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AGE AND GROWTH OF THE GIZZARD SHAD (Dorosoma lacepedi) (Lesueur), IN LAKE NEWNAN, FLORIDA

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Fish population sampling in many Florida lakes by the Florida Game and Fresh Water Fish Commission had indicated a very high concentration of gizzard shad, *Dorosoma lacepedi* (Lesueur).† The use of control measures for this species was suggested by the implications that the gizzard shad was successfully competing for space and other essential factors with species of game fish and was absorbing a large amount of the potential productivity in the lakes concerned into a non-utilizable biomass. The Florida Commission began an investigatory program of haul seining of Lake Newnan, Florida, in October, 1953, that incidentally furnished a source of specimens for an age and growth study of the gizzard shad.

Lagler and Applegate (1942), working with gizzard shad from two ponds in Indiana, were the first to determine the age of this species by the structure of their scales. Lagler and Van Meter (1951) determined the growth rate of gizzard shad from Beaver Dam, Illinois, by scale analysis. Turner (1953) furnished similar information from Herrington Lake, Kentucky. Warner (1940) described the eggs, hatching, and early larvae of the shad. Since completion of the present work, Bodola (1955) has written a very inclusive life history study of the gizzard shad.

Interpretation of scale structure of fish from warm Florida waters was first successfully treated by Huish (1954), working with the black crappie, *Pomoxis nigromaculatus* (Lesueur), in Lake George, Florida. Caldwell and others (1957) commented upon the scale structure of the stumpknocker, *Lepomis punctatus punctatus* (Valenciennes), and the Florida largemouth bass, *Micropterus salmoides floridanus* (Lesueur), from Silver Springs, Florida.

I am grateful to personnel of the Florida Game and Fresh Water Fish Commission for assistance in the field work of this investigation, especially to Melvin T. Huish, and to Harold Moody, Wayne Hook, and George Horel; to members of the University of Florida for direction and help in laboratory analyses and compilation of data, Benjamin B. Leavitt, Coleman J. Goin, David K. Caldwell, and Edward Pete Crittenden; and to William W. Anderson and Jack W. Gehringer, U. S. Fish and Wildlife Service, for review of the manuscript.

METHODS

Gizzard shad were taken for study by haul seine, bag seine, otter trawl, dip net, and rotenone. Body lengths were recorded to the nearest millimeter. Standard length (S.L.) was measured from the tip of the snout to the caudal base (the end of the hypural bones). Total length (T.L.) was measured from the tip of the snout to the tip of the caudal fin with the caudal lobes pressed together.

Scale samples were taken from the area under the tip of the pectoral fin with the fin pressed in normal position against the body. Usually 6 to 20 scales were sampled. The high percentage of regenerated and misshapen scales that were encountered (due to the extreme deciduousness of the scales of smaller shad)

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† The use of this specific name, rather than *D. cepedianum* as constructed by Lesueur, concurrs with the Copenhagen Decisions on Zoological Nomenclature that specific names based on modern surnames that do not consist of the exact surname must be corrected.

were discarded. Scales resembling the shape of that illustrated in figure 1 were selected for analysis. The scales were projected onto a flat surface 9½ feet distant from the projector, producing a magnification of 22.7 times the scale diameter. The anterior scale radius, a perpendicular from the focus at the center of the basal transverse groove to the anterior scale margin, was measured for calculation of the body-scale relationship and the back calculation of body lengths.

The system proposed by Hile (1941), recognizing January 1 as a universal fish birthday, is used. The year of life in which a fish was living is referred to as a calendar year—this follows Hile's system. The years of life that a fish had existed are referred to as actual years.

GROWTH OF LARVAE AND EARLY JUVENILES

Attempts to produce viable young through artificial fertilization by stripping failed in all but one attempt. From eggs and milt stripped on March 26, 1955, hatched larvae were noted in the laboratory five days (119.5 hours) later. The last specimen from this group was taken six days (149 hours) later. The larvae were not seen hatching, but one half of those swimming in the aquarium at each collection period were removed. The aquarium temperature remained around 71° F. Gizzard shad larvae observed by Warner (1940) hatched 95 hours after fertilization at 62° F. and others hatched in 36 hours at 80° F. Larvae of the first collection were similar to Warner's description of one-day-old fish, and those of the last two collections were like his three-day-old fish, but the average lengths were not in agreement. The mean size of the larvae hatched from eggs from Lake Newnan decreaased during the period of collection (Table I), but the cause of this feature is unknown.

TABLE I

TOTAL LENGTH IN MILLIMETERS AT TIME OF PRESERVATION OF 17 LARVAL GIZZARD SHAD HATCHED FROM ARTIFICIALLY FERTILIZED EGGS

	Time (in Hours) Between Fertilization and Preservation				
	119.5	*125.5*	*129.0*	*142.5*	*149.0*
Mean Size (mm.)	5.30	5.23	5.22	5.15	5.00
Range (mm.)	5.3	5.1–5.4	5.1–5.3	5.1–5.3	5.0
Number	2	3	5	6	1

Mean sizes and ranges of early juveniles taken in Lake Newnan are shown in Table II. Fingerling gizzard shad collected in 1954 were seined from inshore. Those obtained in 1955 were taken by dip net and rotenone out in the lake. These figures do not adequately depict growth rates of the young shad because of the prolonged spawning season (several months), and because as the shad reach 50 to 100 mm. S.L. they are taken less frequently inshore. However, they do furnish an idea of sizes of young-of-the-year shad present in the first three or four months following the peak of the spawning season.

TABLE II

EARLY JUVENILE GIZZARD SHAD COLLECTED IN LAKE NEWMAN IN 1954 AND 1955

	Date of Collection						
	1954					*1955*	
	May 5	*June 10*	*July 2*	*July 13**	*July 13†*	*April 1*	*April 18*
Mean (mm.)	24.7	48.0	51.1	46.3	51.8	20.1	27.7
Range (mm.)	18–34	38–80	30–87	36–62	33–85	15–23	16–41
Number	227	75	81	22	185	1,290	167

* Seined at Prairie Creek, south end of lake.
† Seined at Palm Point, near middle of west shore of lake.

SCALE CHARACTERISTICS

Some of the difficulties encountered in interpreting the scale structures of fish from Florida waters have been discussed by Huish (1954) and Caldwell and others (1957). Because certain features of the scales of the gizzard shad from

Lake Newnan have not been discussed and apparently were not encountered by other workers considering scales of this species, a detailed description of the scales and of the interpretations made of the scale structures is given.

The distinguishing lepidological features of the family Clupeidae were outlined by Lagler (1947). The following description of the scales of the gizzard shad is modified from that of Lagler and Applegate (1942) to illustrate interpretations of the present study (see Figures 1 and 2).

The scales are cycloid and typically clupeoid. The exposed portion (posterior field), not covered by the outer part of the dermal scale pocket, is devoid of surface sculpture except for occasional growth rings and irregular deep-set lines resembling radii. Modifications in the occurrence and appearance of circuli and radii occur with growth. Radii on the imbedded portion of scales of the Atlantic shad, *Alosa sapidissima* Wilson, were termed transverse grooves by Borodin (1925), and this terminology is used here.

On the scales of small shad (about 30 to 40 mm. in standard length) a nearly straight dorso-ventral basal, transverse groove is located at the division of the exposed portion and that part of the scale covered by the scale pocket (the imbedded portion). The circuli or ridges formed by the scale pocket intersect the dorsal and ventral margins; those adjacent to the basal transverse groove are parallel to it, while those toward the anterior margin tend to become concentric, being concave posteriorly. In continued formation with growth of the scale, the circuli assume a more crescentric arrangement.

Figure 1. Scale of an age group IV female gizzard shad, 289 mm. S. L., approaching its fourth year of life, taken February 22, 1955, from Lake Newnan.

On the scales from larger fish (above 50 to 75 mm.) the outer margin of the scale pocket, and, consequently, the circuli always extend posteriorly to the ends of the basal transverse groove. However, in the central portion of this groove the margin of the pocket (and the circuli) may variously lie to the anterior or posterior of the groove, or may coincide with it (this last as on the scales of smaller fish). In the case of circuli occurring posterior to the center of the groove, the appearance is wavy and distorted, as if they had been recently formed in this area. When occurring anteriorly, the space between the groove and the edge of the pocket shows evidence of previously existing circuli. Interpretation of the variations given above indicated that the midpoint of the basal transverse groove should be considered as the focus of the scale. This estimated point was used here in measurements of the anterior radius. Additional transverse grooves arise irregularly from the imbedded area of the scales of larger fish and extend inward from the dorsal or ventral margins. Although the number of these secondary transverse grooves tends to increase with the size

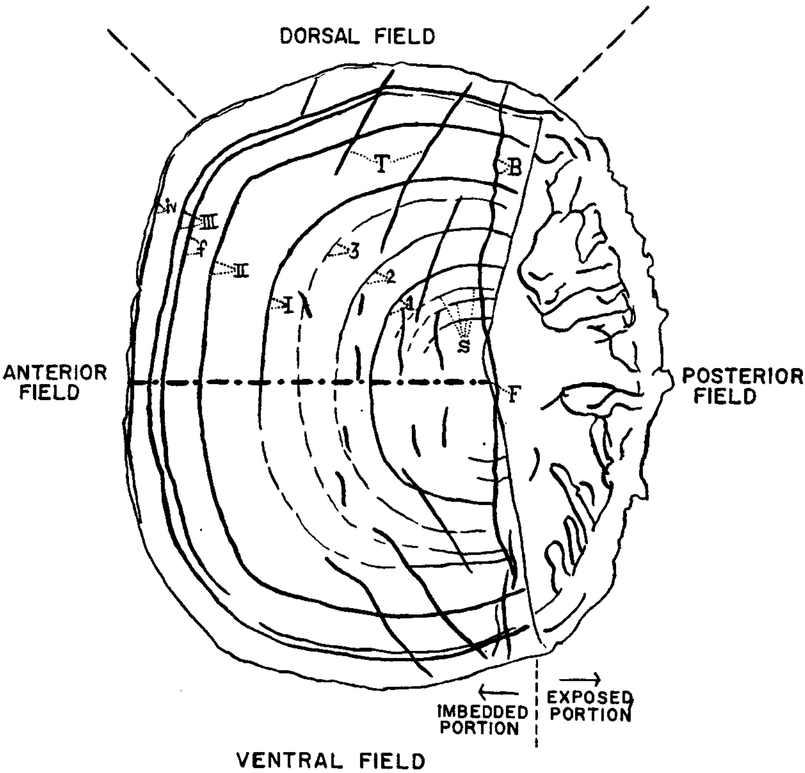

Figure 2. Outline of scale of figure 1, indicating position of growth rings and scale terminology. 1, 2, and 3, first, second, and third primary growth rings. I, II, and III, first, second, and third annuli. iv, fourth annulus beginning formation. f, false annulus. F, focus. S, sub-primary growth rings. T, transverse grooves. B, basal transverse groove. Line of dots and dashes, measurement for anterior radius.

of the scale (and size of the fish), the number and arrangement is not consistent on different scales taken from a single fish. On the scales of some fish, short marks of the same appearance as transverse grooves occur irregularly scattered on the imbedded portion, usually with a general dorso-ventral arrangement.

Growth rings were recognized as variations in the usual close-set pattern of circuli. Growth rings effect a cutting-over of circuli in the lateral (dorsal and ventral) fields. In the anterior field they appear as narrow zones devoid of circuli. Circuli immediately anterior to a growth ring are more widely spaced than those posterior to the ring. They become more closely spaced toward the anterior margin of the scale or the next growth ring. Four types of growth rings were recognized:

1. *Annuli* (yearly growth rings) were differentiated from other growth rings (except false annuli, see below) by their wider zone between circuli, especially in the anterior field of the scale. The maximum number of annuli seen on any scale was three. On some scales with more than one annulus, the first annulus was not clearly marked, but could be designated by its positional relationship to the three primary growth rings (see below). Some fish apparently fail to form the first annulus—these were generally in the lower portion of the size range of fish possessing one annulus.

2. *False annuli* were observed on a small portion of the scales. Some of these effected as wide a spacing between the circuli as did the annuli. They appeared—no more than one to a scale—in very close proximity to an annulus, and were differentiated from the annulus by positional relationship.
3. *Primary growth rings* effect a less pronounced cutting over of circuli in the dorsal and ventral fields and a narrower spacing between circuli in the anterior field than the annuli. Three primary growth rings are formed on scales of fish between about 85 and 175 mm. S.L. (4.5-9.0 ins. T.L.); the number is directly related to the size of the fish; and their positional relationship is relatively constant. The first of these rings forms when the fish is about 85-90 mm. in standard length and usually persists on the scales of larger fish, but the second two primary growth rings are usually erroded off or overgrown on scales of fish with two or three annuli.
4. *Sub-primary growth rings* form on scales of fish between about 30 and 85 mm. S.L. (1.5-4.5 ins. T.L.). Five rings are usually present on scales of 35 mm. fish, and 12 on scales of 105 mm. fish. The number of these rings generally increases with the increase in the size of the scale within these limits. Their presence is marked by more of a bending or distortion of circuli in the dorsal and ventral fields than a cutting-over effect, and by a very narrow space between circuli in the anterior field. They tend to disappear (from the focus outward) with scale growth, and only a few of the latest formed of these rings remain visible on scales of fish with more than one annulus.

The validity of interpretation of the first annulus as a mark produced at the end of the first year of life has been given by Lagler and Van Meter (1951) and by Bodola (1955). A special problem was encountered in this study as to which of the supernumerary growth rings should be designated as the first annulus. This was determined through analysis of the different sizes of gizzard shad present in the lake at different times of the year. The first primary growth ring, with its persistent annulus-like appearance, was well formed on scales of young-of-the-year shad taken in September and October, 1954. Fish of age group I, collected during this period, had the first three primary growth rings as well as the first annulus formed on the scales. Since it was known that the collections made at this time which were designated as young-of-the-year fish comprised a size range with a modal value well separated from that of older and larger shad present in the lake (even the size ranges were distinct in September, see Figures 5 and 6), the primary growth rings were obviously formed during the first year of life.

It is possible that an innate physiological action rather than an environmental effect may be responsible for the formation of the primary growth rings, because their formation may occur during at least seven months of the year, and the number of rings that have formed is related more to the size of the fish than to the season of the year.

Analysis of a collection of shad taken February 22, 1955, by haul seine further illustrates the growth ring interpretation (Table III). Fish of age group I, in their second calendar year of life, had no annulus, but all possessed the three primary growth rings. Fish in age groups II, III, and IV had, respectively, 1, 2, and 3 annuli. This collection effected a complete size separation between age groups I and II, and an overlap in the size ranges of age groups II, III, and IV. A larger sample taken in February of any year might be expected to produce an overlap in the size range of age groups I and II. They would logically be expected to overlap for the remainder of any year, and possibly extremes of the two age groups might overlap as early as January.

The percentages of the total specimens in Table III are biased due to net selectivity. The 2- to 3-inch stretched mesh of the haul seine did not capture the smaller sizes of shad (below about 150 mm. S.L) in quantities representative to the larger and older shad, and shad below 95 mm. S.L. were not recorded from the haul seine catch. The mean length for age group I would actually have been smaller than depicted in Table III. The relative numbers of age groups II, III, and IV are believed to have been characteristic of the lake's population at that time.

TABLE III

SIZES OF AGE GROUPS DETERMINED BY SCALE ANNULI OF MALE AND FEMALE GIZZARD SHAD, TAKEN BY HAUL SEINE, FEBRUARY 22, 1954

Age Group	*I*	*II*	*III*	*IV*
Calendar Years of Life	*2*	*3*	*4*	*5*
Females:				
Mean Standard Length (mm.)	136.2	238.6	264.5	286.0
Size Range (mm.)	107–180	185–268	256–273	277, 295
Number of Specimens	73	67	6	2
Percent of Total	49.3	45.3	4.1	1.3
Males:				
Mean Standard Length (mm.)	143.5	227.4	246.0	252.0
Size Range (mm.)	115–170	204–250	229–255	252
Number of Specimens	52	83	6	1
Percent of Total	36.6	58.5	4.2	.7

TIME OF ANNULUS FORMATION

Annuli were first noted in the beginning of formation in a few scales from samples taken in late February, 1954 and 1955. Newly formed annuli were observed on some of the samples taken in March, 1954 and 1955. By April of both years all scales examined of fish of age groups II and III had completed formation of new annuli. No fish of age group IV with four completely formed annuli were examined. The small percentage of fish of age group I that had not completed annulus formation by June, 1954, tended to remain constant in samples taken during the remainder of the year, indicating that no formation of the first annulus would occur in these fish.

By contrast, Bodola (1955) found annuli of younger shad to form earlier than those of older shad, and annulus formation began in June and was completed by early July.

BODY-SCALE RELATIONSHIP

The relation of the size of the scale (measurement of the anterior radius at a magnification of 22.7) to the length of the fish (measured in millimeters of standard length) was determined to fit the following standard equation:

$$L = a - bS$$

$$\text{Standard length} = 22.75 - (1.83 \times \text{Scale radius})$$

This is illustrated in Figure 3. Measurements of 538 shad from 21 to 295 mm. S.L. were used in establishing this relationship. No changes were evident in the body-scale relationship with the onset or development of sexual maturity.

CALCULATED ANNUAL GROWTH

A nomograph, similar to that suggested by Carlander (1944), was used to determine body lengths that had been attained at the formataion of the various annuli. Sample comparisons of values obtained by this method and by calculation from Lee's formula (1920) were very similar. The compilation of this data is given in Table IV and Figure 4. These values indicate that the population of Lake Newnan gizzard shad average a standard length of about 193 mm. at the end of their first actual year of life, about 241 mm. at the second year, and about 258 mm. at the end of the third year.

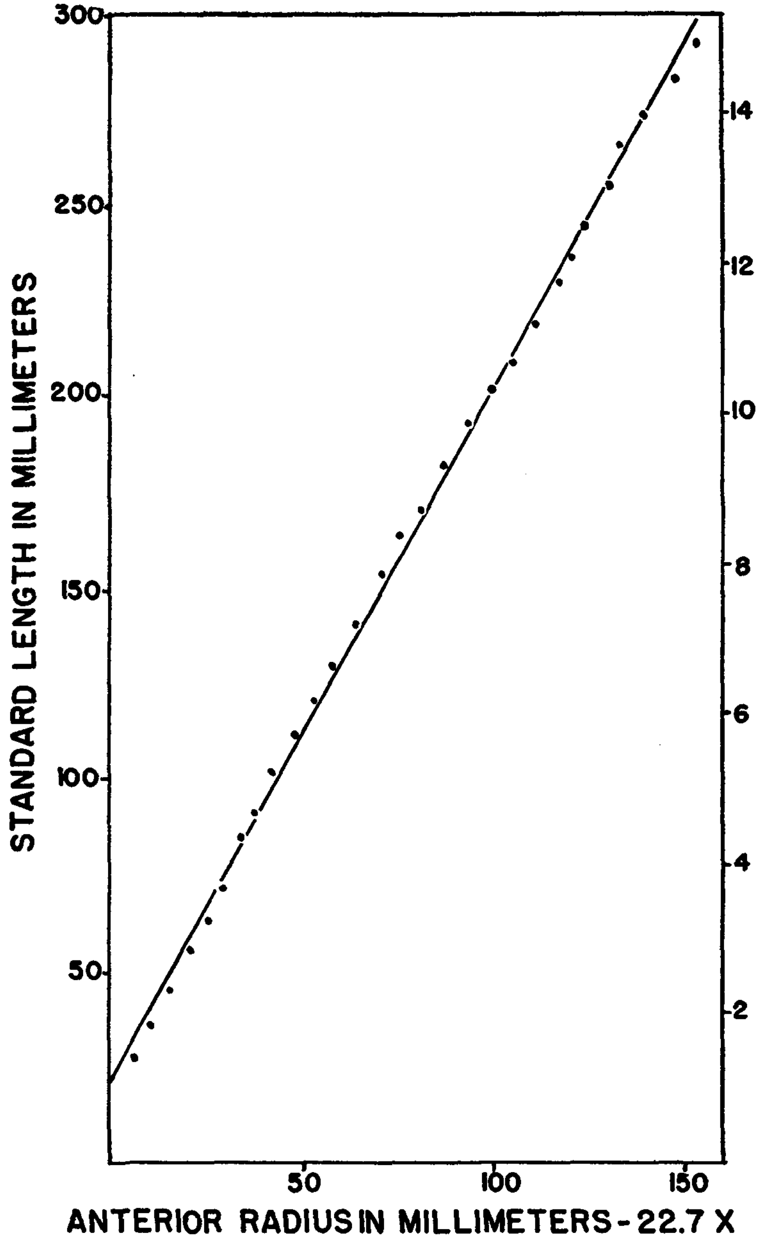

Figure 3. Body-scale relationship of Lake Newnan gizzard shad. The dots are plotted from means of 10 mm. size groups. The best fit line was determined from the regression formula.

TABLE IV

MEAN CALCULATED STANDARD LENGTHS AND ANNUAL LENGTH INCREMENTS IN MILLIMETERS AT THE END OF EACH YEAR OF LIFE OF MALES, FEMALES, AND SEXES COMBINED OF LAKE NEWNAN GIZZARD SHAD COLLECTED FROM FEBRUARY, 1954 THROUGH APRIL, 1955

Age Group	*No. of Fish*	*Mean Std. Length at Capture*	*Length at End of Actual Year of Life* 1	2	3
		Females			
I	148	233.8	194.6	....	....
II	36	264.3	202.9	247.6	....
III	11	275.1	197.3	234.9	259.6
Mean Standard Length	...	....	196.3	244.6	259.6
Mean Length Increment	...	....	196.3	48.3	15.0
Number of Fish	...	....	195	47	11
		Males			
I	140	224.0	189.6	....	....
II	13	243.9	190.0	228.9	....
III	1	252.0	181.0	211.0	239.0
Mean Standard Length	...	....	189.6	227.6	239.0
Mean Length Increment	...	....	189.6	38.0	11.4
Number of Fish	...	....	154	14	1
		Sexes Combined			
I	228	229.0	192.2	....	....
II	49	258.9	199.5	242.6	....
III	12	273.2	195.9	232.9	257.9
Mean Standard Length	...	....	193.4	240.7	257.9
Mean Length Increment	...	....	193.4	47.3	17.2
Number of Fish	...	....	349	61	12

LENGTH FREQUENCIES OF THE HAUL SEINE CATCH

Length frequencies of gizzard shad caught in the haul seine are shown in Figure 5. Two factors are primarily responsible for the differences depicted between the size compositions of the first four months of 1954 and the corresponding months of 1955: A seine with a pocket of 3-inch stretched mesh used into April, 1954, did not catch representative numbers of the smaller sized shad present in the lake that were taken by the 2-and 2½-inch mesh used later; and sample measurements for January, February, June, July, and August, 1954, were taken on smaller numbers of fish (50 to 150), while measurements on 250 to 1,500 fish comprised the samples for the other months. The bimodality expressed by the graph for September, 1954 is not indicative of the total population for that month—this also because of net selectivity.

The mode on the left side of the graph for September, 1954 is composed of fish born in 1954 and can be followed through April, 1955. The mode on the right side of the September, 1954 graph is largely produced by fish born in 1953. The numbers of older fish—in reference to this figure, those born in 1952 and earlier—comprised only a small percentage of the total caught, and their size range overlapped that of the fish born in 1953 so that their values did not produce a distinct mode.

ESTIMATED MODAL LENGTHS OF THE POPULATION

Figure 6 depicts the size range of each age group at the time scale samples were collected (from February, 1954 into May, 1955). From all of the data available, the modal growth of each age group was estimated throughout this period. This treatment does not consider possible differential growth rates during the parts of the two years considered, and it is not expected that the esti-

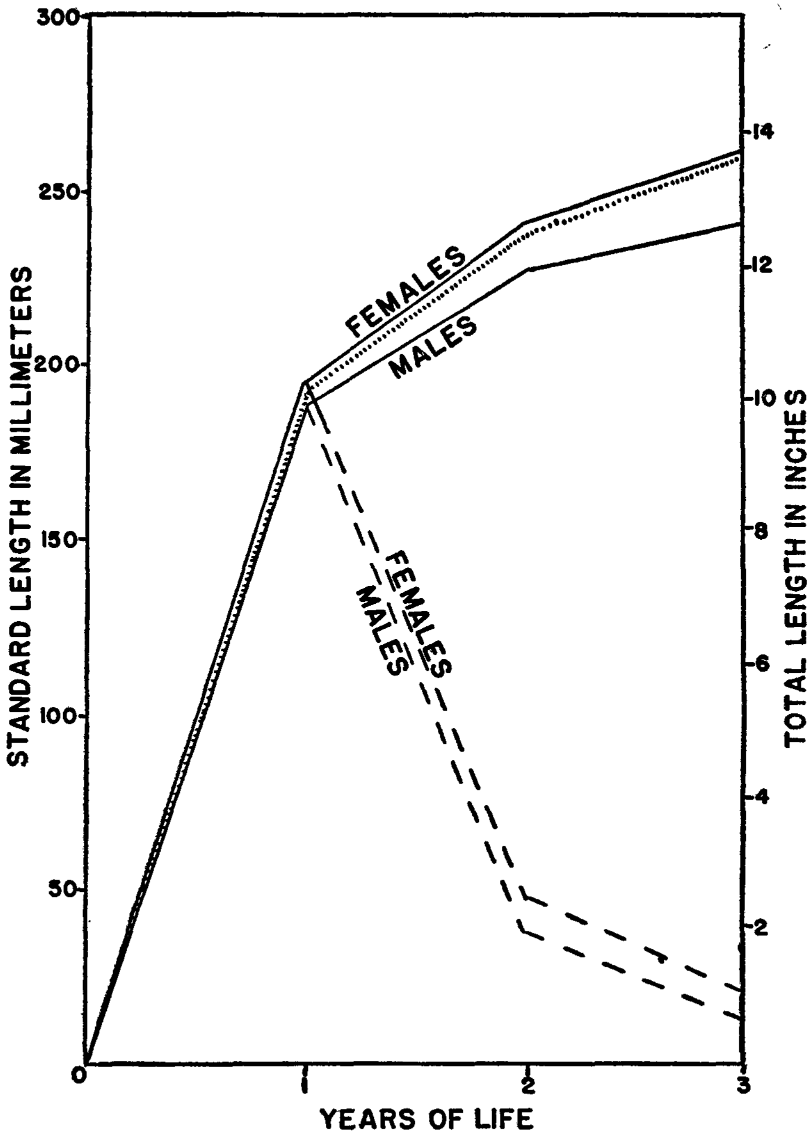

Figure 4. Mean calculated lengths of males and females (solid lines) and of combined sexes (dotted line) and average length increments of males and females (broken lines) of Lake Newnan gizzard shad.

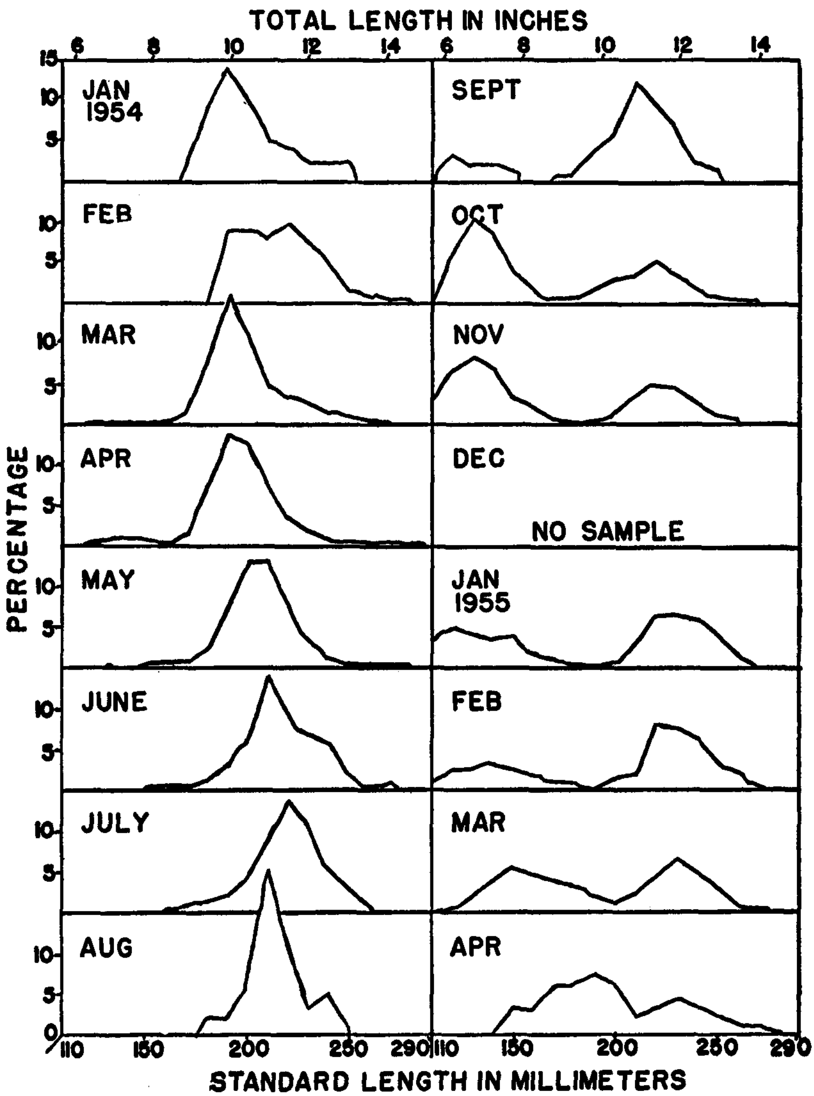

Figure 5. Length frequencies of the haul seine catch of Lake Newnan gizzard shad in percent of the sample measurements for each month.

mates are precisely accurate. It is sufficiently accurate, however, to indicate the modal size of each age group at different times of the year. For example, this figure allows the estimation of the greatest frequency of age group 0 shad present in the lake in mid-September to be at about 115 mm. S.L., that of age group I shad to be at about 200 mm. S.L., and so on.

COMPARISON WITH GROWTH REPORTED FROM OTHER AREAS

The comparison of yearly growth of gizzard shad from Lake Newnan with that recorded from other areas may be derived from the mean calculated lengths at the end of each year of actual life given in Table V. Lake Newnan gizzard shad are shown to have grown to a much larger size at the end of their first actual year of life than shad from the other areas. Lake Newnan's abundant food supply available to the shad and a long, favorable growing period may account for the major portion of this. The percentage of growth between the first and the second and between the second and the third actual years of life, however, was greater in shad from the other areas. Lake Newnan gizzard shad are shown to have a much shorter life span than those from the more northern waters.

TABLE V

MEAN CALCULATED LENGTHS OF GIZZARD SHAD FROM LAKE NEWNAN AND FROM OTHER AREAS. THE CORRESPONDING TOTAL LENGTH IN INCHES IS PLACED IN PARENTHESIS BELOW THE STANDARD LENGTH IN MILLIMETERS IN EACH BLOCK. CERTAIN OF THE LENGTHS INCLUDED HAVE BEEN CONVERTED FROM THE ORIGINAL DATA BY THE CONVERSION FACTORS GIVEN IN THE TEXT

Investigation and Locality	*No of Fish*	*Mean Cal. Length at End of Year of Life* 1	2	3	4	5	6
Turner (1953)	170	85.2	151.0	201.3	240.1	259.4	....
Herrington Lake, Ky.		(4.4)	(7.8)	(10.4)	(12.4)	(13.4)	
Jenkins, Leonard and Hall (1952)	81	87.1	209.1	276.8	313.6	334.9	....
Illinois River, Okla.		(4.5)	(10.8)	(14.3)	(16.2)	(17.3)	
Thompson (1950)	54	102.6	152.9	174.2	214.9	261.4	....
Grand Lake, Okla.		(5.3)	(7.9)	(9.0)	(11.1)	(13.5)	
Lagler and Van Meter (1951)	410	120.0	199.4	242.0	259.4	....	....
Beaver Dam, Ill.		(6.2)	(10.3)	(12.1)	(14.0)		
Bodola (1955)	1,131	137.7	279.2	320.6	354.3	358.0	320.0
Western Lake Erie		(7.1)	(14.4)	(16.6)	(18.3)	(18.5)	(16.5)
Berry	349	193.4	240.7	257.9	....	....	....
Lake Newnan		(10.2)	(12.4)	(13.4)			

Conversion factors for standard and total lengths were calculated from Lake Newnan specimens to facilitate the above comparisons. These are: To convert standard length in millimeters to total length in inches, multiply by 0.05163. To convert total length in inches to standard length in millimeters, multiply by 19.36000.

SEXUAL DIFFERENCES IN GROWTH

Table IV shows much larger numbers of females than males in age groups II and III. For these groups, and their corresponding size range, females were found to be appreciably more numerous than males in all collections made. The relative numbers of males and females of age group I varied appreciably in individual samples, but in an average of all collections the numbers were similar. This indicates that the males average a higher mortality than the females after the first actual year of life.

In Table III, giving lengths of males and females of a February collection, the males of age Group I—which were actually fish less than 12 months old—were larger than the females (this difference was statistically significant, furnishing a t value of 2.43). A collection of age group I fish taken April 18, 1955, contained 40 males with a mean size of 181.5 mm. S.L. and 62 females

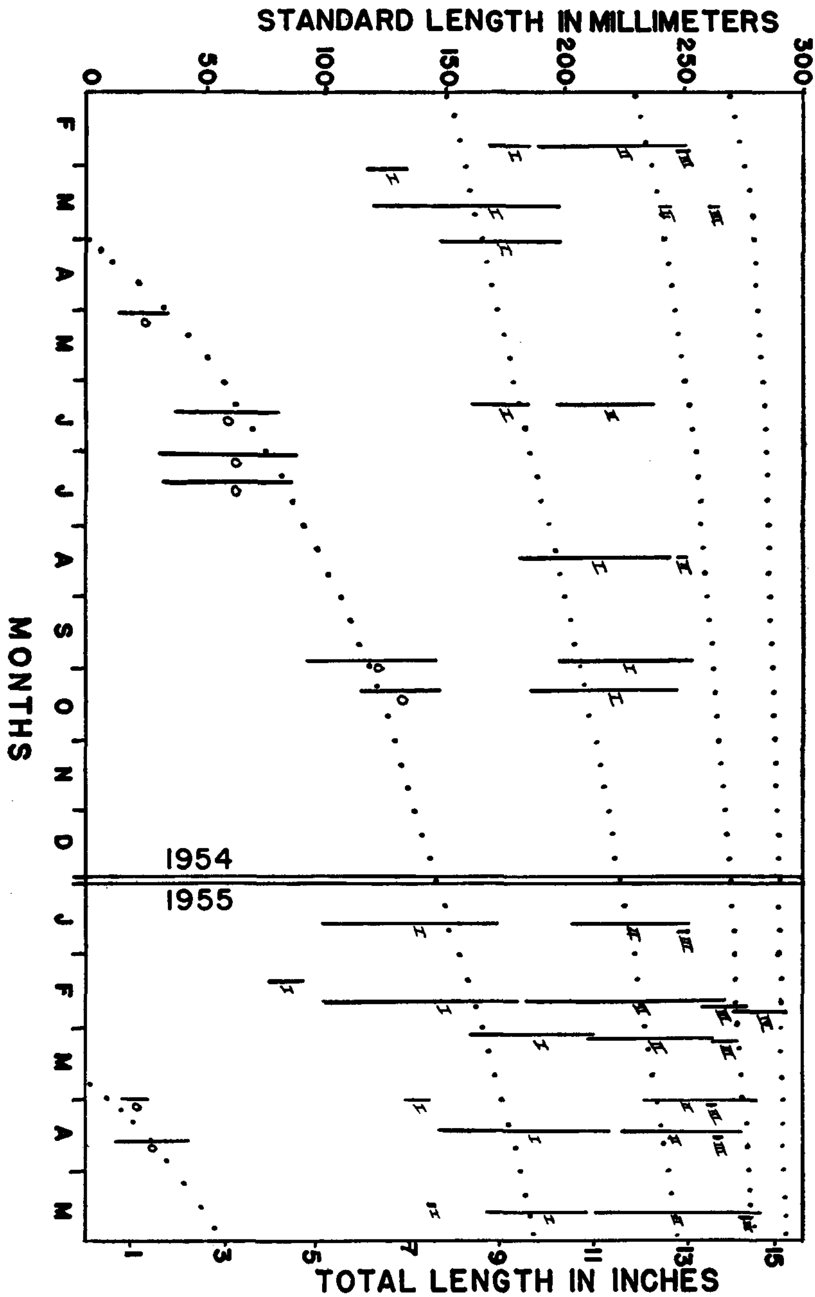

Figure 6. Size ranges of different age groups of gizzard shad (solid, vertical lines) from sample collections of February 1954 through May 1955, and estimated modal lengths of each age group (dotted lines) throughout the year.

of mean size 182.6 mm. S.L. (these fish were near the end of one actual year of life), in which the means were not statistically significant (t value, 0.3). The females of age group II of the February collection (Table III) were significantly larger than the males (t value, 5.86). Females of age groups II and III were observed to average a larger size than males of these age groups in all other collections. The above differencies indicate that the males have grown larger (and faster) than the females at some time during the first actual year of life, but that at about the end of the first actual year of life the females have compensated for this growth so that the mean sizes of the two sexes are similar. The females then continue to grow faster and average a larger size.

Table IV, giving lengths back calculated from the scales of older fish, shows the mean standard length of females to be greater than that of the males at the end of the first actual year of life. This change from lengths of near similarity in mid-April (above) must occur in late April or May.

It was observed in sample measurements and proven statistically for the February collection that the variation in size ranges of males was less than that of the females.

SPAWNING AND MORTALITY

The first evidence of the gizzard shad's spawning in 1954 and 1955 was observed in March. The gonads of some shad were appreciably enlarged in January of both years, and spawning may possibly have occurred in February. Examination of the gonads showed that the peak of spawning occurred around the end of March and the beginning of April of both years and was essentially completed by mid-May, as indicated by the high percentage of spent individuals. Immense numbers of eggs observed around the lake shore adherent to submerged cypress roots, moss fibers, and debris were largely gizzard shad eggs, but a portion of these came from spawning by the threadfin shad, *Dorosoma petenense* (Günther), which appears to have a later peak of spawning in the lake, in late April or May.

All shad with ripe or near-ripe gonads observed from January through March were in age groups II, III, and IV. One male of age group I was found with enlarged testes in April, and several age group I males and females with enlarged gonads were recorded in early May.

An appreciable decline in the percentages of older fish (age groups II, III, and IV) became apparent in the March and April, 1955 collections (see Figure 5). In 1954 a decrease in numbers of large shad over 250 mm. S.L. was noted to occur between April and August. It is believed that the yearly mortality of age groups II and older is concentrated in a post-spawning die-off. The threadfin shad population is apparently also affected by a concentrated mortality associated with the termination of its spawning season (Berry, Huish, and Moody, 1956).

SUMMARY

Interpretation of scale structure and statistical analyses of collections indicated the following to be components of the life history of the gizzard shad in Lake Newnan, Florida: Gizzard shad average about 10 inches in total length at the end of their first year of life, about 12.5 inches at the end of the second year, and about 13.6 inches at the end of the third year. The shad have a very short life span. Only about 5 percent approach their third actual year of life. Shad over four years old were not discovered. The Lake Newnan shad grow faster (at least during the first actual year of life) and die younger than those reported from other, more northern areas. The female population has a more variable growth rate than that of the male. Before the end of their first actual year of life, males have grown slightly more than the females; and after this time the females grow faster. Males die at an earlier age than the females.

Spawning is concentrated in March and April and probably extends from February into May. A small portion of the population matures during the second calendar year of life, but the majority does not mature until its third calendar year. A concentrated mortality is associated with the later portion of the spawning period.

Peculiarities in scale markings were noted in these fish that had not been described in previous studies of gizzard shad scales from more northern waters.

Prior to the formation of the first annulus, primary annulus-like growth rings developed on the scales (from 4 to 15 on fish 1.5 to 9 inches total length). The number formed was directly related to the size of the fish (and the size of the scale), and the positional relationships of these rings were relatively constant. An innate physiological action is suggested to be the cause of this formation, rather than an environmental influence.

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ESSENTIALS OF AN EFFECTIVE CONSERVATION COMMUNICATIONS PROGRAM

By J. J. Shomon
Chief, Education Division and Editor, Virginia Wildlife
Virginia Commission of Game and Inland Fisheries

Twenty years of close association with state and federal natural resources agencies has convinced me that much of our conservation information-education work can stand scrutiny.

Instead of coming to these conferences with pats on the back over what a marvelous job we're doing, may I suggest we occasionally gird ourselves and give our programs the real critical look. We might ask ourselves, critically: *What are we trying to accomplish in our information-education effort? What are we doing, and where are we heading?*

If we are honest—and we should be—and give these questions serious thought, then there is much that we can learn, much that we can profit thereby.

Not so long ago a well-known and accomplished administrator made this courageous statement: "Attendant to any terminology having to do with our natural resources—soil, water, minerals, timber and wildlife—it can be said with considerable factual proof that there has been a staggering amount of mismanagement, inexcusable waste and general manhandling of our resources. I say this in spite of any testimonials that may be forthcoming to the contrary."

I do not know, of course, what specifics Mr. Swift had in mind, and it does not matter. The important thing is that, generally speaking, we are not doing as good a conservation job as we are capable of doing. The criticism is not against any one state, federal agency or group. It is a general criticism and it can be supported by factual proof. Anyone who believes differently need only see for himself—need only examine present-day operations, as I have tried to do recently on my 33,000-mile study of conservation agencies, ministries, bureaus, departments, commissions, and private companies throughout the continent, a survey which took me into 24 states, most of the provinces of Canada, and the territory of Alaska. If there was anything that was made plain on this trip, it was this: That while conservationists are making headway everywhere, much improvement in management and communications can yet be done. By communications I refer to information-education processes and not equipment. The hour is short. There is no time for vacillation. If we are to win the conservation battle of our time, we've got to redirect and realign our programs in the direction of more worthy programs—programs possessed of mature judgment, humbleness, and dedicated conservation ideals.

Before I go on further, let me make clear that I am casting no aspersions on the good conservation work that is being or that has been done. God forbid. There is too little praise of good programs and conscientious effort, as it is. I only say we have not had enough o fit. We must have more. We must not be satisfied with our performance but get on with the big job that still remains to be done.

In too many of the states and areas I have visited, it is clearly evident that we are not doing as good a job as we're capable of doing, and the boys admit