
AGE AND GROWTH OF LEPIBEMA CHRYSOPS IN LAKE TEXOMA

A. O. WEESE, University of Oklahoma, Norman

Leuwenhoek observed that the scales of the carp bear concentric rings increasing in number with the age of the fish, and later workers all over the world have used this phenomenon to determine ages. Einar Lea (1) was probably the first to attempt to deduce the dimensions of a fish at each stage of its past life from the corresponding dimensions of the space included within the annuli marking the cessation of each year's growth. Especially since the publication of the review of Rosa Lee (2) this method of determination of growth in earlier years has been used widely but often somewhat uncritically. The simplest assumption that has been made is that the length of the scale is, at all ages, directly proportional to the length of the fish. This may be represented graphically by a regression line which has its origin at the zero point of the coordinates for body length and scale length. It is rare that this relationship can be shown to exist, even approximately, and in most cases a much closer agreement may be found with a relationship expressed by a regression line intercepting the y (body-length) axis at some point above zero. Literally interpreted this might be taken to indicate the length of the fish at the time scale growth began. This interpretation is probably more rarely jusifiable than is assumed. Other more complex relationships have been found in various species.

The most usual procedure in the determination of body-scale-length relationships for a given species is to take the requisite measurements from a collection of fish of various sizes and ages from the habitat being investigated and to determine the regression line of body length upon scale length from this sample of the population. It is the purpose of the present paper to show how the relationships between scale and body length vary with age (size) in the white bass, *Lepibema chrysops*, and how the age composition of a population sample may influence the determination of over-all "constants."

The material upon which this report is based consists of something over a thousand scales obtained from collections during 1946, 1947 and 1948 by Mr. William H. Thompson of the Oklahoma Game and Fish Department and the University of Oklahoma Biological Survey, to whom the author is indebted also for the measurements and interpretations.

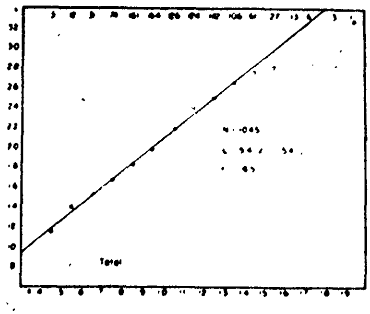

FIGURE 1. The Relation Between Scale Length and Body Length in Lepibema chrysops, for the Entire Sample of 1045 Fish. Standard length in centimeters is indicated on the y axis and scale length (x28) in centimeters on the x axis. The straight line is the regression line of body length on scale length. The circles indicate the mean body length of each 10mm. array of scale length and the figures at the top give the numbers of individuals in each array.

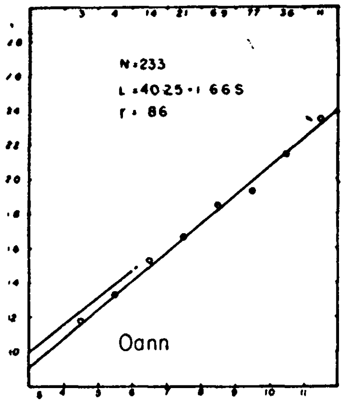

FIGURE 2. The Relation Between Scale Length and Body Length in Lepibema chrysops, for Fish Without a Scale Annulus. The heavy broken line is the regression line from Fig. 1. For further explanation see Figure 1.

Fig. 1 shows the straight line representing most closely regression of body length on scale length as computed from the entire sample of 1045 fish. This result was obtained from ungrouped data and the intercept on the y axis is at 54.2 mm. That there may be a considerable departure from the straight line relationship on the part of the fish with larger scales is indicated by the circled points which represent the mean standard length associated with scales of each 10 mm. array of scale length (as magnified by the scale projector). Above a magnified scale length of 130 mm. (actual scale length, 4.64 mm.) there is but little increase in body length.

For the purpose of further analysis the fish were divided into year-classes according to the number of visible annuli on the scales and Figure 2 portrays the results of the examination of data on those without an annulus, i.e., in their first year of growth. The regression line obtained from this sample is very similar to the previous one, differing in the somewhat lower y intercept (40.25 mm.). In this case there is no apparent departure from the straight line of the array means corresponding to the larger scale sizes. The regression line for the group having one annulus (in the second year of growth) (Fig. 3) intercepts the y axis at 72.15 mm. The intercept for the total sample thus lies between that for the first year's growth and that for the second year. This was to be expected since the bulk of the entire sample was composed of fish of these two year classes (764 out of 1045). In this diagram we begin to see the beginning of the departure from the straight line of the points representing the array means. This phenomenon begins at about the same point in relation to scale size as indicated in the previous figure but at a somewhat shorter body length.

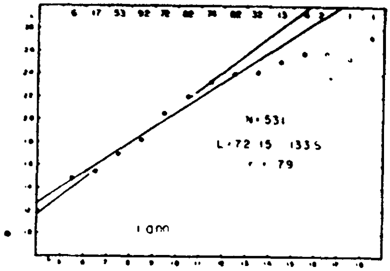

FIGURE 3. The Relation Between Scale Length and Body Length in Lepibema chrysops, for Fish Having One Annulus. For further explanation see Figures 1 and 2.

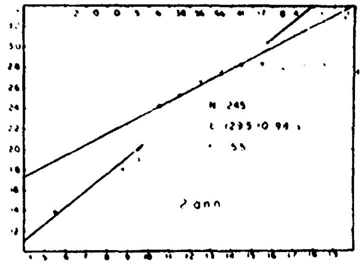

FIGURE 4. The Relation Between Scale Length and Body Length in Lepibema chrysops for Fish Having Two Scale Annuli.

Fig. 4, based on the specimens with two annuli, indicates a still higher intercept for this group and here again there is a departure from the straight line on the part of the data as to the larger scales. It is of interest that in both the one-annulus and the two-annuli groups, the individuals yielding the discrepant data were taken from late autumn to early spring before the resumption of growth of the following year. The possibility is suggested that, in some cases at least, scale growth may continue after growth in length has ceased. The contrary possibility that scale growth may lag behind body growth in the early part of the season is suggested by certain data but has not been investigated. The fish with three annuli were small in numbers, but, as will be shown, the regression line obtained belongs to the same "family" as those previously discussed. The regression formulae for the respective age classes are as follows:

General formula	$L = a + bS$
without annuli	$L = 40.25 + 1.66S$
with one annulus	$L = 72.15 + 1.33S$
with two annuli	$L = 129.5 + 0.98S$
with three annuli	$L = 207.5 + 0.55S$

where L is the standard length of the fish in millimeters, S is the length of the anterior field of the scale multiplied by 28, a is the position of the intercept on the y axis and b is the regression coefficient.

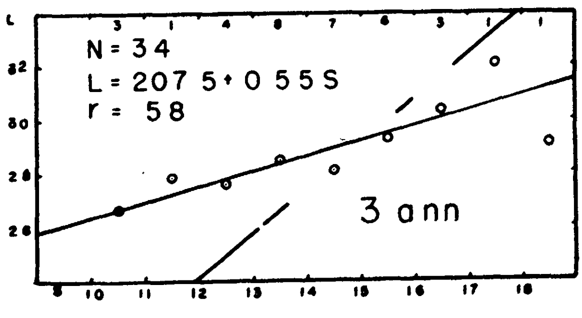

FIGURE 5. The Relation Between Scale Length and Body Length in Lepibema chrysops for Fish Having Three Scale Annuli.

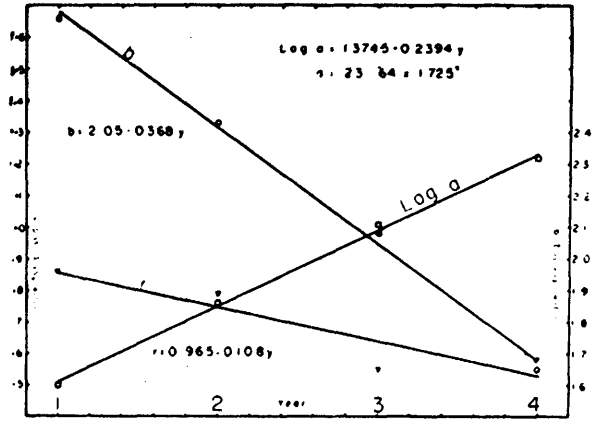

FIGURE 6. The Variations of the Constants of Scale-Length Relationships with the Age of Lepibema chrysops from Lake Texoma. Age (number of annuli plus one) is indicated on the x axis. The regression coefficient (b) — small circles; and the coefficient of correlation (r) — triangles — are indicated on the y axis at the left. At the right on the y axis is indicated the $\log_{10}$ of the y intercept (a) — squares.

The intercept value increases with age and the coefficient expressing the slope of the regression line decreases. These changes are regular, as shown in Fig. 6. The relation between age and the intercept value may be expressed by the formula:

$$a = 23.64 \times 1.725^{y} \qquad (1)$$
$$\text{or } a = 1.725^{y+5.8}$$

where y = age class or the number of annuli, plus one. That between the regression coefficient and age is expressed by:

$$b = 2.05 - 0.368y \qquad (2)$$

It is possible to combine equations (1) and (2) in an expression of the relation between L and S over the entire "family" of regression lines, as follows:

$$L = 1.725^{y} + (2.05 - 0.368y)S$$

There is also a decrease with age in the correlation between scale size and body length, r being successively 0.86, 0.79, 0.55 and 0.58, the final determination being the least reliable because of the small number of individuals in the last age class. This decrease may be expressed approximately by:

$$r = 0.965 - 0.108y$$

These figures do not represent the real correlations between the respective *increments* of scale length and body length since data with respect to the fish of each age represent the sums of the most recent increments and the more highly correlated previous lengths. While no actual computations of correlation between increments are at present available the data suggest the almost entire absence of positive correlation between the later increments of scale and body length.

LITERATURE CITED

1. LEA, EINAR. 1911. A study on the growth of herrings. Cons. perm. int. pour l'exploration de la mer, Publications de Circonstance. 53:7-174.
2. LEE, ROSA. 1920. A review of the methods of age and growth determination in fishes by means of scales. Ministry of Agriculture and Fisheries. Fishery Inv. Series II, 4(2):1-32.