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USE OF PECTORAL SPINES AND VERTEBRAE FOR DETERMINING AGE AND RATE OF GROWTH OF THE CHANNEL CATFISH [1]

Richard C. Marzolf

Missouri Conservation Commission, Columbia, Missouri

In the management of any species of fish, accurate information on age and growth is needed along with other life history information. When this study of age and rate of growth of the channel catfish, *Ictalurus lacustris punctatus*, was initiated in 1950, there was no record in the literature which described a technique for determining the age of that species. Recently, however, techniques which involve use of different parts of the skeleton have been successful. Appelget and Smith (1951) and Barnickol and Starrett (1951) used vertebrae to determine age and growth of channel catfish in the Mississippi River. Sneed (1951) used the pectoral spine in a study of the growth of channel catfish in Grand Lake, Oklahoma. Pectoral and dorsal spines were employed in a statewide investigation of the growth rate of channel catfish in Oklahoma by Hall and Jenkins (1952), and the dorsal spine was recommended as the better indicator of the two. Jenkins, Leonard, and Hall (1952) used the dorsal spine to determine the age and rate of growth of channel catfish from the Illinois River. However, the values of the characteristics of spines and vertebrae for determining the age of catfish have not been compared.

In this study, both the pectoral spines and the vertebrae were used to determine the age and to calculate the growth rate of the channel catfish. One hundred ninety-five channel catfish were collected from the Niangua Arm of Lake of the Ozarks during the summer of 1950 and 466 fish were taken from the same area in the spring of 1951. Those fish were taken by hoop net, gill net, trap net, set line, and rotenone. Twelve year classes were represented in the samples. During the same period, 161 fish of known age, up to 5 years, were removed from farm ponds near Columbia to provide a check.

METHODS

Pectoral spines were sectioned at the distal end of the basal groove (Fig. 1) as

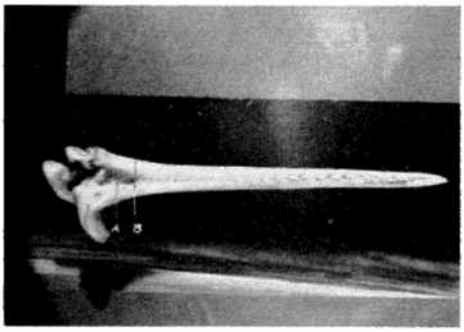

FIG. 1. Posterior view of the left pectoral spine of a channel catfish showing basal groove (A) and the point of sectioning (B).

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proposed by Sneed (1951). The sections were placed in a watch glass containing enough water to cover them and were read without further preparation. Under a binocular microscope with transmitted light, the zones of growth appeared as translucent rings alternating with opaque bands (Fig. 2). The rings were regarded

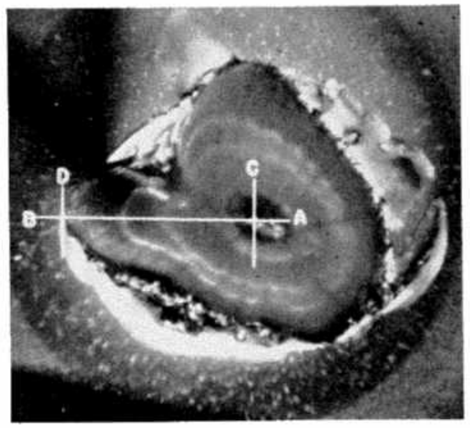

FIG. 2. Pectoral spine section taken from a channel catfish collected in Lake of the Ozarks. The fish was four years old and 9.5 inches in total length. Reference points: AB, posterior radius along which measurements were made; C, center of lumen; D, edge of section.

as year marks when they were distinct and appeared in all fields of the section. False marks were incomplete or indistinct.

The vertebrae were disjointed after drying, which usually left the centrum smooth and clean. The fifth vertebra of each specimen (also chosen for study by Appelget and Smith, 1951), was examined under a binocular microscope by reflected light. The arrangement of growth zones was identical with those on the spine sections, but reflected light caused the translucent rings to appear dark and the opaque bands white (Fig. 3). True annual rings were distinct, complete, and often accompanied by a change in elevation of the surface of the centrum.

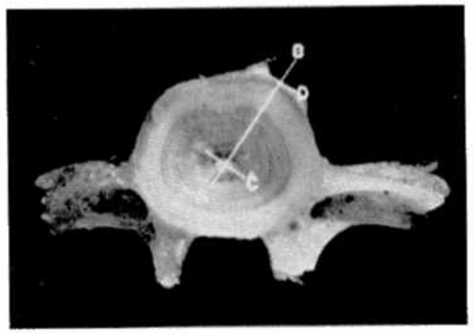

FIG. 3. Fifth vertebra from the same fish described in Fig. 2. Reference points: AB, radius along which measurements were made; C, center, D, edge.

Measurements along radius AB (Figs. 2 and 3) were made with an ocular micrometer which contained a movable scale. When age was assigned to fish, January 1 was considered as the birth date.

AGE DETERMINATION FROM SPINES AND VERTEBRAE

The annual marks on cross sections of pectoral spines of known-age fish were distinct and agreed in number with their known age. There was no question concerning the number or identity of winter and summer growth zones. This fact, coupled with the low incidence of false rings, indicated that growth marks on the spine were reliable for indicating age of channel catfish.

Distinct annual marks were present on the vertebral centra of known-age fish; but false rings occurred more frequently on the vertebral centra than on the spines and some of the false rings exhibited all the characteristics of true annual marks. Nevertheless, the close agreement of the number of annual marks with the known age of the fish indicated that seasonal marks on the vertebrae were satisfactory for aging channel catfish.

Annual marks on whole centra and

sections of spines from fish of the Niangua Arm collections were not as clearly defined as those on the known-age material. The age assessments of all the fish from Niangua Arm were made independently from spines and from vertebrae before the results were compared. There was agreement between the two methods in 85 per cent of the cases in the combined 1950 and 1951 samples.

When the spine section and vertebra of the same fish were compared, agreement in age was effected for an additional 7 per cent of the fish. Fewer than one per cent of the bones were discarded as unsuitable because of malformations. The remaining 7 per cent could not be brought into agreement and were rejected.

Age determinations were supported further by agreement between the peaks of a length-frequency distribution of the sample and the modes of length frequency of age groups. The extent of agreement in the 1951 sample is shown in Figure 4 and was equally good in the 1950 sample. Age groups X, XI and XII are omitted in Fig. 4 and in subsequent tables and figures because of small sample size.

Both vertebrae and pectoral spines were satisfactory for determining the age of channel catfish; however, the spines were preferred since they were collected with less time and effort, required no preparation other than sectioning, contained distinct annual marks, and had few false marks. Deterioration of tissue around the lumen in spines from older fish partially obliterated the first annual mark. This did not prevent accurate aging but did interfere with measurement of the first year's growth of age groups VII, VIII and IX. Vertebrae were more difficult to remove from the fish, occasionally required cleaning, and frequently contained false marks. The vertebrae did record permanently the first annual mark.

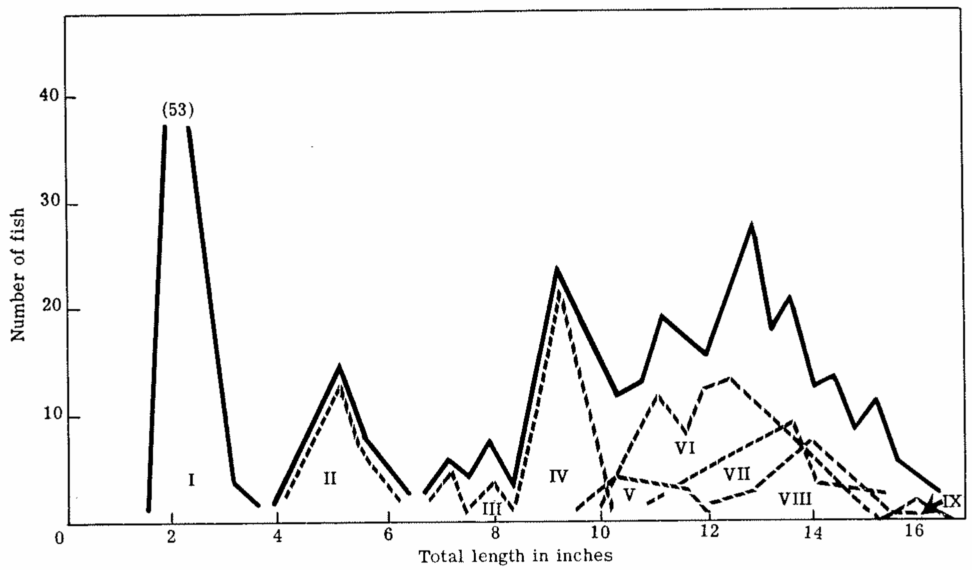

FIG. 4. Length frequency distribution (solid line) and the length frequency distribution within age groups (broken line) of the 1951 sample of channel catfish, Niangua Arm of Lake of the Ozarks. Roman numerals indicate successive age classes.

CALCULATION OF GROWTH

The calculation of growth was based on catfish collected in 1951 in which there was agreement between the seasonal marks on the vertebrae and on the spine sections. Intervals of total body length were plotted against corresponding radial measurements of spine sections (Fig. 5) and of vertebral centra

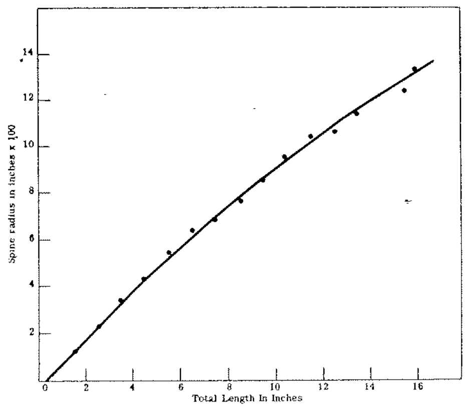

FIG. 5. Relationship of body length to spine radius in 434 channel catfish collected in May-June, 1951.

(Fig. 6). From this it was apparent that the relationship of body length to spine radius was curvilinear in form and the relationship of body length to vertebral radius could be described by two straight lines. Growth was calculated from radial measurements by use of a nomograph similar to that described by Carlander and Smith (1944).

Although the calculated lengths for each year of life based on spine measurements (Table 1) and vertebral measurements (Table 2) tended to vary inversely with the age of the fish, this tendency was most pronounced in the spine data. It was concluded that calculated lengths based on vertebral measurements offer a better measure of growth history than do calculated lengths based on spine measurements. Evidence suggests that the greater

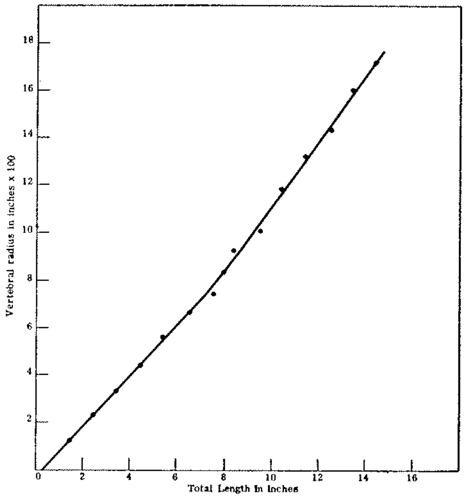

FIG. 6. Relationship of body length to vertebral radius in 434 channel catfish collected in May-June, 1951.

variations in spine data result from the structure and manner of growth of the spine.

The spine retains essentially the same form throughout life. Transverse and longitudinal sections of the spine suggest that growth is accomplished by seasonal deposit of tissue on the outside. The basal groove continues within the spine as a central lumen. As the spine grows this lumen enlarges at the expense of the earliest bone deposits. The basal groove also enlarges and lengthens with spine growth. Because of this lengthening of the groove, the point of sectioning in successive years is moved distally along the spine. Evidence of this distal movement is found in a comparison of sections from young and from older fish. A spine section from a one-year-old fish resembles a heart with unequal lobes. The first annual mark in a spine section from an older fish is not heart shaped, but oval, because it is actually a cross-section from the distal portion of the first year's growth.

An example of the effect of the distal movement of the point of sectioning on growth calculations is shown in Figure 7. The body-spine relationship is based on measurements from sections A, B, C, and D from 1-, 2-, 3-, and 4-year-old fish respectively. However, section D intersects the 1st, 2nd-, and 3rd-year growth strata along line EF where the radii of these earlier growth zones have decreased due to the taper of the spine. When these decreased radial measurements were employed in a nomograph the resulting calculated lengths were too short.

A cross-section of any pectoral or dorsal spine would contain comparable areas of growth if the point of sectioning remained constant with respect to each year's growth. The same would hold true if the spine were cylindrical instead of conical. It is possible that measure-

TABLE 1.—AVERAGE TOTAL LENGTH (INCHES) AT THE END OF EACH YEAR OF LIFE, CALCULATED FROM SPINE MEASUREMENTS OF 434 CHANNEL CATFISH TAKEN IN LAKE OF THE OZARKS IN 1951

Age group	Number of fish	Average length at capture (May-June)	Year of life							
			1	2	3	4	5	6	7	8
I.......	53	2.5	...	...	...	...	...	...	...	...
II.......	50	5.2	2.4	...	...	...	...	...	...	...
III.......	14	7.6	2.0	5.0	...	...	...	...	...	...
IV.......	66	9.3	2.0	4.8	7.2	...	...	...	...	...
V.......	17	10.9	2.1	4.6	6.9	8.9	...	...	...	...
VI.......	102	12.5	1.9	4.1	6.2	8.1	10.4	...	...	...
VII.......	64	13.6	...	4.0	5.9	7.8	9.5	11.4	...	...
VIII.......	52	14.4	...	4.0	5.3	7.0	8.6	10.2	11.8	...
IX.......	16	14.8	...	3.7	5.4	6.8	8.3	9.8	11.3	13.0
Average calculated length.........			2.1	4.3	6.1	7.7	9.2	10.4	11.5	13.0
Average annual increment........			2.1	2.2	1.8	1.6	1.5	1.2	1.1	1.5

TABLE 2.—AVERAGE TOTAL LENGTH (INCHES) AT THE END OF EACH YEAR OF LIFE, CALCULATED FROM VERTEBRAL MEASUREMENTS OF 434 CHANNEL CATFISH TAKEN IN LAKE OF THE OZARKS IN 1951

Age group	Number of fish	Average length at capture (May-June)	Year of life							
			1	2	3	4	5	6	7	8
I.......	53	2.5	...	...	...	...	...	...	...	...
II.......	50	5.2	2.3	...	...	...	...	...	...	...
III.......	14	7.6	2.3	4.9	...	...	...	...	...	...
IV.......	66	9.3	2.3	5.0	7.1	...	...	...	...	...
V.......	17	10.9	2.0	4.9	6.8	8.5	...	...	...	...
VI.......	102	12.5	2.0	4.6	6.9	8.5	10.1	...	...	...
VII.......	64	13.6	2.1	4.7	6.8	8.5	10.0	11.6	...	...
VIII.......	52	14.4	2.0	4.3	6.3	7.9	9.1	10.3	11.9	...
IX.......	16	14.8	2.1	4.1	5.6	7.2	8.8	10.0	11.1	12.8
Average calculated length.........			2.1	4.6	6.6	8.1	9.5	10.6	11.6	12.8
Average annual increment........			2.1	2.5	2.0	1.5	1.4	1.1	1.0	1.2

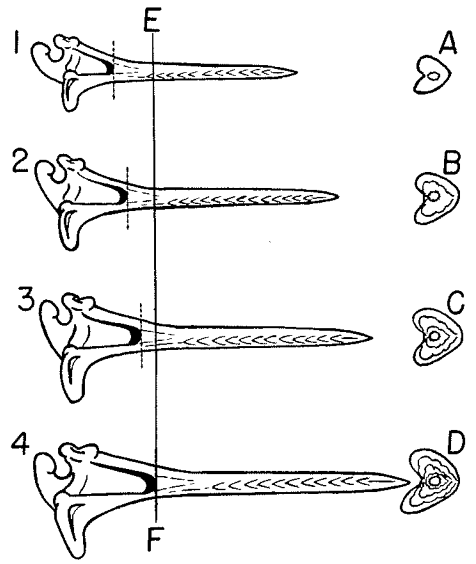

FIG. 7. Whole catfish spines of ages 1 to 4 years inclusive and cross sections. Sections A, B, C, and D are from spines 1, 2, 3, and 4 respectively and were cut at the end of the basal groove as shown by the broken line. Line EF indicates the areas of first, second and third year's growth that appear in section D. Drawing by Charles R. Walker.

ments along the anterior radius would reduce this error, since the growth lines were nearly parallel to the long axis of the spine in this region. The dorsal spine is more regular in shape than the pectoral spine and would probably be better for measurement of growth. Only a few dorsal spines were sectioned and comparison of the two kinds of spines was not possible.

The rate of growth calculated from vertebral measurements was more uniform, and in closer agreement with empirical measurements than was the growth history calculated from spine measurements. Because the spine method, as used in this study, has an inherent defect, it appears that the use of vertebrae resulted in a more accurate approximation of growth. Modification of the spine technique by measurement along the anterior radius might minimize this error and allow reasonably accurate calculations of growth from spine sections.

SUMMARY

1. Vertebrae and pectoral spines were used in a study of the age and growth of 661 channel catfish taken from the Niangua Arm of the Lake of the Ozarks.

2. Each structure contained annular marks which were shown to be true year marks by the usual tests of validity. This was further substantiated through the study of the same structures from 161 channel catfish of known age.

3. From the standpoint of collection, preparation, and reading, pectoral spine sections were preferred over the vertebrae as they required the least expenditure of time and effort in preparation and were more reliable for age determination because they showed fewer false marks. Deterioration of tissue around the spine lumen obscured part of the first annual mark in older fish. This did not prevent aging but did make the measurement of the first year growth less accurate.

4. The relationship of body length to spine radius appeared to be curvilinear. The relationship of body length to vertebral radius was best described as two straight lines.

5. Growth data derived from vertebral measurements was thought to be the better approximation of growth history for the following reasons: (1) growth was more uniform and in better agreement with the empirical data; (2) the spine method, as used in this study, had an unavoidable error that caused calculated lengths to be too short.

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