Fisheries Bulletin #13 October, 1953

The Age and Growth of The Gizzard Shad

Dorosoma cepedianum (LeSueur)

IN HERRINGTON LAKE, KENTUCKY

by

William R. Turner

***

Division of Fisheries

Department of Fish and Wildlife Resources

Frankfort, Kentucky

THE AGE AND GROWTH OF THE GIZZARD SHAD, *Dorosoma cepedianum* (LeSueur), in Herrington Lake, Kentucky[1]

by

William R. Turner
Division of Fisheries
Kentucky Department of Fish & Wildlife Resources

Abstract

An age and growth study was conducted on Herrington Lake gizzard shad during July, 1953. The growth rate of this species was found to be 4.4 inches at the end of the first year of life, 7.8 inches at the end of the second year, 10.4 inches at the end of the third year, 12.4 inches at the end of the fourth year, and 13.4 inches at the end of the fifth year of life.

Body-scale relationship data for Herrington Lake gizzard shad shows the fish to form its scales at a total length of 0.57 inches.

A length-weight relationship was plotted and the logorithmic equation was determined as Log W = 3.4539 + 2.9697 Log L.

[1]A joint contribution of the Division of Fisheries and the Department of Biology, University of Louisville.

INTRODUCTION

The gizzard shad, Dorosoma cepedianum (LeSueur), is probably the most important forage fish found in Kentucky's large impoundments. It is the most abundant forage fish in the diet of all of our game fishes in these waters.

In Herrington Lake, a 2940 acre reservoir famed for its white bass fishing, the gizzard shad was found to make up almost 90% of the total volume of food of this fish (Tompkins and Peters 1951). The reason the gizzard shad is such a successful forage fish is because of its high reproductive potential and rapid growth rate. Since the shad attains a large size so rapidly that it cannot be readily depleted by predation, a good breeding stock is always assured. This latter factor, however, tends to discredit its worth in other circumstances. Some idea of its importance in Herrington Lake may be obtained by referring to Table 1. It is readily seen that the gizzard shad made up the greatest percentage by weight for every year that the population studies were conducted.

As a forage fish, the shad fills an important place in a rather simple food chain. The shad has a low trophic level, feeding almost exclusively on plankton. Plants, mostly plankton algae, make up from 70 to 100 percent of the food material of the gizzard shad (Wickliff 1945). Since the shad is in turn devoured by carnivorous fishes, it constitutes an efficient link in a relatively short food chain.

The status of the shad as a forage fish does not describe all of its values, however. Lagler and Applegate (1942) found the shad to be an important "buffer" species, that is, it tends to lessen the pressures of predation on the young of game and other species of fish.

Table I - Percentage by Weight of Fish Recovered from Herrington Lake, Kentucky during Population Studies Conducted from 1948 to 1953.

SPECIES	1948	1949	1950	1951	1952	1953	Mean
Game Fish	30.35	10.40	27.96	25.22	63.37	16.67	28.99
Largemouth Bass	5.83	2.47	4.48	2.89	4.34	3.78	3.97
Kentucky Bass			0.55	1.20	0.01	0.06	0.46
Smallmouth Bass	0.27	0.07	0.11	0.26		0.28	0.20
White Crappie		4.12	4.90	2.39	5.44	1.09	3.59
Black Crappie	1.36	0.08	0.31	1.09		0.56	0.68
Northern Pike			0.22				0.22
Bluegill	10.68	2.06	5.81	4.41	4.14	6.36	5.58
Green Sunfish	2.89	0.41	0.03	0.44	0.27	0.06	0.68
Longear	1.47	0.34	1.07	1.49	1.15	1.70	1.20
White Bass	7.85	0.85	10.48	11.05	48.02	2.78	13.51
Forage Fish	36.46	76.03	51.97	49.18	28.67	62.58	50.81
Gizzard Shad	36.24	75.99	51.90	49.13	27.32	62.34	50.49
Misc. Minnows	0.22	0.04	0.07	0.05	1.35	0.24	0.33
Rough Fish	33.19	13.42	19.98	33.24	7.97	20.71	21.41
Channel Catfish	1.69	1.38	2.06	2.61	0.86	1.53	1.69
Flathead Catfish	0.76	2.30	1.36	0.70	0.41	3.49	1.50
Smallmouth Buffalo	24.69	6.74	10.44	12.05	1.37	9.86	10.86
Carp		0.56	0.02	0.17			0.25
Carpsucker			0.76	1.88			1.32
Redhorses		0.32	2.51		2.67	2.69	2.05
Drum	6.05	2.12	2.83	15.83	2.66	3.13	5.44

In this paper an attempt has been made to determine the age and growth of the gizzard shad in Herrington Lake. It is hoped that this information will be of some use in helping to understand better the relationship of this species to the total population of this reservoir.

MATERIALS AND METHODS

All the shad used in the present study were collected from Herrington Lake during the course of two population studies. The fish were obtained as a result of the chemical treatment of two different coves. The treatment of the first cove on July 6, 1953, provided all of the young of the year fish used in the study. On July 13 and 14 the second cove was treated and the remainder of the fish were gathered. The number of shad obtained and their size ranges are summarized in Table 2.

The smallest fish were preserved in formalin and taken to the laboratory where they could be weighed more accurately on a gram scale. Later these weights were converted into pounds. No correction was made for shrinkage that may have occurred, for such a small error was thought to be insignificant for the purpose involved.

Since the scales on small shad are very deciduous and barely discernable beneath a binocular microscope, it was found to be very helpful to immerse the specimens in an aqueous solution of Alizarin Red S. This dye shows the scales as red and at the same time leaves the unscaled areas their natural silvery color. With such a color contrast the use of a microscope is unnecessary to detect the scales.

The scale samples from the larger shad were taken from freshly obtained specimens. Each fish was measured to the nearest .05 of an

inch and then weighed to the nearest .01 of a pound.

All the scale samples were taken from the mid-region of the body, below and slightly anterior to the origin of the dorsal fin. Most of the samples were taken from the left side of the body, but when this sampling area was found devoid of scales, the right side was used. When both of these areas were destitute of scales, the fish was discarded.

In the laboratory the scales were mounted by using the plastic impression method. Sheets of 50-gauge cellulose acetate (Lumarith), as used by Lowry (1951) for constructing nomographs, were cut into cards three inches wide by five inches in length. These cards were then marked off into fifteen one-inch squares. From four to six scales (the number depending upon the size of the scales) were arranged, sculptured side down, on each square inch of plastic surface. The plastic card was then placed between two ferrotype plates and subjected to heat and pressure from a hydraulic Carver Laboratory Press. A pressure of 12,000 pounds per square inch maintained for one and one-half minutes at 148° F. was found to be the most satisfactory for shad scales. Upon removal from the press, the scales are discarded and a clear impression of the scales remains in the plastic. Such a card will accommodate fifteen scale samples and they may be conveniently filed away for future reference.

The scales were then read using an Eberbach micro-projection machine at a magnification of 32X. Whenever possible four scales from each fish were read and the average of these readings was used in the back calculations. 12.70% of the shad were rejected from the study because of regenerated scales. The scales of the gizzard shad are des-

cribed very well by Lagler and Applegate (1942) as follows:

"The scales of the gizzard shad are cycloid and typically clupeoid. The exposed portion is generally devoid of surface sculpture except for the growth rings and annuli which may sometimes be discerned in this region. The circuli ... in the shad run across the scale from dorsal to ventral margin in a crescentric pattern, being concave posteriorly. Radii ... do not originate from the focus but arise irregularly from the imbedded area of the scale and intersect the two lateral, or the dorsal and ventral margins ...

The annuli ... are more or less concentric structure, apparently lying deep within the scale, which are always sub-parallel with the margin of the scale and pass through all fields, often including the exposed portion. The annulus is further characterized in the anterior field by the irregularity and discontinuity in the circuli themselves plus an apparent 'cutting over' of the circuli by the year mark."

PREVIOUS AGE AND GROWTH STUDIES OF THE GIZZARD SHAD

Very little work has geen done on the age and growth of the gizzard shad. The three most complete works are briefly summarized in the following paragraphs.

In 1942, Lagler and Applegate conducted a comparative study on the age and growth of the gizzard shad in two Indiana lakes. They found that the shad may be expected to attain an average total length of 7.6 inches in its second summer of life, 9.7 inches in the third summer, 10.5 inches in the fourth summer, 11.3 inches in the fifth summer, and 12.8 inches in the sixth summer.

In 1944, Eschmeyer, Stroud and Jones conducted a study of the fish

population of a TVA main-stream reservoir in Tennessee. They found the average length of one-year-old fish to be 7.0 inches in June, and the two-year-olds to be about 8.5 inches in April. They also determined the growth rate of young-of-the-year shad. They found that young shad, hatched in late May or early June, attained an average total length of $1\frac{1}{2}$ inches by the last week of June. By the middle of August the average length was $2\frac{1}{2}$ inches, and by late September they averaged $3\frac{1}{2}$ inches.

In 1951, Lagler and Van Meter made a study of the abundance and growth of shad in Beaver Dam Lake, Illinois. They found the average total lengths to be as follows for each age group. Age group I, about 6 inches; II, about 10 inches; III, about 12 inches; and IV, about 14 inches.

BOYD-SCALE RELATIONSHIP

The relationship between the total body length and the anterior scale radius (x32) was determined in order to find the necessary correction (a value) for the direct proportion calculated lengths. This correction factor is equal to the body length of the fish at the time of its scale formation, therefore, this value must be added to each scale reading to obtain the correct calculated lengths. The correction factor was found by plotting the data (Table 2) to the formula for a straight line. The formula for a straight line body-scale relationship is,

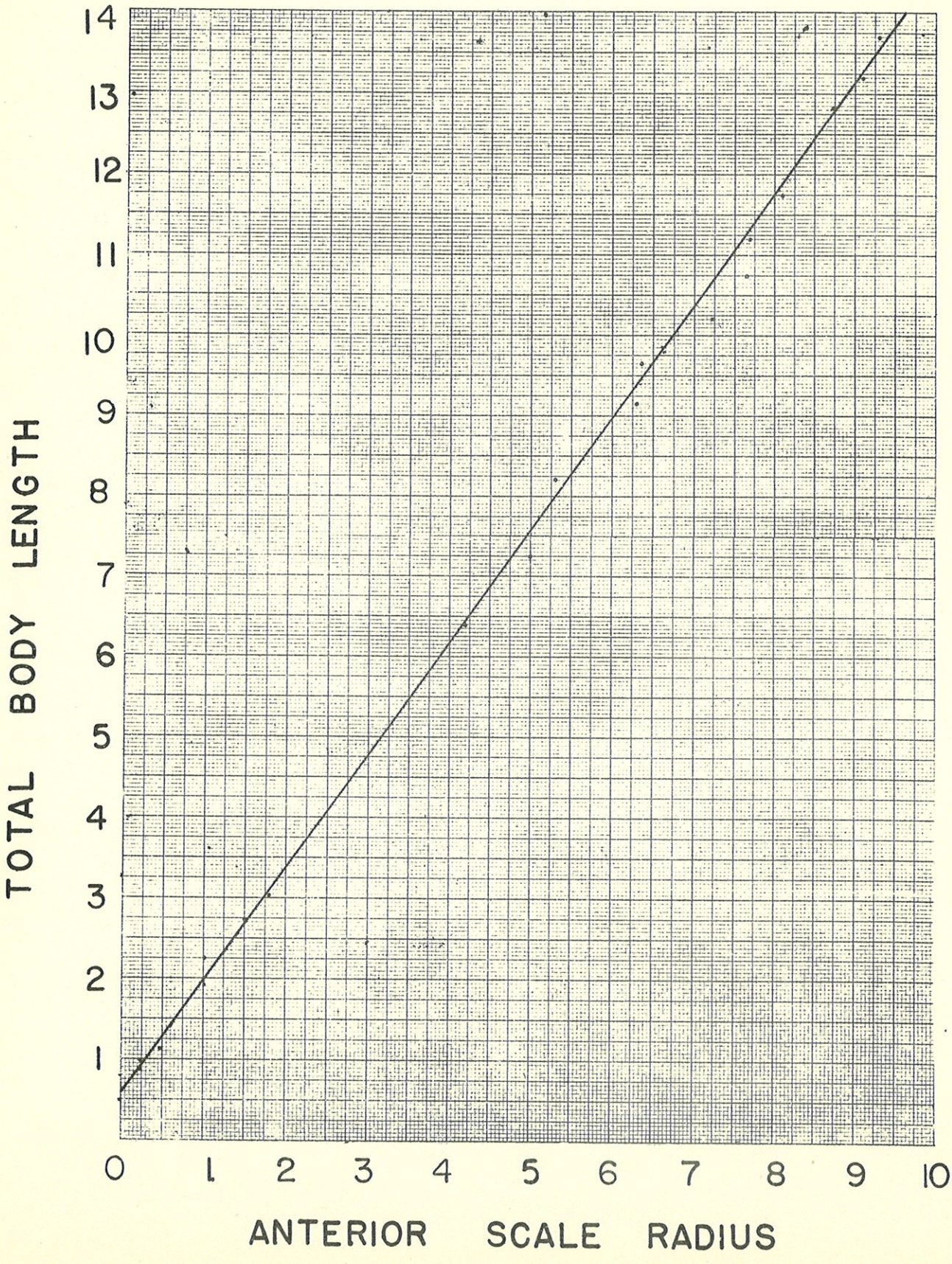
$$L = a + bS$$

where

L = total length of the fish
S = total scale radius
a and b = constants to be determined by solving the following equations simultaneously:

Figure I

BODY-SCALE RELATIONSHIP OF HERRINGTON LAKE GIZZARD SHAD



$$\Sigma L = na + b\ (\Sigma S)$$
$$\Sigma LS = a\ (\Sigma S) + b\ (\Sigma S^2)$$
$$n = \text{frequency}$$

The values for a and b were determined to be 0.57 and 1.40 respectively. Therefore, a regression line having an intercept of 0.57 (correction factor) and a slope of 1.40 was found to fit the plotted data (Fig. I). By substitution in the original equation, a straight line relationship L = 0.57+1.40S is obtained.

The direct proportion calculated lengths of the gizzard shad were corrected by the following formula:

$$Lx = \frac{Sx\ (L - 0.57)}{S} + 0.57$$

where

Lx = total length of the fish at time of formation of annulus x

Sx = scale radius at annulus x

L = total length of the fish

S = total scale radius

AGE COMPOSITION AND LENGTH - FREQUENCY

The age composition and length frequencies of the shad collected from Herrington Lake during July, 1953 are given in Table 3. It is indicated that the annulus is formed quite early in the spring. At this time the shad average 4.4 inches in total length. This accounts for the lack of fish between the lengths of 3.50 to 6.00 inches in the samples.

Table 2

Body-scale Relationship of 213 Herrington Lake Gizzard Shad Arranged by Average Total Lengths Based on 0.50-inch Intervals With all Age Groups Combined.

Average Total Length	Average Scale (x32) Measurement	Average LS	Average S^2	Number of fish n = 22
.93	.250	.231	.063	2
1.15	.492	.566	.242	10
1.94	1.080	2.095	1.166	3
2.26	1.082	2.445	1.171	13
2.72	1.497	4.072	2.241	13
3.05	1.800	5.490	3.240	2
6.40	4.130	26.432	17.051	1
7.25	4.980	36.105	24.800	1
7.75	5.104	39.556	26.050	10
8.23	5.298	43.603	28.068	13
8.70	5.867	51.043	34.421	4
9.16	6.360	58.258	40.449	6
9.65	6.350	61.278	40.322	5
10.20	7.230	73.746	52.273	1
10.76	7.623	82.024	58.110	4
11.21	7.675	86.037	58.905	4
11.73	8.177	95.916	66.863	10
12.28	8.421	103.410	70.913	21
12.83	8.711	111.762	75.881	52
13.18	9.130	120.333	83.356	30
13.69	9.300	127.317	86.490	6
14.05	9.625	135.231	92.640	2
Total				
179.12	120.18	1266.95	864.72	213

Table 3

Age Composition and Length-Frequency Distribution of 213 Herrington Gizzard Shad Collected in July, 1953.

Total Length in 0.50 inch intervals	Age Group 0	I	II	III	IV	V	Frequency	%
.50 - .99	2						2	.9
1.00 - 1.49	10						10	4.7
1.50 - 1.99	3						3	1.4
2.00 - 2.49	13						13	6.1
2.50 - 2.99	13						13	6.1
3.00 - 3.49	2						2	.9
6.00 - 6.49		1					1	.5
7.00 - 7.49		1					1	.5
7.50 - 7.99		10					10	4.7
8.00 - 8.49		13					13	6.1
8.50 - 8.99		4					4	1.9
9.00 - 9.49		6					6	2.8
9.50 - 9.99		5					5	2.3
10.00 -10.49			1				1	.5
10.50 -10.99			4				4	1.9
11.00 -11.49			4				4	1.9
11.50 -11.99			2	8			10	4.7
12.00 -12.49				21			21	9.9
12.50 -12.99				51	1		52	24.4
13.00 -13.49				9	21		30	14.1
13.50 -13.99					5	1	6	2.8
14.00 -14.99						2	2	.9
Total	43	40	11	89	27	3	213	100.0

INCREMENTS OF GROWTH

The shad were not sexed during this study, so no data concerning differential growth rate between the sexes can be given. The annual increment of growth, shown in Table 4, is for both sexes combined. The growth rates for the gizzard shad in Herrington Lake are, with the exception of the first year, about comparable to other populations. For a comparison of the growth of gizzard shad in Herrington Lake with other localities, see Table 5.

Table 4

Average Calculated Lengths and Annual Length Increment in Inches for Herrington Lake Gizzard Shad Collected in July, 1953.

Age Group	Number of Fish	Average Total Length at Capture	Calculated Length at end of year of life				
			1	2	3	4	5
0	43	2.09					
I	40	8.41	4.82				
II	11	11.02	4.82	8.62			
III	89	12.55	4.11	7.41	10.10		
IV	27	13.30	4.38	7.73	10.39	12.45	
V	3	14.00	3.80	7.62	10.60	12.39	13.37
Grand Av. and Total:	213		4.38	7.84	10.36	12.42	13.37
Increments of Growth			4.38	3.46	2.52	2.06	.95
Number of Fish			170	130	119	30	3

Table 5

Comparison With Growth Rates of Gizzard Shad from other Localities

Locality	Number of Specimens	Calculated Total Length in Inches at End of Year of Life				
		1	2	3	4	5
Foots Pond, Indiana Lagler & Applegate (1942)	274	7.6	9.9	10.6	11.3	13.9
Grassy Pond, Ind. Lagler & Applegate (1942)	202	7.7	9.1	10.3	11.3	11.8
Beaver Dam Lake Ill. Lagler & Van Meter (1951)	259	6.2	10.3	12.1	14.0	
Herrington Lake, Kentucky	213	4.4	7.8	10.4	12.4	13.4

LENGTH - WEIGHT RELATIONSHIP

In plotting the length-weight relationship of the Herrington Lake gizzard shad, 244 specimens were used. The logarithmic equation from Beckman (1948) was used, and is stated as follows:

$$\text{Log } C = \frac{\log W \cdot \Sigma(\log L)^2 - \Sigma \log L \cdot \Sigma(\log L \cdot \log W)}{N \cdot \Sigma(\log L)^2 - (\Sigma \log L)^2}$$

By substituting the data arranged in Table 6 into the above equation a value of - 0.45395 = log C is obtained. This value is now put into the following equation:

$$n = \frac{\log W - (N \cdot \log C)}{\text{Log } L}$$

$$n = 2.9697$$

LENGTH-WEIGHT RELATIONSHIP OF
HERRINGTON LAKE GIZZARD SHAD

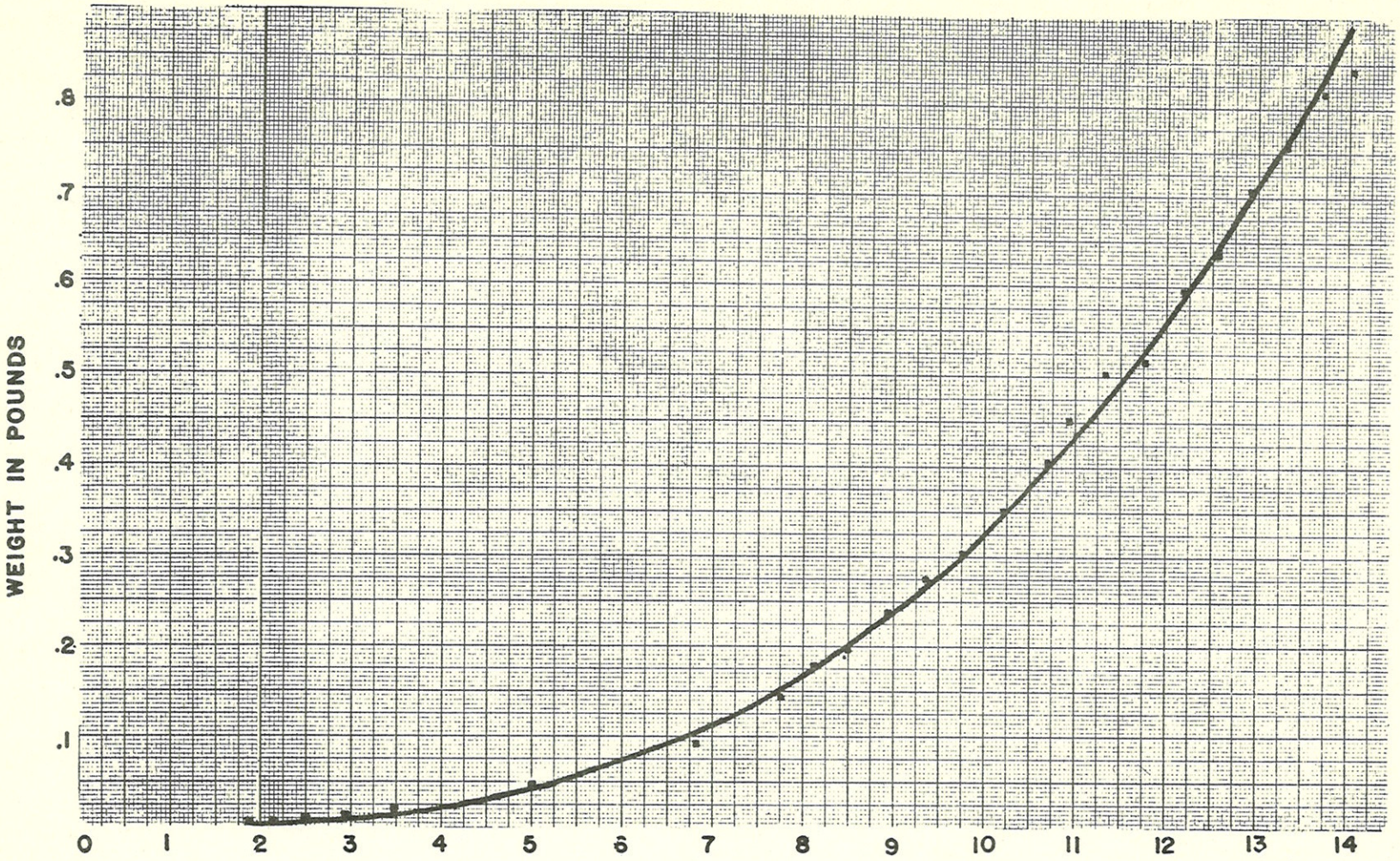


Figure II

The resulting equation for the length-weight relationship is Log W = 3.45395 + 2.9697 Log L. See Fig. II for graph. The weights of Herrington Lake gizzard shad are just slightly less than those found by Lagler and Van Meter (1951) in Beaver Dam Lake, Illinois.

Table 6

Length-Weight Relationship of 244 Herrington Lake Gizzard Shad Arranged by Mean Total Lengths Based on 0.4 inch Intervals

Mean Length in Inches	Mean Weight in Pounds	Log L.	Log (W x 1000)	Log L x Log W	$(\text{Log L})^2$	No. of Fish
1.90	.0026	.2788	.4150	.1157	.0777	2
2.15	.0033	.3324	.5185	.1723	.1105	11
2.51	.0053	.3997	.7243	.2895	.1598	9
2.87	.0081	.4579	.9085	.4160	.2097	9
6.83	.0900	.8344	1.9542	1.6306	.6962	2
7.75	.145	.8893	2.1614	1.9221	.7908	10
8.14	.173	.9106	2.2380	2.0379	.8292	9
8.50	.198	.9294	2.2967	2.1345	.8638	6
8.94	.224	.9513	2.3502	2.2357	.9050	5
9.35	.276	.9708	2.4409	2.3696	.9425	5
9.75	.307	.9890	2.4871	2.4597	.9781	3
10.20	.350	1.0086	2.5441	2.5660	1.0173	1
10.68	.410	1.0286	2.6128	2.6875	1.0580	2
10.93	.503	1.0386	2.7016	2.8059	1.0787	3
11.31	.556	1.0535	2.7451	2.8920	1.1099	5
11.76	.539	1.0704	2.7316	2.9239	1.1458	9
12.18	.592	1.0856	2.7723	3.0096	1.1785	12
12.55	.636	1.0986	2.8035	3.0799	1.2069	48
12.90	.678	1.1106	2.8312	3.1443	1.2334	44
13.31	.756	1.1242	2.8785	3.2360	1.2638	21
13.69	.816	1.1364	2.9117	3.3089	1.2914	8
14.05	.840	1.1477	2.9243	3.3562	1.3172	2
Total		19.8464	48.9515	48.7941	19.4642	244

DISCUSSION

The growth of the gizzard shad in Herrington Lake is fairly comparable to that of populations studied elsewhere, with the exception of the first year of life. In other localities this species has been reported as averaging about seven inches in total length at the time of the formation of the first annulus. The Herrington Lake gizzard shad form their first annulus at an average length of 4.4 inches. Whether or not this is due to the density of the population cannot be determined, but no correlation is apparent between the first year's growth of the several year classes (Table 4) and the percentage of weight of the total population which this species comprised during the same years (Table 1). This comparatively slow growth during the first year of life makes individuals of this species available as forage longer than previously suspected.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to the entire staff of Kentucky's Department of Fish and Wildlife Resources, Division of Fisheries. I especially thank Messrs. William A. Tompkins, Mercer M. Peters, Bernard T. Carter, and Lewis M. Gerow for their assistance in many ways.

LITERATURE CITED

Beckman, William C. 1948. The length-weight relationship, factors for conversions between standard and total lengths, and coefficients of condition for seven Michigan fishes. Trans. Amer. Fish. Soc., 75 (1945): 237 - 256, 7 figs.

Carter, B. T. 1953. A report on the fish populations of Cumberland Lake during the third year of impoundment. Special Report # 102, Ky. Div. of Fisheries. 16 pp.

Eschmeyer, R. W., Stroud, R. H., and A. M. Jones. 1944. Studies of the fish population on the shoal area of a TVA main-stream reservoir. Jour. Tenn. Acad. Sci., 19 (1) pp. 70 - 112.

Lagler, K. F. and V. C. Applegate. 1942. Age and growth of the gizzard shad, Dorosoma cepedianum (LeSueur), with a discussion of its value as a buffer and as forage of game fishes. Invest. of Ind. Lakes and Streams, 2 (6): 47 - 72 pp. 99-110.

Lagler, K. F. and H. Van Meter. 1951. Abundance and growth of gizzard shad, Dorosoma cepedianum (LeSueur), in a small Illinois Lake. Jour. Wildlife Mgt., 15 (4)pp.357-360.

Lowry, E. M. 1951. A nomograph for rapid back-calculation of fish lengths. Prog. Fish-Cult. 13 (4) pp. 199-205.

Tompkins, W. A. and M. M. Peters. 1951. The age and growth of the white bass, Lepibema chrysops, of Herrington Lake, Kentucky. Ky. Fish. Bull. #8, 12 pp.

Wickliff. E. L. 1945. Food of the gizzard shad. Ohio Fish Mgt. Leaflet # 184, 4 pp.