completed seasons of growth. This method has been widely and successfully used for many species of fishes, and has been reviewed in detail by Van Oosten (1929). The method is based on the assumption that the scale size increases in proportion with increase in the length of the fish. In order to apply it, one must first determine the relationship between the growth of the scale and the growth in length of the fish.

Scale-Sampling Procedure

Key scales, i.e., identically located, must be used for a critical study of body-scale relationship. Because brook trout scales are so small and so often regenerated, it was not feasible to use exact key scales; however, approximate key scales were obtained by restricting the sampling to a certain small area. The sample area selected for this study, on the basis of scale size, uniformity and ease of reading, was the first few scale rows immediately below the lateral line just anterior to the anus.

Of the approximately 50 scales which composed each sample, five were mounted in glycerin-gelatin medium and studied with the aid of a scale-projection machine at a magnification of 90 diameters. All measurements of projected images were made with a millimeter rule at this magnification. Since annuli usually cannot be distinguished on the exposed (posterior) portion of the scale, the distance from the center of the focus to the approximate midpoint of the anterior margin of the scale (anterior scale radius) was used as the scale length. Measurements from center of focus to annuli were made on the same radius. All five of the scales on each slide were measured in this way.

The standard length of the fish in millimeters was used in all computations of body-scale relationship. Previous growth history was also computed on a basis of standard length in millimeters. However, the data in Table 1 are given in total lengths in inches following the suggestion of Hile (1948). The conversion of standard length to total length was made from the empirically determined relationship as follows: Total length = 1.4137 standard length $^{0.964}$.

Body-Scale Relationship

Hazzard (1932), in calculating the previous growth history of brook trout, assumed that the body-scale relationship could be expressed as a straight line, with an intercept on the length axis corresponding to the length of the fish at the time scales first appear. This was in line with the proposals of Johnston (1905) and Fraser (1916). Hazzard stated that the calculated average lengths determined from the use of this formula were found to be consistent with the actual average lengths of the year classes. However, since most of his specimens were taken by angling some time after growth had started in the spring, no extensive comparison between the calculated lengths and actual lengths of the fish at the time of annulus formation was possible. Shetter and Leonard (1943) also used a direct proportion method in their calculation of previous growth history of brook trout in Hunt Creek, Montmorency County, Michigan.

In the present study, when the empirical data were plotted, it was apparent that the body-scale relationship could best be expressed by a curve, rather than by a straight line (Figure 1). As the fish grows in length, the scale lags behind, producing a simple depressed curve. Minor differences in the form of the curve were noted for the different populations and even among the sexes, but in every case a satisfactory fit of the data was obtained by using the general formula:

$$ASR = CL^{n}$$

where ASR = anterior scale radius, L = standard length in millimeters, and C and n are constants to be determined empirically.

In this general formula, because the exponent n determines the slope of the line, the differences between the values of n and 1.0 indicate the amount of deviation of the curve from a straight line. Thus the body-scale relationship curve of the Gangle Lake population is more depressed than any of the other populations examined (Table 1). The variation in values of n for the different populations is considerable, being 0.630 for Gangle Lake and 0.843 for the Pigeon River.

Scales from different portions of the body were studied to determine the amount of difference in body-scale relationship due to this factor. Two body areas were sampled, one anterior to the dorsal fin and above the lateral line, the other immediately anterior to the anus and below the lateral line. For the most part, the same individual fish were included in the sampling from both body areas. This comparison indicated that the body-scale relationship was quite different between the samples (1,234 and 1,430, respectively) drawn from the two body areas; values of n were 0.802 in the posterior position and 0.900 in the anterior position (Table 1). A comparison of the sexes as to body-scale relationship disclosed a small but significant difference in n, cf., 0.828 for males and 0.780 for females (Table 1).

Computation of Previous Growth History

The most accurate method of computing growth history of individual fish would be to use the body-scale relationship obtained for the particular population, sex, and body area in question. However, a great saving of time would be effected by using a general curve derived from some prior study--a desirable procedure, provided that resultant errors are minor. An estimate of these errors may be obtained by comparing the values calculated by using different body-scale relationship curves. Such a

comparison has been made (Table 2) for a hypothetical brook trout 12.5 inches long and in its fourth summer of life. The direct-proportion method with a correction added to compensate for the size of the fish at the time of scale formation, as proposed by Fraser (1916), results in extreme error when applied to the Gangle Lake population, or to most of the other populations. The direct-proportion method, also, results in considerable error in calculating earlier growth history. The data from some of the other populations, such as for the North Branch of the Au Sable River, the Pigeon River, and Hunt Creek, might be logically combined in the calculation of previous growth history without sacrificing much in accuracy.

Acknowledgment

The data used in this report were obtained with the assistance of many different persons connected with the Michigan Department of Conservation. This assistance is gratefully acknowledged. Dr. A. S. Hazzard supervised the study and Dr. Ralph Hile furnished valuable advice in the interpretation of the results.

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Report typed by B. A. Lowell

Table 1.--Body-scale relationship of the brook trout in Michigan

Locality, Sex or Method	Number of fish	Range in total length in inches	Body-scale relationship ASR =
All localities combined[1/] Posterior "key" position	1,430	1.7-15.8	$0.781\ L^{0.802}$
All localities combined[1/] Anterior "key" position	1,234	2.2-16.0	$0.415\ L^{0.900}$
N. Br. Au Sable River, Crawford County	546	2.4- 8.7	$0.830\ L^{0.801}$
Hunt Creek, Montmorency County	620	2.4- 7.8	$0.641\ L^{0.832}$
Pigeon River, Otsego County	532	2.4- 7.8	$0.782\ L^{0.843}$
Sucker Creek, Alcona County	442	2.4- 9.6	$0.848\ L^{0.789}$
Gangle Lake, Montmorency County	827	2.4- 8.3	$0.552\ L^{0.630}$
All males combined	673	2.4- 7.8	$0.700\ L^{0.828}$
All females combined	697	2.4- 7.8	$0.854\ L^{0.780}$
Johnston (1905)	...	...	Direct proportion
Fraser (1916)	...	...	Direct proportion plus correction

[1/] See caption to Figure 1 for list of localities sampled.

Table 2.—Comparison of the total lengths in inches of brook trout at various annuli, calculated[1] by different methods

Locality, Sex or Method	I	II	III	Margin
All localities combined[2] Posterior "key" position	2.6	5.8	9.5	12.5
All localities combined[2] Anterior "key" position	3.0	6.3	9.6	12.5
N. Br. Au Sable River, Crawford County	2.6	5.8	9.5	12.5
Hunt Creek, Montmorency County	2.7	6.0	9.6	12.5
Pigeon River, Otsego County	2.7	6.1	9.7	12.5
Sucker Creek, Alcona County	2.2	5.4	9.3	12.5
Gangle Lake, Montmorency County	1.7	4.8	8.9	12.5
All males combined	2.7	5.9	9.6	12.5
All females combined	2.4	5.7	9.4	12.5
Johnson (1905)	3.5	6.8	10.1	12.5
Fraser (1916)	4.8	7.6	10.4	12.5

[1] Scale readings used are as follows: Annulus I - 20, Annulus II - 40, Annulus III - 60, Margin - 75.

[2] Numbers of fish involved are the same as listed in Table 1.

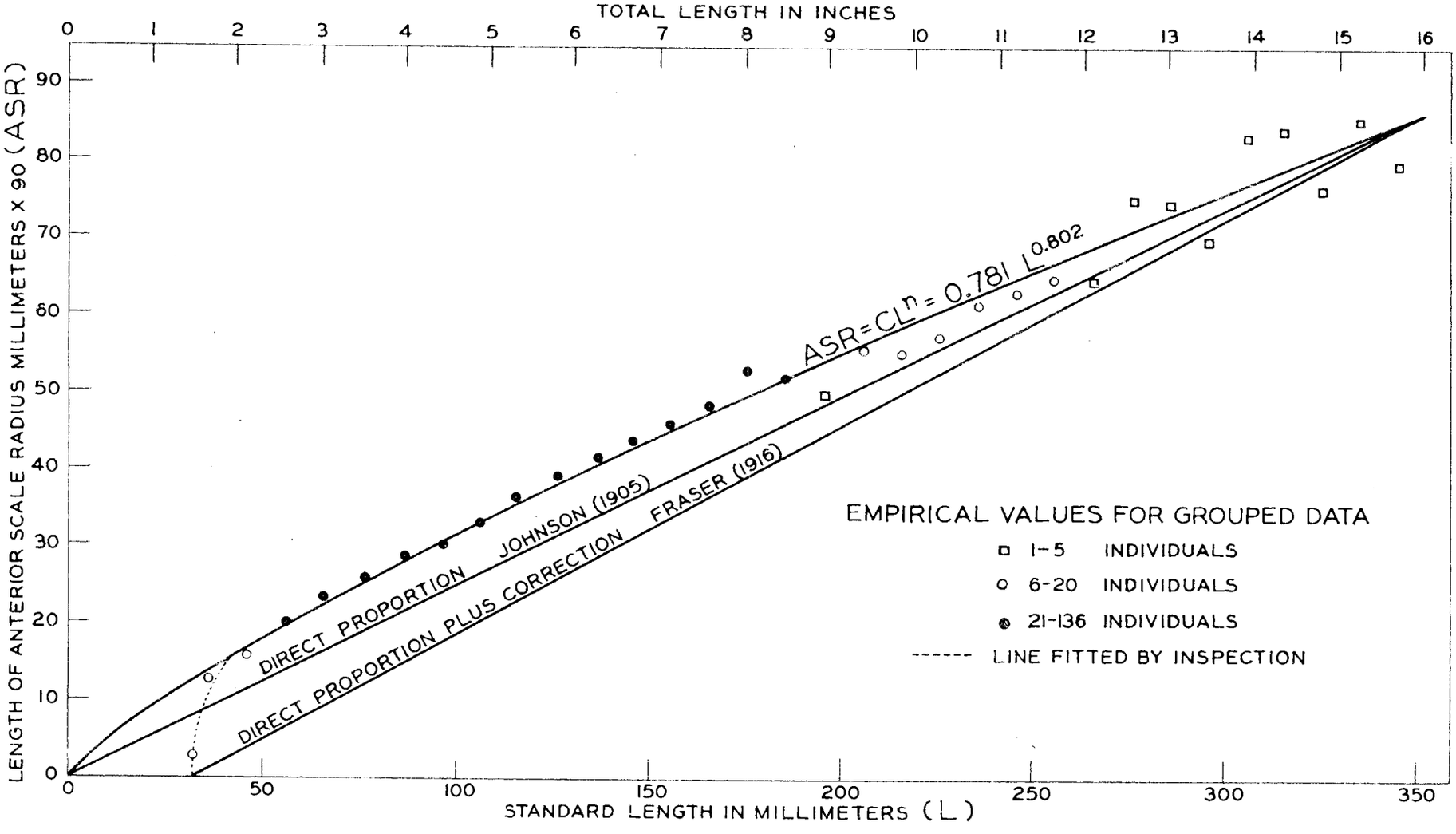

Figure 1.--Body-scale relationship of the brook trout in Michigan. Scales taken from the body immediately anterior to the anus and just below the lateral line. Combined data from 1,430 brook trout from Gangle Lake, East Fish Lake, Hunt Creek, the Upper Black River (all in Montmorency County), Sucker Creek in Alcona County, and the North Branch of the Au Sable River in Crawford County.