AGE AND GROWTH OF THE WESTERN BLACKNOSE DACE *RHINICHTHYS ATRATULUS MELEAGRIS* AGASSIZ, IN DOE RUN, MEADE COUNTY, KENTUCKY[1,2]

DONALD C. TARTER
Biology Department, Kentucky Southern College
Louisville, Kentucky 40222

INTRODUCTION

The age and growth of fishes of the different year classes reflect, to a large extent, the well-being of the population and its ability to maintain itself under the extant environmental conditions. Two methods applicable to a study of the age and growth of the western blacknose dace, *Rhinichthys atratulus meleagris* Agassiz, in Doe Run are the scale method (Van Oosten, 1929) and the length frequencies as displayed by the individuals of the population (Van Oosten, 1938). These methods are particularly useful in studies of short-lived fishes where the lengths of the different year classes, particularly the juveniles, are easily separated and can readily be identified by examination of the scales.

In the present study, age and growth of the western blacknose dace were based on 3,358 specimens collected from the upper 3.1 miles of Doe Run. Length frequencies, verified by the scale method, were used in aging the fish. In addition, length-weight relationship, coefficient of condition, pattern of scale development, and growth in length and weight were determined.

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DESCRIPTION OF THE STUDY AREA

A detailed description of Doe Run (Minckley, 1963) has been summarized by Krumholz (1967) as a large torrent spring that rises near Ekron, in eastern Meade County, Kentucky. The stream flows north-northeast for about 3.5 miles and empties into Doe Valley Lake, a recent impoundment of more than 500 acres and about 4 miles long. As it leaves the lake, Doe Run flows over the floodplain of the Ohio River for about 2 miles and empties into the Ohio River 3.5 miles east of Brandenburg, Kentucky, and about 36 miles downstream from Louisville (Figure 1).

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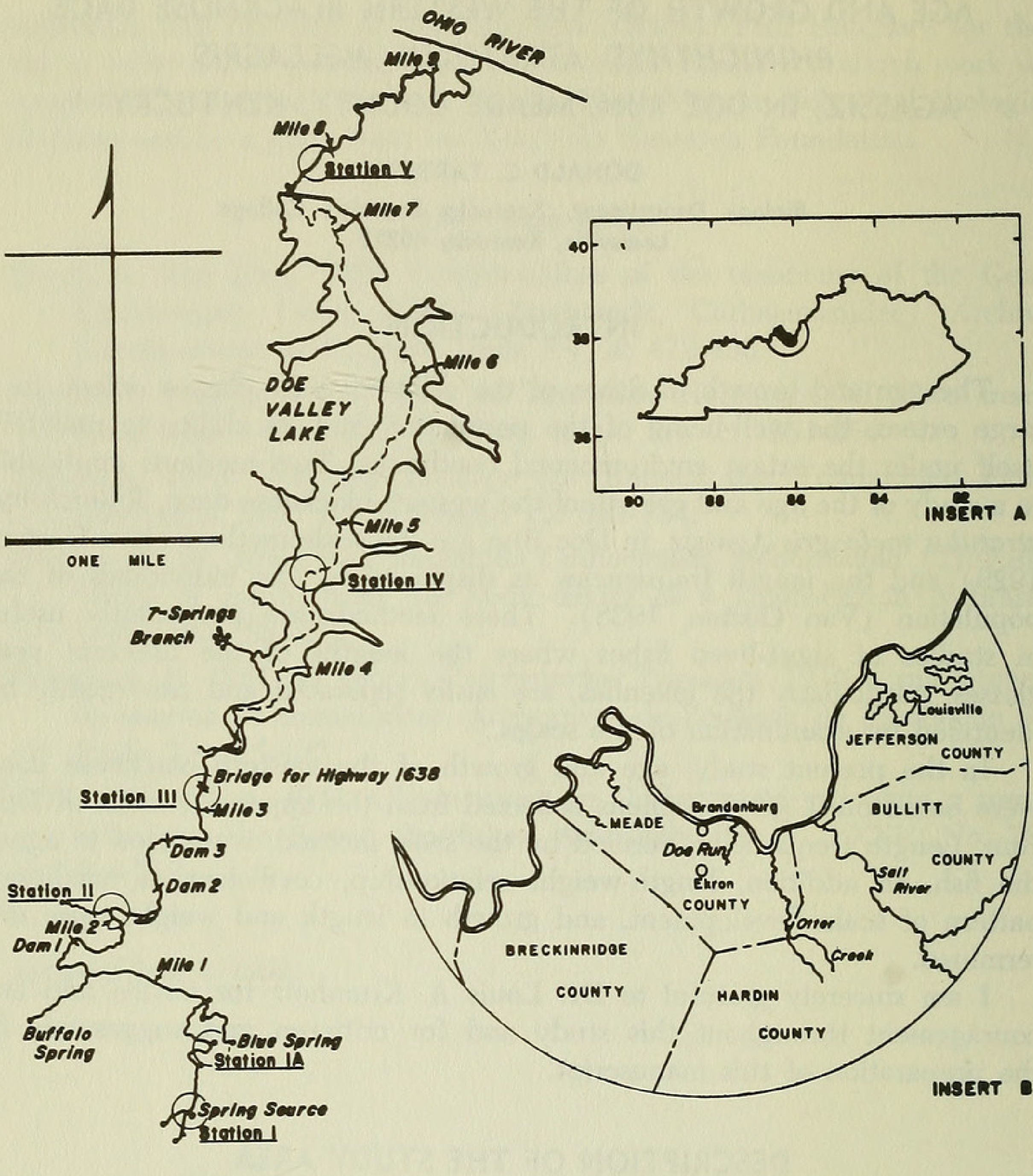

Figure 1.—Doe Run, Meade County, Kentucky, showing locations of collecting stations, stream miles, extent of Doe Valley Lake, and other features. The broken line through Doe Valley Lake shows the course of the stream prior to impoundment (after Krumholz, 1965).

MATERIALS AND METHODS

Each fish to be weighed was placed in cheesecloth to remove the excess preservative and was immediately weighed to the nearest milligram on a Mettler electric, single-pan balance. Total and standard lengths, to the nearest millimeter, were determined with a divider and the reading taken from a steel ruler. Both lengths were measured by the methods described by Hubbs and Lagler (1958). Total length is used consistently in this study. A conversion factor based on 274 dace of all sizes can be expressed as follows:

$$\frac{\text{T.L.}}{\text{S.L.}} = 1.23$$

Length frequencies, verified by the scale method, were used to determine the age groups of 3,358 western blacknose dace collected from three stations in Doe Run. Data for the monthly collections were arranged in 2-mm length groups and the percentage frequency of each group was determined. The scales were removed by forceps from the left side of the body about midway between the dorsal fin and lateral line. Four or five scales were mounted in water under a cover slip and the number of annuli counted with the aid of magnification from a conventional scale reader. The most important characteristics used to recognize the annuli were crowding of circuli and the "cutting over" of circuli near the lateral margin of the scale (Lagler, 1956).

The relationship between total length and weight was calculated from data on 3,358 western blacknose dace from three stations in Doe Run. There were no consistent differences in length and weight when each station was determined separately. For ease in presentation, those data were placed in 3-mm length groups and plotted on the average millimeter interval. A curve was constructed comparing empirical averages with calculated values. The following length-weight equation, in logarithmic form, was solved by the method of least squares:

$$\text{Log W} = \log a + n \log \text{L}$$

where W = weight in grams,
L = total length in millimeters, and
log a and n = constants.

As a part of the study of the length-weight relationship, K, the coefficient of condition, the physical condition of a fish, was calculated for 3,358 dace (sexes combined), and 743 dace (sexes separate), using the following equation:

$$K = \frac{W \times 10^5}{L^3}$$

where W = weight in grams,
L = total length in millimeters.

Standard length usually is used in this equation since the caudal fin contributes very little to the total weight, but for consistency in length measurements, I used total length.

Growth curves based on 3,358 dace, were constructed for each age group, from monthly averages in length, to obtain the absolute growth rate. Growth curves also were constructed from computed lengths and weights for comparison with computed increments of length and weight for each age group. The percentage increase for length and weight of each age group was calculated.

A series of smaller dace was preserved in 10 percent formalin for studying the pattern of scale development.

AGE AND GROWTH

Age Groups

Length frequencies were used to distinguish the age groups of dace collected monthly from three stations in Doe Run (Figure 2). Histograms constructed for each station were quite useful in separating the younger age groups, but the overlap between the older age groups limited their usefulness.

Age groups were designated by Roman numerals to indicate the age in years of fish. A fish which belonged to Age Group II had two annuli. There was very little overlap between Age Group 0 and Age Group I in the length-frequency distribution, but it increased between the older age groups. The number of annuli on the scales of fish in the areas of overlap was helpful in separating the older age groups. Three complete age groups, O, I, and II, were represented in the population, and there were a few individuals belonging to Age Group III.

Length-Weight Relationship and Coefficient of Condition

The length-weight relationship of the western blacknose dace in Doe Run was expressed by the following equation:

$$W = aL^n$$

where W = weight in grams,
L = total length in millimeters, and
a and n = constants.

The values for a and n were computed mathematically by the method of least squares. The equation was fitted to the average total lengths and weights between 28 and 88 mm in Figure 3, A and B, respectively. The length-weight equation is:

$$W = 3.42 \times 10^{-6} L^{3.251}$$

There was a high coefficient of correlation (r = .90) between total length and weight of dace collected from Doe Run.

In Figure 3, the circles represent empirical length-weight averages and the curve was plotted from the total lengths and calculated weights using the length-weight equation in Table 1. The calculated weights agreed quite well with the empirical weights and provided additional evidence that the length-weight equation can be used to determine the weight of a dace in Doe Run if only its length is known. The curve showed a gradual rise with increasing total lengths of dace, indicating that the weight increased proportionately faster than the total length of dace. A thorough review of the length-weight relationship in fishes was reported by Beckman (1948).

Calculations of the coefficient of condition (K), based on the cube law, are:

$$K = \frac{W \times 10^5}{L^3}$$

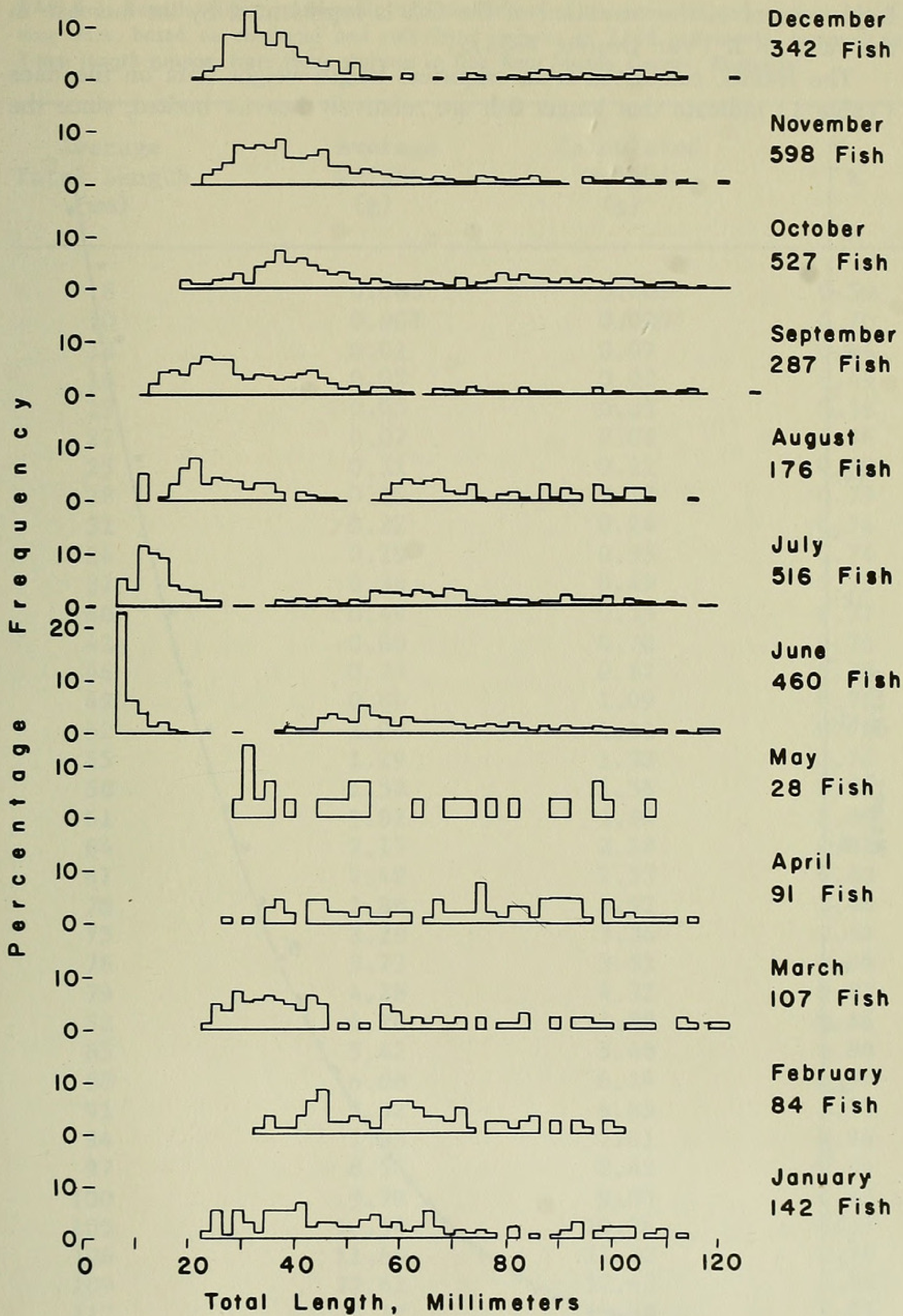

Figure 2.—Length frequencies at monthly intervals of western blacknose dace from three stations in Doe Run, Meade County, Kentucky.

Improvement in the condition of the fish is represented by an increase in the value of K (Van Oosten, 1938).

The results, calculated from empirical length-weight data on the dace (Table 1) indicate that longer fish are relatively heavier bodied, since the

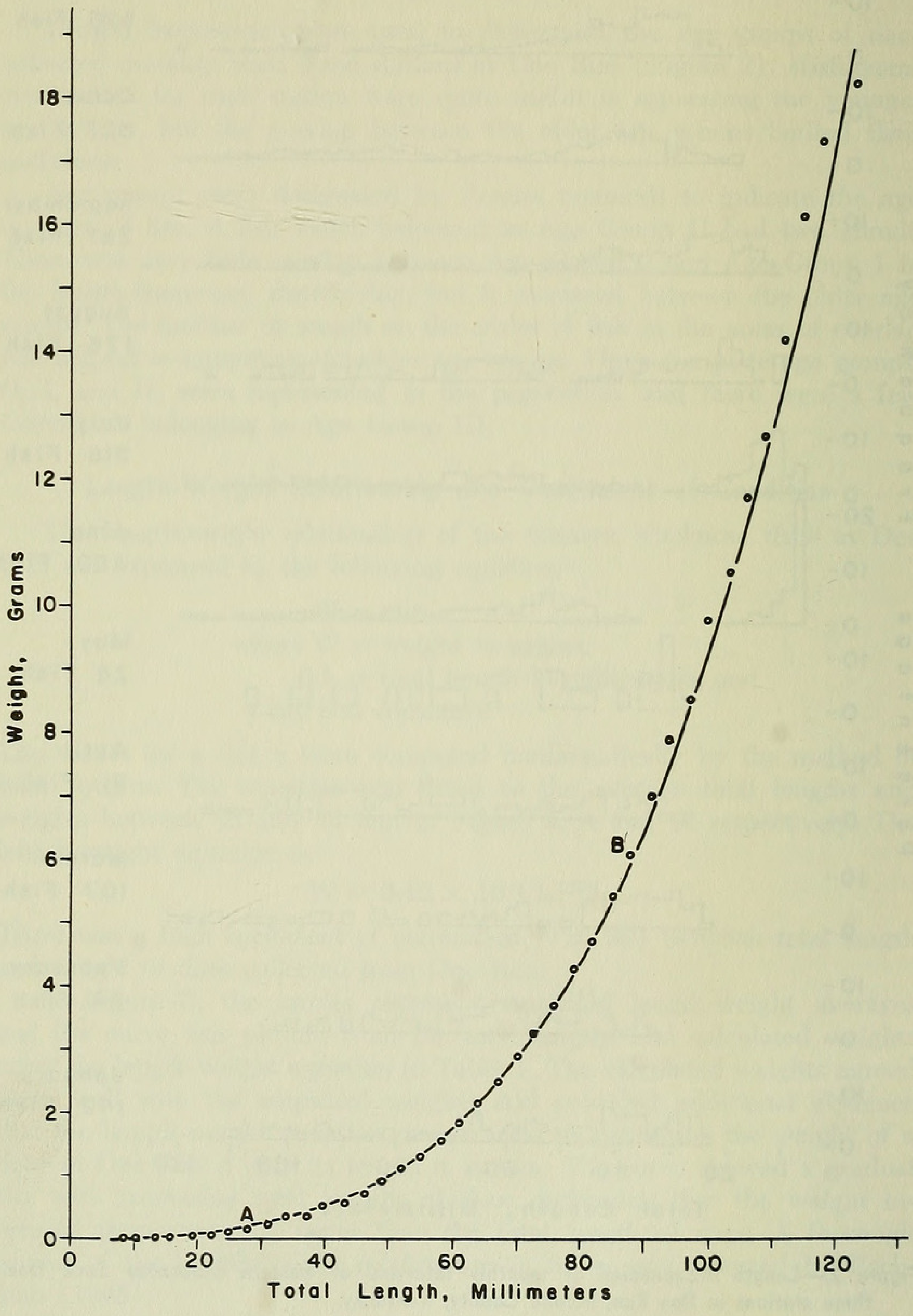

Figure 3.—Length-weight relationship of western blacknose dace from three stations in Doe Run, Meade County, Kentucky.

TABLE 1. Length-weight relationship and coefficient of condition (K) of western blacknose dace, based on empirical and calculated weights of 3,358 individuals, arranged in 3-mm length groups, from three stations in Doe Run, Meade County, Kentucky.

Average Total Length (mm)	Average Weight (g)	Calculated Weight (g)	K
8	0.003	0.003	0.59
10	0.007	0.006	0.70
13	0.01	0.01	0.46
16	0.02	0.03	0.49
19	0.05	0.05	0.58
22	0.07	0.08	0.66
25	0.11	0.12	0.70
28	0.16	0.17	0.73
31	0.22	0.24	0.74
34	0.29	0.33	0.74
37	0.38	0.43	0.75
40	0.49	0.55	0.77
43	0.60	0.70	0.76
46	0.74	0.87	0.76
49	0.89	1.09	0.76
52	1.09	1.11	0.78
55	1.29	1.33	0.78
58	1.58	1.58	0.81
61	1.82	1.86	0.80
64	2.15	2.18	0.82
67	2.48	2.53	0.83
70	2.88	2.92	0.84
73	3.28	3.34	0.84
76	3.73	3.81	0.85
79	4.28	4.32	0.87
82	4.76	4.88	0.86
85	5.42	5.48	0.88
88	6.08	6.14	0.89
91	7.02	6.85	0.93
94	7.93	7.61	0.96
97	8.54	8.43	0.94
100	9.79	9.30	0.98
103	10.54	10.34	0.97
106	11.69	11.32	0.98
109	12.61	12.43	0.98
112	14.17	13.52	1.01
115	16.08	14.74	1.06
118	17.26	16.04	1.05
124	18.21	18.71	0.96

slope of the logarithmic length-weight equation is greater than 3.0. The value of K increased with age since fish tend to gain proportionately more in weight than in length (Figure 3) as they grow older (Rounsefell and Everhart, 1953).

An attempt was made to determine if any sexual differences in the coefficient of condition were present during the different seasons (Figure 4). Generally, both sexes showed similar fluctuations in condition in all seasons except winter. The mean coefficient of condition for both sexes started to increase in the middle of spring and reached its highest value just priod to spawning. Condition declined after spawning and was somewhat constant in summer. Females showed a sudden rise in condition in early fall. Males sharply declined in condition in early winter but gradually increased from then until spring. The decline in condition of males in winter and early spring may be correlated with the high percentage of empty stomachs (Tarter, in press). The good condition of females in winter, early fall, and early spring may be correlated with the low percentages of empty stomachs at various stations during those seasons. Females had a higher mean coefficient of condition (1.22) than males (1.04), and the combined average of both sexes was 1.13 (based on 743 sexed specimens); the range was 0.94 to 1.57. The average coefficient of condition based on 3,358 specimens from Doe Run (sexes combined) was 0.82; the range was 0.46 to 1.06. The lower coefficient of condition was to be expected from the larger number of specimens since many of them were small.

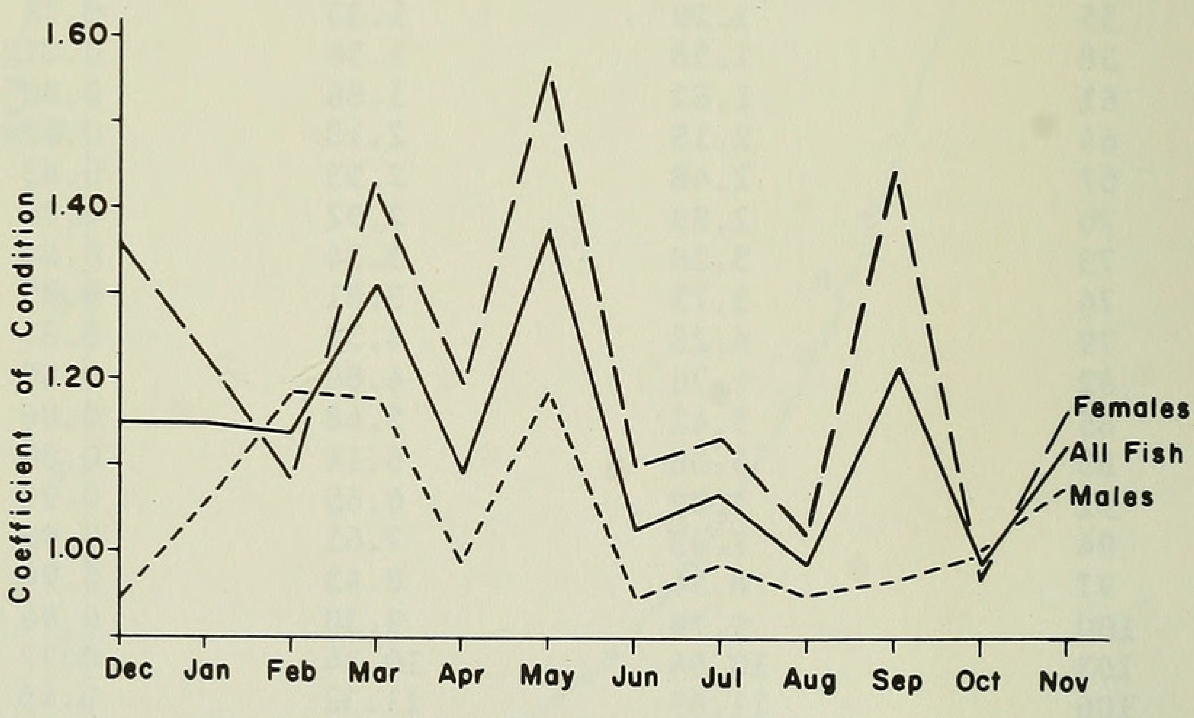

Figure 4.—Mean coefficient of condition of both sexes of western blacknose dace collected at all seasons from three stations in Doe Run, Meade County, Kentucky.

Pattern of Scale Development

The pattern and sequence of scale development in western blacknose dace follows the pattern common to other minnows. No scales were found on any dace less than 19 mm total length. There were a few cycloid scales along the lateral line area on the caudal peduncle of dace 19 mm long. As the fish increased in length, scale development proceeded gradually anteriorly from the caudal peduncle along the lateral line area with more scale rows developing below the lateral line than above it. By the time the fish reached a length of 21 mm, the scale pattern had developed beyond the origin of the dorsal fin, and had reached the area of the pectoral fins at a total length of 23 mm. Western blacknose dace in Doe Run are completely scaled at a total length of 26 to 27 mm.

Growth in Length and Weight

Total Length

The greatest absolute growth occurred during the first two years of life, with a gradual decline in the third year, in western blacknose dace collected from Doe Run (Figure 5). A preliminary study, based on 743 dace, indicated that only a small difference existed between the growth rates of males and females. Females were only slightly larger than males, therefore all the growth curves were based on combined data from both sexes. Growth rate was slightly faster the first year, and slowest in the

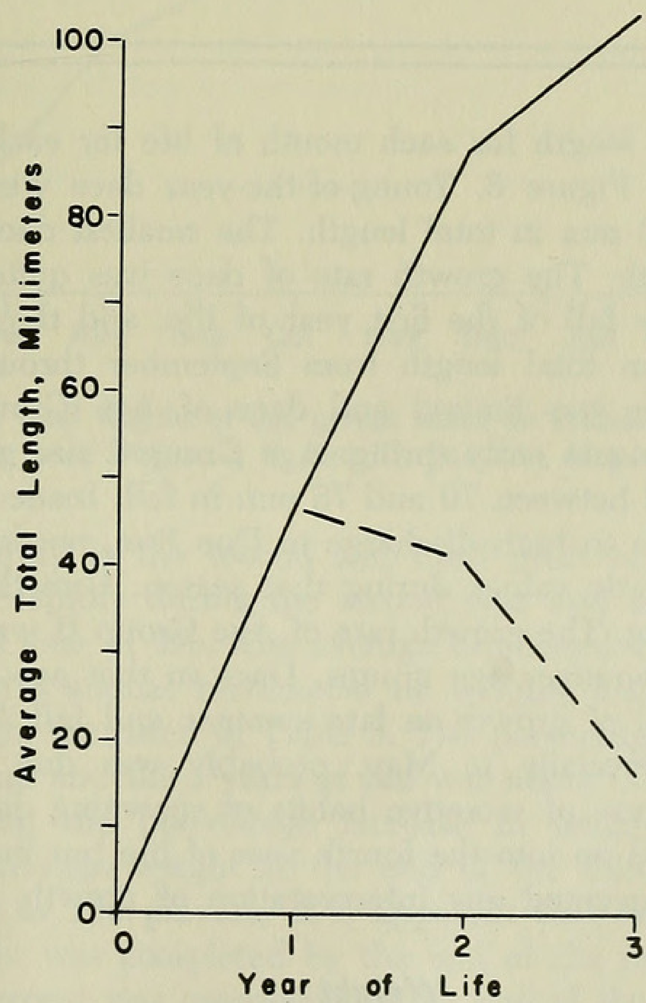

Figure 5.—Average calculated total length at the end of each year of life (solid line), and average yearly increment of growth (broken line) of western blacknose dace in Doe Run, Meade County, Kentucky.

third year (Table 2). If the average length at the end of the third year of life (104 mm) is taken as 100 percent, it is obvious that 45 percent and 85 percent of the total length was completed by the end of the first and second years of life, respectively. The total length at the end of each year of life and also the annual increments of length are shown graphically in Figure 5. The percentage increases in total length for the second and third years of life are listed in Table 2.

TABLE 2. Average calculated total lengths in millimeters, annual increments of length, and annual percentage increase in total lengths of western blacknose dace in Doe Run, Meade County, Kentucky.

	Year of Life		
	1	2	3
Total Length	47	88	104
Increment of length	47	41	16
Percentage of increase	—	87	18

The average total length for each month of life for each age group is shown graphically in Figure 6. Young-of-the-year dace were collected in June and averaged 10 mm in total length. The smallest dace fry collected was 8 mm total length. The growth rate of dace was quite rapid during the summer and early fall of the first year of life, and they averaged between 32 and 39 mm total length from September through November. Growth during winter was limited and dace of Age Group 0 averaged only about 38 mm long in early spring. Age Group I also grew rapidly in summer and averaged between 70 and 75 mm in fall. Inadequate sampling of dace in winter, due to high discharge in Doe Run, no doubt accounted for the somewhat erratic values during that season. Growth gradually increased again in spring. The growth rate of Age Group II was much slower in summer than the younger age groups. Dace in that age group reached a fairly constant level of growth in late summer and fall. The decline in growth in spring, especially in May, probably was due to inadequate sampling of fish because of secretive habits of spawning dace. A few fish (Age Group III) lived on into the fourth year of life but inadequate numbers of specimens prevented any interpretation of growth.

Weight

The absolute growth curve of weight increased very slowly during the first year of life (Figure 7), quite the antithesis of length. The curve of

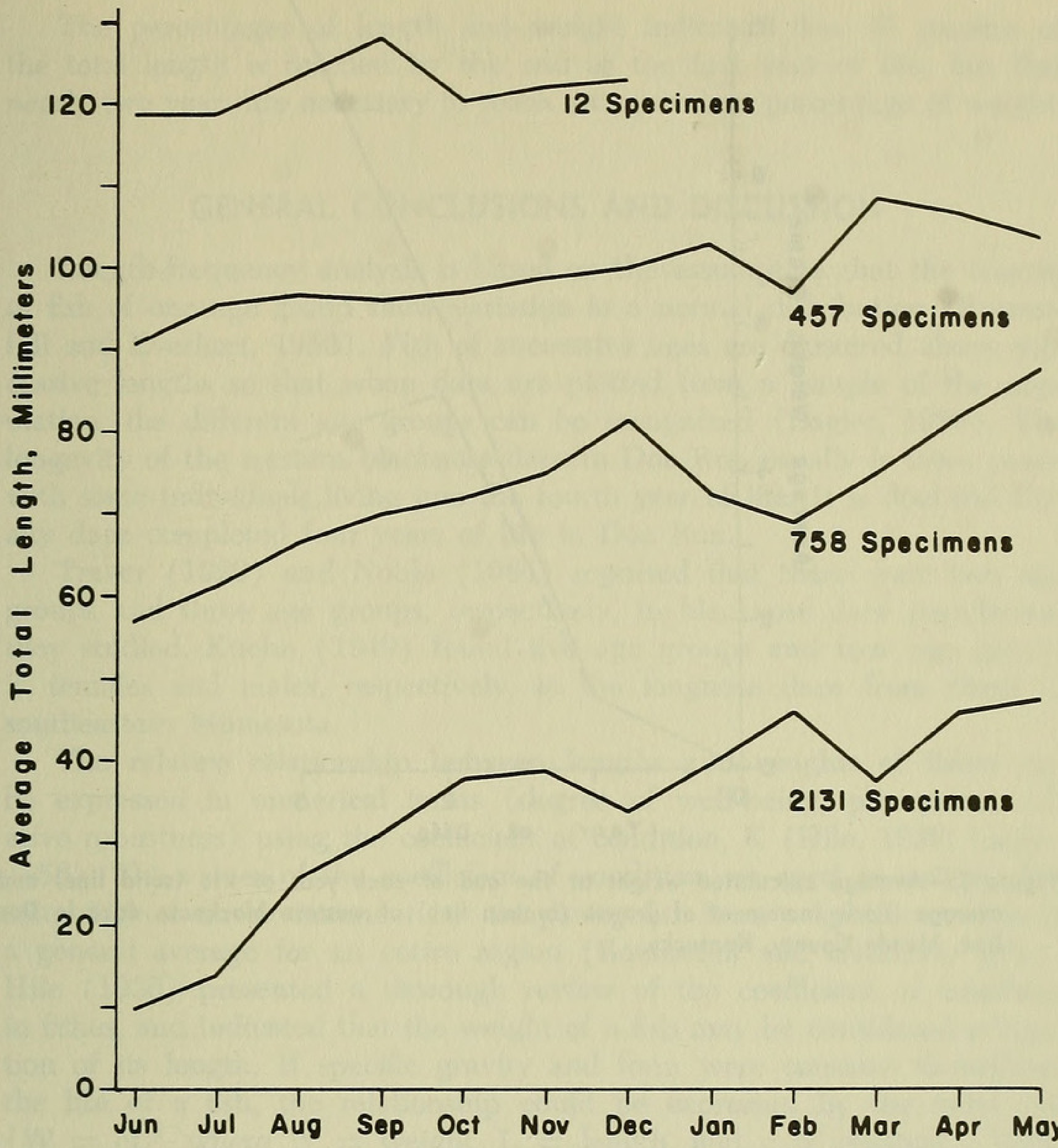

Figure 6.—Average total lengths of age groups based on measurements of 3,358 western blacknose dace from Stations I, II, and III, Doe Run, Meade County, Kentucky.

weight rose sharply in the second and third years of life. The increment curve increased rapidly during the second year and declined only slightly during the third year of life. The average calculated weight (from length-weight equation), annual increments of weight, and annual percentage increase in weight are listed in Table 3. The percentage increase of weight during the second and third years of life was about 6 and 4 times greater, respectively, than the percentage increase in length during that same period. If the average weight at the end of the third year of life (10.6 grams) is taken as 100 percent, it is apparent that only 9 percent of the growth in weight was completed by the end of the first year and that an additional 50 percent was completed at the end of the second year of life. During the third year of life in Doe Run an additional 41 percent of the weight is added.

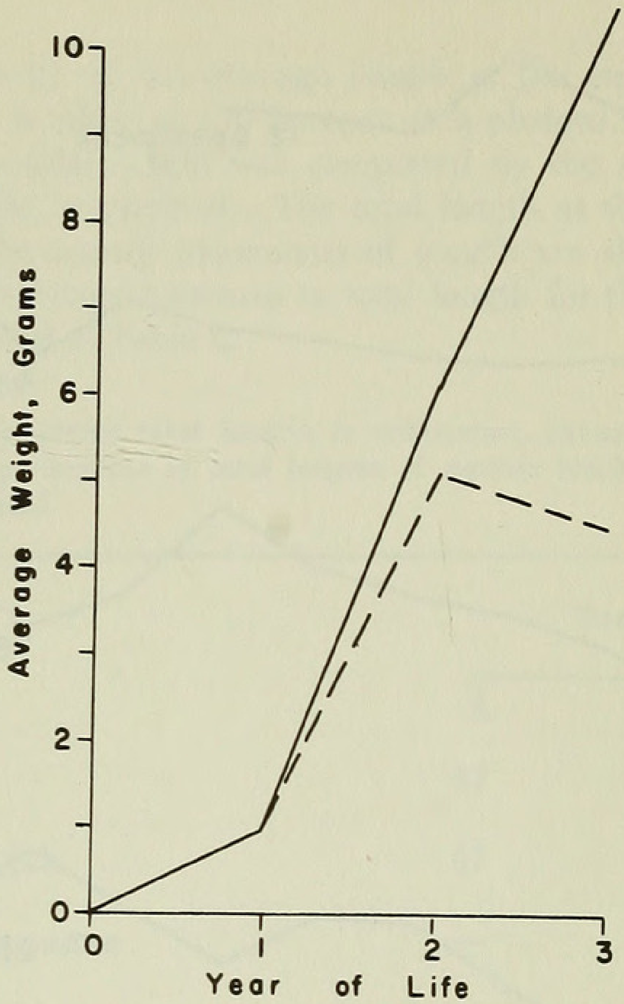

Figure 7.—Average calculated weight at the end of each year of life (solid line) and average yearly increment of growth (broken line) of western blacknose dace in Doe Run, Meade County, Kentucky.

TABLE 3. Average calculated weights in grams corresponding to the average calculated total lengths in Table 2, annual increments of weight, and annual percentage increases in weight of western blacknose dace in Doe Run, Meade County, Kentucky.

	Year of Life		
	1	2	3
Calculated weight	1.0	6.1	10.6
Increment of weight	1.0	5.1	4.5
Percentage of increase	--	510	74

The percentages of length and weight indicated that 45 percent of the total length is reached by the end of the first year of life, but that nearly two years are necessary to reach an equivalent percentage of weight.

GENERAL CONCLUSIONS AND DISCUSSION

Length-frequency analysis is based on the assumption that the lengths of fish of one age group show variation in a normal distribution (Rounsefell and Everhart, 1953). Fish of successive ages are clustered about successive lengths so that when data are plotted from a sample of the population, the different age groups can be recognized (Lagler, 1956). The longevity of the western blacknose dace in Doe Run usually is three years, with some individuals living into the fourth year of life. It is doubtful that any dace completed four years of life in Doe Run.

Traver (1929) and Noble (1964) reported that there were two age groups and three age groups, respectively, in blacknose dace populations they studied. Kuehn (1949) found five age groups and four age groups in females and males, respectively, in the longnose dace from rivers in southeastern Minnesota.

The relative relationship between lengths and weights of fishes can be expressed in numerical terms (degree of well-being, plumpness, relative robustness) using the coefficient of condition, K (Hile, 1936; Lagler, 1956). The values of the coefficient of condition are used to indicate the suitability of an environment by comparing fish from a specific area with a general average for an entire region (Rounsefell and Everhart, 1953). Hile (1936) presented a thorough review of the coefficient of condition in fishes, and indicated that the weight of a fish may be considered a function of its length. If specific gravity and form were constant throughout the life of a fish, the relationship could be expressed by the cube law ($W = cL^3$, where W = weight, L = length, and c = constant). Wide variation exists in nature for the value of c, which is not constant for a species or population. Noble (1964) reported the coefficient of condition (sexes combined) of backnose dace in Iowa to range from about 1.4 to 1.9, but no data were given for December, January, or February. No averages for sexes separate or combined were given for comparison. Males were more robust at one station and females at another station in his study.

The direct proportion method for aging fish has been in use for many years (Van Oosten, 1929), and assumes a direct proportion between the growth of the scale and growth of the body throughout the life of the fish. Since it is well known that newly hatched fishes do not have scales, it was suggested by Fraser (1916) that a correction factor must be introduced as an addendum to the direct proportion method. The length of the body prior to development of the scales must be subtracted from the actual total length since it was present before any scales were formed. Such a correction factor is determined by actual measurements from specimens at hand or by extrapolating the regression line obtained when scale length is plotted against body length.

The longest male and female dace collected from Doe Run were 121 mm (Station III) and 128 mm total length (Station II), respectively, both in their fourth year of life. The longest blacknose dace previously reported in the literature, so far as I could determine, was by Moore et al. (1934), who reported an individual of 97 mm total length but did not report the sex. Kuehn (1949) reported that the largest longnose dace in his study was a 124-mm female, and that males never exceeded 96 mm total length. Traver (1929) indicated that the largest blacknose dace taken from Cascadilla Creek, New York, was 63 mm but did not indicate whether the measurement was in total length or standard length.

The heaviest male and female dace collected from Doe Run weighed 17.2 grams (Station III) and 20.9 grams (Station II), respectively. The stage of development of the eggs in the female was no doubt partly responsible for the greater weight.

The constancy of water temperature, abundance of food on a yearly basis, and a long growing season at this latitude were important factors in Doe Run which influenced the fast rate of growth and produced larger blacknose dace than any reported in the literature.

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