

INSTITUTE FOR FISHERIES RESEARCH  
DIVISION OF FISHERIES  
MICHIGAN DEPARTMENT OF CONSERVATION  
COOPERATING WITH THE  
UNIVERSITY OF MICHIGAN

A. S. HAZZARD  
DIRECTOR

ADDRESS  
UNIVERSITY MUSEUMS  
ANN ARBOR, MICHIGAN

Report 243

AGE AND GROWTH OF THE GREEN SUNFISH, APOMOTIS CYANELLUS, IN  
MICHIGAN

By Gerald P. Cooper and Carl L. Hubbs

In a previous paper (Hubbs and Cooper, In press) we have elucidated several features in the life history of the long-eared sunfish, Xenotis megalotis peltastes, in Michigan. The investigation reported upon in this paper involves a similar study of the green sunfish, Apomotis cyanellus, in the same state. Preliminary examination of the collections of green sunfish in the University of Michigan Museum suggested that its growth is stunted in Michigan and that it should receive, along with the long-eared sunfish, legal consideration separate from that accorded the larger sunfishes. The study undertaken to test these indications, has involved the examination of the scales of 514 specimens representing 85 collections. The distribution of these collections is shown in Fig. 1. The methods used are those becoming standard for age determination of fishes. The scales were mounted in glycerine jelly and age determinations were made by the aid of a projecting machine. The scale method of age determination for fishes in the family Centrarchidae, to which Apomotis is referred, has been described by Creaser (1926) and by others referred to by Hubbs and Cooper (In press). These authors have sufficiently described the characters of the annulus (the winter line on the scale) in centrarchid fishes.

Correlation of Growth Rate with Climatic Features.---As for the long-eared sunfish, we find for Apomotis a good correlation between growth rate and two climatic gradients indicated by Seeley (1922): (1) "The average number of days

in the growing season (from last killing frost in spring to first killing frost in autumn)" and (2) "The mean temperature for the year". The distribution of our collections with respect to length of growing season is shown in Fig. 1. A change from this basis of classification to the mean temperature basis, with groupings of 39°-47° F. and of 47°-50° F. would involve the transference of only 9 specimens, in their second and third summers, representing three collections, and would in no way modify the conclusions.

A study of Table I and Fig. 2 reveals a decreased growth rate in the northern part of the state. The northern fish in the first and second summers, however, were larger than the southern fish of the same age groups.

Table I. Average size (standard length in mm.) for green sunfish of each age group in Michigan, arranged according to length of growing season. The inferior figure appended to each average represents the number of specimens on which the average is based.

Growing season	Summer of life							
	1st	2nd	3rd	4th	5th	6th	7th	8th
110-150 days	19.8 <sub>80</sub>	44.0 <sub>129</sub>	59.8 <sub>57</sub>	80.8 <sub>22</sub>	91.7 <sub>11</sub>	114.3 <sub>3</sub>	114.4 <sub>5</sub>	158.0 <sub>1</sub>
150-180 days	11.0 <sub>6</sub>	40.8 <sub>45</sub>	65.6 <sub>83</sub>	89.2 <sub>45</sub>	118.3 <sub>7</sub>	127.5 <sub>13</sub>	146.5 <sub>6</sub>	145.0 <sub>1</sub>

This relation, inconsistent with our general conclusion, is however easily explained. When we separately tabulated the number of specimens collected before July 11 and after July 10, for the two climatic districts in each age grouping (Table II), we find that the majority of the northern fish (with a 110-150 day growing season) were collected after July 10, while the majority of the southern fish (150-180 day season) were taken before July 11. Thus the fish from the northern area had lived through a longer portion of the last

growing season than had those fish of the same age group from the southern area. By the third and fourth summers the difference in size affected by climatic factors is sufficient to more than counterbalance the effect of this difference in time of capture.

Table II. The number of specimens of green sunfish collected before July 11 and after July 10 for the two climatic districts in each age grouping.

N refers to fish from the northern region with a 110-150 day growing season; S refers to those from the southern region with a 150-180 day growing season.

Summer of life Climatic district	1st		2nd		3rd		4th		5th		6th		7th		8th	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
Before July 11	2	6	4	31	6	31	-	35	1	3	-	11	-	5	-	1
After July 10	78	-	125	14	51	51	22	10	10	2	3	1	5	1	1	-

Differential growth of the sexes.--- It has been indicated by several workers, and has been emphasized in our first contribution, that the males of the centrarchid fishes which have been studied grow faster than the females. We find the same relation to hold for the green sunfish (Table III and Fig. 3). The difference in the size of the sexes in their second summer, as determined by averaging the lengths of all specimens studied, is slight and seemingly not significant. But when we compare the sizes of specimens of each sex within single collections, (Table IV), we find that the males apparently average somewhat larger than the females even before maturity is attained. The sexual difference in size seems to increase during the third and fourth summers. While the numbers of specimens in their fifth and subsequent summer groups were too small to include them in Table IV, a study of Table III and Fig. 3 strongly suggests that this sexual dimorphism of size continues to increase throughout the latter year groups. It

is clear that Apomotis cyanellus in Michigan is typical of most, if not all, of the centrarchid fishes in displaying a sex differential in growth rate. This may be correlated with the nest-guarding habit of the males, as postulated in our previous contribution.

Table III. Average sizes of the sexes of green sunfish in each age group, arranged according to the length of the growing season.

The inferior figure appended to each average represents the number of specimens on which the average is based.

Growing Season		Summer of Life						
		2nd	3rd	4th	5th	6th	7th	8th
110-150 days	Female	44.9 <sub>60</sub>	59.2 <sub>32</sub>	75.6 <sub>8</sub>	83.0 <sub>2</sub>	96.0 <sub>1</sub>	-	-
	Male	45.4 <sub>54</sub>	62.0 <sub>22</sub>	83.8 <sub>14</sub>	93.7 <sub>9</sub>	123.5 <sub>2</sub>	114.4 <sub>5</sub>	158.0 <sub>1</sub>
150-180 days	Female	41.7 <sub>26</sub>	59.8 <sub>36</sub>	81.1 <sub>19</sub>	110.3 <sub>3</sub>	126.3 <sub>4</sub>	122.0 <sub>1</sub>	-
	Male	40.8 <sub>18</sub>	70.0 <sub>47</sub>	95.2 <sub>26</sub>	124.3 <sub>4</sub>	128.1 <sub>9</sub>	151.4 <sub>5</sub>	145.0 <sub>1</sub>

Table IV. Deviation of the standard length of individual male specimens from the mean length of female specimens of the same age group and collection.

Only those age groups in any one collection which contain at least 4 females were used. Measurements and computations expressed to the nearest millimeter.

Summer of Life	Deviation in mm.																
	-10 to -8	-7 to -5	-4 to -2	-1 to +1	2 to 4	5 to 7	8 to 10	11 to 13	14 to 16	17 to 19	20 to 22	23 to 25	26 to 28	29 to 31	32 to 34	35 to 37	38 to 40
2nd	4	4	8	5	3	11	4	2	2	1	-	1	-	-	-	-	-
3rd	1	1	4	2	4	7	5	3	4	2	2	2	-	-	-	-	1
4th	-	-	1	1	2	-	2	2	1	2	1	2	-	-	1	-	-

Time of Spawning.--Our data on the size distribution of the young of the year, given in Table V, indicate a prolonged spawning season for this species in Michigan. The first two collections given in this table definitely indicate June spawning, while the sizes of the young of subsequent collections make it clear that spawning extends through July and probably into August, judging from the growth attained at the time of capture. Gravid females were noted in collections made as early as June 25 and as late as July 27. We have taken males in southern Michigan, with milt running as late as September 28. Forbes and Richardson (1909: 250) indicated spawning in Illinois as late as August 14.

Table V. Size of fish in their first summer of life. Each group represents the young of one collection.

Growing Season	Lake	County	Date	Mean Length	Number of Specimens
150-180 days	Third Sister L.	Washtenaw	7-1-22	11.0	6
110-150 days	Whipple Creek	Newaygo	7-9-26	31.0	2
" " "	Railroad Lake	Lake	7-18-31	17.0	1
" " "	Little Log Lake	Kalkaska	8-9-30	18.0	1
" " "	Highbank Lake	Newaygo	8-24-26	18.1	34
" " "	Kichners Lake	Menominee	8-30-27	21.8	29
" " "	Cranberry Lake	Kalkaska	9-11-30	20.2	5
" " "	Sand Lake	Newaygo	9-17-26	16.0	1
" " "	Onatoga Lake	Otsego	9-27-25	23.0	1
" " "	Hotseshoe Lake	Otsego and Crawford	9-29-25	16.7	6

Age and Size at Maturity.--All of the fish in their fourth or subsequent summers were found to be mature. Roughly about three-fourths of the third summer fish and a very few of the second summer fish were mature. In single collections the early spawners within a given year group were the larger individuals of that year group, yet no significant differences in age of maturity were found to be correlated with the differential growth rates of fish from the northern and southern part of the state, nor with sex. The usual size at first maturity for both sexes was found to be approximately three inches. Age and size at maturity are indicated in Tables VI and VII.

Table VI. Sex ratios for green sunfish as determined from the specimens studied.

Summer of Life	Maturity	Number of males	Number of females	Per cent males
2nd	Almost all immature	72	86	46%
3rd	About three-fourths mature	69	68	50%
4th	All mature	40	27	60%
5th to 8th	All mature	36	11	77%

Sex Ratio.--We found for Xenotis megalotis peltastes an equal sex ratio in yearling fish; an aberrant ratio with 70% males, in third summer fish, explainable as due to the ease of collecting the gregariously breeding males of that species on their spawning beds; an equal ratio in fourth summer fish, and a slightly larger percentage of females in the fish in their fifth and subsequent summers, thus an actual preponderance of the more retiring females in the fourth and subsequent summer groups was indicated. Data on the sex ratio in Apomotis cyanellus, given in Table VI, show an increasing percentage of males among the older fish, thus contrasting with the condition found in Xenotis. Since the males of Apomotis are not so gregarious in their breeding, collections having an abnormally large number of that sex did not occur. As an apparent consequence, the sexes were more equally represented in the collections of green sunfish. The increasing ratio of males in Apomotis with age suggests that the males may be more viable than the females. This is contrary to the general rule, and needs confirmation.

Spawning Mark on the Scales.--In Xenotis we definitely distinguished a spawning mark on the scales, a feature which had not previously been definitely described for the centrarchids. The scales of a large percentage but not all of the mature adults of Apomotis cyanellus develop in the summer an entirely similar mark, also indicative of an abrupt though temporary slackening or

cessation of growth during the spawning season (Plates II & III). The spawning mark separates the clear band of widely spaced circuli, produced during the apparently rapid pre-spawning growth, from the darker band of more closely approximated ridges, which represents the apparently slackened growth during the latter part of the season. The spawning mark is sharply developed only on the anterior field of the scale, where on account of lenticular gaps between the ridges it may be more conspicuous than the winter mark. On the lateral field it approximates the winter mark, into which it merges in advance of the posterolateral angle. This would seem to indicate that the scale grows chiefly in the anterior direction after the spawning time, making the scale more deeply imbedded in the fall. Dorsoventral growth of the scale seems to be very slight after spawning, except toward the anterolateral angle, along which the growth is about as great as on the anterior field.

Relation of Size and Growth to Legal Limit.--The green sunfish is listed in the laws of Michigan as a game fish with the legal size stipulated as 6 inches. The size frequency distribution of the 514 specimens examined, with total lengths in inches is given in Table VII. Only 4% of the specimens studied were of legal size. Whether this percentage is representative of the natural fauna or not is debatable, since most collecting is done in shallow water with small seines and is somewhat selective of the smaller fish. However, of the 20 fish of legal size, 11 were collected by T. L. Hankinson in Oakland County, mostly from Walnut Lake. Since his collections contained only 5 illegal fish with the 11 fish of legal size, he apparently selected for preservation chiefly the larger fish. This compensates more or less for the selectiveness of seining methods for the smaller fish. All of the legal fish were taken from lakes, 85% from the southern part of the state (150-180 day growing season), and only 15% from the northern district (110-150 day growing season). Of the fish studied, only 1 in 100 from the northern zone were of legal size. If the selected Walnut Lake collections be excluded, only 1 fish in 32 from the southern zone was of

legal size. The green sunfish occasionally reaches this size in certain lakes in the southern fourth of Michigan, but very rarely attains the six-inch length in the more northern portions of the state. By giving this small fish the present legal protection, it is being aided in its competition with the larger sunfishes. It is a voracious competitor, its large mouth enabling it to eat the same food as taken by the larger species. It would seem desirable that the green sunfish, as well as the long-eared sunfish, be removed from the list of game fish and that the legal size limit of 6 inches be specified for the bluegill and pumpkinseed only. As the green sunfish is easily distinguished from the two larger species, little confusion should result from such a regulation.

#### Summary

1. This study was based on the age determination of 514 green sunfish (apomotis cyanellus) from Michigan, using the scale method.
2. The growth rate of this species is found to be positively correlated with the length of the growing season and with the mean annual temperature.
3. As in most, if not all other centrarchids the males of Apomotis grow faster than the females, a phenomenon which may be correlated with the nest-guarding habit of the males.
4. This species has a long spawning season extending through June and July and probably through August.
5. A few individuals become mature as yearlings, in their second summer. Most individuals become mature for the first time in their third summer. All are mature in their fourth and subsequent summers. The average size at the attainment of maturity is about 3 inches. There is little variation in age or size at maturity between the sexes or between the growing season groupings.
6. Our data suggest that the males possess a greater variability than the females, as the proportion of males in the collection increases with age.
7. The scales of this species show a well defined spawning mark, indicating

a severe interruption in growth during the spawning season.

8. Since the green sunfish very seldom attains the legal size limit of 6 inches, except in a few lakes in the southern fourth of Michigan, and since it is a voracious competitor of the better species, it would seem desirable that it be omitted from the list of game fish and exempted from a legal size limit.

#### Literature Cited

- Creaser, Charles William. 1926. The Structure and Growth of the Scales of Fishes in Relation to the Interpretation of Their Life-History, with Special Reference to the Sunfish *Eupomotis gibbosus*. Misc. Publ. Mus. Zool. Univ. Mich., 17: 1-82, figs. 1-12, pl. 1.
- Forbes, Stephen Alfred, and Richardson, Robert Earl. (1909). The Fishes of Illinois. Nat. Hist. Surv. Ill., 3: i-cxxxi, 1-357, many figs. and pls.
- Hubbs, Carl L. and Cooper, Gerald P. In Press. Age and Growth of the Long-eared Sunfish in Michigan. Pap. Mich. Acad. Sci. Arts and Letters.
- Seeley, Dewey A. 1922. Michigan Agriculture. Climate: 1-46, charts 1-16.

RECEIVED  
 FEB 11 1934  
 FISH DIVISION

Table VII. Distribution of specimens of green sunfish according to total length in inches and to maturity.

Summer of Life	Growing Season, in days	Total length in inches																								Total	
		0.3 to 0.5	0.6 to 0.8	0.9 to 1.1	1.2 to 1.4	1.5 to 1.7	1.8 to 2.0	2.1 to 2.3	2.4 to 2.6	2.7 to 2.9	3.0 to 3.2	3.3 to 3.5	3.5 to 3.8	3.9 to 4.1	4.2 to 4.4	4.5 to 4.7	4.8 to 5.0	5.1 to 5.3	5.4 to 5.6	5.7 to 5.9	6.0 to 6.2	6.3 to 6.5	6.6 to 6.8	6.9 to 7.1	7.2 to 7.4		7.5 to 7.7
First	110-150	-	34	28	17	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80
	150-180	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Second	110-150	-	-	-	3	17	38	36	21	5	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129
	150-180	-	-	1	2	12	14	5	4	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45
Third	110-150	-	-	-	-	-	-	5	13	17	10	6	2	1	1	2	-	-	-	-	-	-	-	-	-	-	57
	150-180	-	-	-	-	-	-	2	13	12	21	13	12	5	3	-	1	-	1	-	-	-	-	-	-	-	83
Fourth	110-150	-	-	-	-	-	-	-	-	1	2	3	5	3	3	3	1	1	-	-	-	-	-	-	-	-	22
	150-180	-	-	-	-	-	-	-	-	-	-	2	10	6	8	7	7	3	2	-	-	-	-	-	-	-	45
Fifth	110-150	-	-	-	-	-	-	-	-	-	-	1	-	2	2	3	1	1	1	-	-	-	-	-	-	-	11
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	1	-	2	1	-	-	-	-	7
Sixth	110-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	3
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3	1	3	3	-	1	1	1	13
Seventh	110-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	1	-	-	-	-	-	5
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	2	-	6
Eighth	110-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Totals	110-150	-	34	28	20	18	38	41	34	23	18	13	7	6	6	9	2	5	3	-	1	-	1	-	-	1	308
	150-180	4	2	1	2	12	14	7	17	18	22	15	22	12	11	7	9	5	7	2	5	4	1	4	3	-	206
Total		4	36	29	22	30	52	48	51	41	40	28	29	18	17	16	11	10	10	2	6	4	2	4	3	1	514
		Almost always immature. Less than three inches.										Mostly mature but below legal size. Three inches or more, but less than six inches										Always mature and of legal size. Six inches or longer					
		61%										35%										4%					