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Age and growth of the long-eared sunfish in Michigan*

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I. Introduction

The investigation reported upon in this paper was undertaken to elucidate several features in the growth of the dwarfed form of long-eared sunfish, Xenotis megalotis peltastes. The study has been based on an examination of the scales of 727 specimens representing 78 collections, all from the Lower Peninsula of Michigan. The distribution of these collections is indicated by Figs. 1 and 2.

The methods employed were those now becoming more or less standard in fish life-history investigations. The scales were mounted in glycerine jelly and were examined by aid of a projecting machine.

The validity of the scale method for the determination of the age of fishes in the family Centrarchidae, to which Xenotis is referred, was demonstrated by Creaser (1926) and has been aptly confirmed by the earlier and subsequent researches of Potter (1925), Bolen (1925), Wright (1929), Hile (1931), Tester (1932) and Hubbs and Hubbs (1931 and 1933). The papers by Creaser and Hile give references to the contributions which introduced and which have established the scale method for the determination of the age of fishes in general.

The characteristics of the annulus or winter line on the scales of centrarchid fishes have been adequately indicated by the writers just cited, and need not be re-described. The figures of the scales on Plate 1 show that the year marks in Xenotis are entirely like those of the other species of

the family which have been studied.

II. ~~The growth of the dwarfed subspecies~~ Increased dwarfing toward the north,

Xenotis megalotis peltastes

In the central parts of the United States, the long-eared sunfish (Xenotis megalotis) is a species of fair size. Northward it grades into a dwarfed subspecies, as Forbes and Richardson indicated in 1909 (p. 255):

> Northward this species grades into a smaller dwarfish variety, probably Xenotis lythrochloris, which has been taken only in the clear swift water of the Fox at Ottawa, Lacon, and Algonquin; in the Du Page at Naperville; in the Vermilion at Pontiac and Fairbury; in a small creek in Du Page county; and in Indian creek, La Salle county. These small forms have the ear-flaps red and the scales of the cheek smaller than typical megalotis. Their size is along sufficient to distinguish them, gravid females having been found only 1 5/8 inches long, and no specimen exceeding three inches.

The proper name of this northern subspecies seems to be Xenotis megalotis peltastes (see Hubbs, 1926: 72).

In Michigan we likewise find that the species becomes progressively dwarfed toward the north. The correlation is good between growth and certain climatic features, which change abruptly through Michigan. The two climatic gradients selected, from those mapped by Seeley (1922), as having a clear relation to the growth of this sunfish as determined by us, are (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 in respect to three divisions in each of these climatic gradients is shown in Figs. 1 and 2. An examination will make it clear that the groupings of the collections according to the three divisions of these two climatic features are similar for only five collections involving 84 specimens, mostly yearlings, are shifted between the northern and the central divisions by a change from the one scheme to the other.

The data are summarized in Tables I to III and in Fig. 3. It seems clear that Xenotis megalotis peltastes shows a progressing dwarfing toward the north in Michigan, and that this dwarfing is correlated with a decrease in the mean length of the "growing season" (between killing frosts) and in the mean temperature of the year.

Table II. Average size (standard length in mm.) for long-eared 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.

	Summer of Life								
Growing Season	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
110-130 days	34.8_{40}	47.3_{124}	55.5_{70}	61.3_{72}	61.2_{12}	82.7_{3}	79.5_{2}	...	74.0_{1}
130-150 days	37.3_{59}	53.8_{34}	58.7_{15}	63.0_{11}	70.5_{2}	109.0_{1}	...	...	...
150-180 days	43.5_{59}	56.6_{142}	73.2_{35}	77.7_{38}	111.0_{1}	105.0_{2}	...	...	...

Table III. Average size (standard length in mm.) for long-eared sunfish of each age group in Michigan, arranged according to mean annual temperature. The inferior figure appended to each average represents the number of specimens on which the average is based.

	Summer of Life								
Means Temp.	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
41°-43°F.	35.9_{7}	47.6_{120}	55.6_{69}	61.4_{71}	61.2_{12}	82.7_{3}	79.5_{2}	...	74.0_{1}
43°-47°F.	35.0_{112}	51.4_{32}	58.1_{16}	62.1_{13}	70.5_{2}	109.0_{1}	...	...	...
47°-49°F.	43.5_{59}	56.6_{142}	73.2_{35}	77.7_{38}	111.0_{1}	105.0_{2}	...	...	...

Table I. Size frequency distribution of long-eared sunfishes of each age group in Michigan, arranged according to length of growing season.

Summer of life	Growing season	Standard length in mm., by groups of 5																			
		20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	100-104	105-109	110-114	Total
~~Second~~ 2nd	110-130	-	6	20	28	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60
	130-150	-	3	18	20	14	3	1	-	-	-	-	-	-	-	-	-	-	-	-	59
	150-180	1	2	2	6	22	20	2	1	1	2	-	-	-	--	-	-	-	-	-	59
Third	110-130	-	-	5	14	33	28	21	13	12	-	-	-	-	-	-	-	-	-	-	126
	130-150	-	-	-	-	1	10	5	6	1	-	1	2	-	-	-	-	-	-	-	26
	150-180	-	-	-	-	8	32	34	17	15	18	11	4	2	1	-	-	-	-	-	142
Fourth	110-130	-	-	-	-	8	9	15	18	7	9	4	-	-	-	-	-	-	-	-	70
	130-150	-	-	-	-	-	-	6	2	4	2	-	1	-	-	-	-	-	-	-	15
	150-180	-	-	-	-	-	-	-	3	2	7	7	7	6	2	1	-	-	-	-	35
Fifth	110-130	-	-	-	-	-	-	10	21	20	13	7	1	-	-	-	-	-	-	-	72
	130-150	-	-	-	-	-	-	2	-	4	4	1	-	-	-	-	-	-	-	-	11
	150-180	-	-	-	-	-	-	-	-	1	5	7	3	5	3	2	1	1	-	-	28
Sixth	110-130	-	-	-	-	-	2	4	1	2	1	-	-	1	-	-	-	-	1	-	12
	130-150	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	2
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Seventh	110-130	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	-	-	-	-	3
	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2
Eighth	110-130	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	2
	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ninth	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		all blanks																			
~~Ninth~~ Tenth	110-130	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ALL AGES	110-130	-	6	25	42	47	39	50	53	41	23	12	3	3	-	1	-	-	1	-	346
	130-150	-	3	18	20	15	13	14	8	10	6	2	4	-	-	-	-	-	1	-	114
	150-180	1	2	2	6	30	52	36	21	19	32	25	14	13	6	3	2	1	-	2	267
TOTALS	ALL	1	11	45	68	92	104	100	82	70	61	39	21	16	6	4	2	1	2	2	727

A study of Table I of VIII will suffice to show that a very considerable percentage of long-eared sunfish in Michigan, which reach maturity, live through two years of maturity. About as many four-year old as three-year old fish were collected. Relatively few, however, live to be older: for all sections of the state there is a sharp drop in numbers between the fifth and the sixth summer of life. Of the 727 fishes studied, only 6 were in the seventh summer, 2 in their eighth and 1 in its tenth year (approximately nine years old). All three of the eighth and tenth summer fish were from the northern growing district (110-130 days). Of the 24 fish in their sixth to tenth year, 18 were from the northern district, although somewhat less than half the total number of fish studied were from that district. The average age of fish (figuring all second-summer fish as having the age of 1.0, all third-summer fish as having the age of 2.0, etc.) is:

2.6 years for the northern growing district (110-130 days)

1.9 years for the central growing district (130-150 days).

2.2 years for the southern growing district (150-180 days).

It is therefore probable that the long-eared sunfish live longer on the average in the northern than in the southern part of Michigan. It is clear, at least, that the extreme dwarfing of this sunfish in northern Michigan is not due to any reduction in its life span.

III. Correlation between the growth of the first and of the second year

Some authors have indicated[1] a tendency toward "growth compensation" in several fishes, that is, an adjustment leading toward reduced variation in size with increasing age. This would involve a negative correlation between early growth and later growth. We find no indication that this tendency holds for the growth of the long-eared sunfish in Michigan. Our data are adequate for a conclusive comparison of only the first two years' growth. Since the growth type varies with locality and with sex, it is desirable to restrict the correlations to the separate sexes in single collections.

We find that a positive correlation exists between the growth of the first year and that of the second year (see Table IV). Of seven computations, four give a positive coefficient of correlation of 0.52 to 0.76, with the coefficients 5 or 6 and in the best case 19 times the probable error of the coefficient. Two computations gave coefficients of correlation of +0.40 and of -0.42, but these coefficients were approximately only 3 times their probable error. In computing the first year's growth from fish two years old (in third summer), the method of computation adopted by Hubbs and Hubbs (1933: 619-623) was employed. The scale measurements were made of the anterior embedded field along the median axis.

The data used by Hubbs and Hubbs in the paper just cited show a similar positive correlation between the growth of the first year and that of the second year (up to time of capture of the yearling fish on October 25), for

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[1] Three such indications were given by Hubbs, Ecology, 2, 1921: 275.

two other species of sunfish and for the hybrids between them. These data are included in Table IV.

Table IV. Correlation between growth of first year and of second year in sunfishes in Michigan.

Species	Growing Season	Locality	Sex	Specimens	Coefficient of correlation (r)	Probable error of r.	$\frac{r}{PE_r}$
Xenotis megalotis	110-130 days	Tomahawk Lake, Montmorency Co.	Male	12	+0.63	0.12	5
			Female	12	-0.42	0.16	3 -
"	"	Bass Lake, Kalkaska Co.	Male	32	+0.54	0.08	6
"	"		Female	18	+0.60	0.10	6
"	150-180 days	Huron River, Washtenaw Co.	Male	22	+0.40	0.12	3+
"	"	Wilson Lake, Hillsdale Co.	Male	48	+0.76	0.04	19
"	"		Female	20	+0.52	0.11	5
Eupomotis gibbosus	"	Crystal Lake, Oceana Co.	Male	90	+0.46	0.06	8
	"		Female	96	+0.47	0.05	9
Eupomotis x Helioperca	"	"	Male	67	+0.41	0.03	14
	"	"	Female	16	+0.54	0.12	4.5
Helioperca incisor	"	"	Male	92	+0.90	0.01	90
	"	"	Female	91	+0.79	0.03	26

The positive correlation between the growth of the first and of the second year in sunfishes means of course that those individuals of one sex at one locality which grew more than the average during the first year, usually grew more than the average during the second year as well, while those which grew less during their first year usually grew poorly in their second year also. This naturally leads to an increased dispersion in size with age, which is well shown on the size frequency graphs for separated age groups in sunfish (Creaser, 1926, fig. 4; Hubbs and Hubbs, 1933, figs. 69 and 70, etc.).

The positive correlation between growth of the first and of the second year at one locality may be due to any one of three reasons:

(1) The individuals which attain a greater growth during their first year, owing to early hatching or any other factor, may possess such a competitive advantage over the slowly growing fish of the same age, as to obtain more food during the second year. In rearing sunfish in aquaria it is obvious that the larger fish become the masters, obtaining food first and worrying the smaller individuals in combat.

(2) Some fish may select and inhabit through both years ecological niches particularly conducive to rapid growth in both years, or the reverse.

(3) There may be genetic differences in growth potential between different individuals.

IV. Differential growth of the sexes

It is a very general belief, as Van Cleave and Markus (1929: 534) have indicated, that female fishes grow somewhat larger and presumably faster than the males. There is a very considerable body of evidence to indicate that the growth of the sexes is either very similar, or that the females grow faster than the males. The general circumstance that very large specimens of a species are usually females, however, is explainable in part at least as the consequence of the greater viability of the females.

The long-eared sunfish forms a conspicuous exception to this apparently general rule that the female fish grow faster than the males of the same species. Tables V and VI and Fig. 4 give adequate evidence that the males in this species grow faster than do the females. The difference is already apparent among yearling fish (that is, those in their second year), and becomes accentuated in the mature fish. When the differential growth starts is uncertain. It becomes apparent a year before first spawning. It is rather doubtful if there is

significant difference in the average size of the sexes at the end of their first season's growth, that is, in their first winter (Table VII).

Table V. Average size of the sexes of long-eared sunfish in each age group, for each of the three growing season districts in Michigan. The inferior figure appended to each average represents the number of specimens on which the average is based.

Growing Season	Sex	Summer of Life: 2nd	3rd	4th	5th	6th	7th	8th	9th	10th
110-130 days	Female	34.6_{14}	45.4_{42}	53.3_{35}	38.7_{45}	53.0_{5}	77.0_{1}	82.0_{1}	...	74.0_{1}
	Male	35.4_{34}	48.4_{83}	57.7_{39}	65.4_{27}	67.0_{7}	85.5_{2}	77.0_{1}	...	....
130-150 days	Female	39.6_{18}	48.6_{11}	55.5_{10}	62.3_{7}	64.8_{3}	109.0_{1}	...	...	...
	Male	40.0_{19}	57.5_{15}	65.0_{4}	64.3_{4}	77.0_{1}	...	...	...	...
150-180 days	Female	43.4_{19}	51.5_{34}	70.0_{1}	69.6_{13}	...	99.0_{1}	...	...	...
	Male	46.6_{32}	58.2_{108}	75.2_{19}	84.7_{15}	110.0_{1}	110.0_{1}	...	...	...

Table VI. Deviation of the standard length of individual male specimens from the mean length of females of the same age group in the same 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.

Deviation in size of individual males from average size of females

Summer of Life	-13 to -11	-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
2nd	1	0	6	7	13	22	11	2	...	...	...	...
3rd	...	1	7	11	13	15	14	13	12	5	1	2
4th	...	...	...	...	1	3	4	2	4	1	2	...
5th	...	...	...	1	2	1	1	2	4	2	...	...

For all the sexed specimens in our collection (409 males and 285 females), the average size is 55.5 mm for males and 49.0 mm for females. This is probably not due to a greater longevity of the males. Of the three oldest fish, two are females in their eighth and tenth summer, and one is a male in its eighth summer. Among the second-summer or yearling fish, which are almost all immature, we find a slight preponderance of males. Seven-tenths of the fish a year older, in their first usual year of maturity, are males. This aberrant sex ratio is certainly not representative of the actual natural population, but results from the ease of collecting breeding males on their nests. But by the next year (fourth summer) the sexes in the collections are approximately equal, indicating an actual preponderance of the more retiring females. For subsequent years, the females in the collections somewhat outnumber the males, and are presumably decidedly more numerous in nature. Data are given in Table VIII.

Table VIII. Sex ratios as determined from specimens in the collections studied.

Summer of Life	Usual Maturity	No. of males	No. of females	% males
2nd	Immature (yearlings)	85	61	58%
3rd	First year of maturity	206	87	70%
4th	Second year of maturity	59	61	49%
5th to 10th	Subsequent years (mature)	59	75	44%

Table VII. Comparative size of sexes of long-eared sunfish at three localities in Michigan, as computed from fish in their third summer.

Growing Season	Locality	Sex	Specimens	Average size
110-130 days	Tomahawk Lake, Montmorency Co.	Male	12	21.7
		Female	12	22.6
110-130 days	Bass Lake, Kalkaska Co.	Male	32	24.3
		Female	18	23.7
150-180 days	Wilson Lake, Hillsdale Co.	Male	48	20.6
		Female	20	20.3

It is probable that the males of at least most species in the family Centrarchidae grow faster than the females. This was suggested by Creaser's data (1926, fig. 3) for Eupomotis gibbosus, and was definitely indicated by Tester (1932: 215) to hold for Micropterus dolomieu. Hubbs and Hubbs (1933: 622) that the males of Eupomotis gibbosus, of Helioperca incisor, and of hybrids between them, grow at about the same rate as the females during their first year of life, but at a faster rate during their second year. Dr. Ralph Hile informs us that in Amplopites rupestris he finds the males to grow faster than the females.

The significance of this apparently alterred differential growth rate of the sexes is of course a matter of speculation. Our supposition is, that the increased growth of the males has been of selectional significance, enabling them the better to ward off enemies from the nests, which they guard so pugnaciously.

This hypothesis will be of course very difficult to test. It receives confirmation, however, from the differential growth rate of the sexes in Cyprinidae. In that family most species show no specific nest-building or nest-

guarding habits, and in these the females reach as large a size or become larger than the males, and probably grow as fast or faster. But there are some notable exceptions, in which the male becomes much larger than the female. These are the very species which build or guard some sort of a nest, or perform ~~some~~ both functions. This correlation of differential growth rate with breeding habits can hardly seem to be a coincidence, since it involves a considerable number of unrelated genera. The greater growth rate of the male has been indicated in published papers for only two cyprinids, for Hyborhynchus notatus by Van Cleave and Markus (1929) and for Semotilus atromaculatus by Greeley (1930). But Hubbs and Creaser observed this phenomenon in 1921, for the two species just mentioned, and also for Nocomis biguttatus and Notropis cornutus frontalis. Males of other American cyprinids which guard the eggs grow larger than the females, notably the other subspecies of Notropis cornutus, and Nocomis micropogon, Leucosomus corporalis, Exoglossum maxillingua, Pimephales promelas and Campostoma anomalum. Prof. Yuanting T. Chu calls our attention to the fact that the males of an Asiatic cyprinid, Pseudorasbora parva, are notable in displaying the same correlation of guarding the eggs and of growing larger than the females.

V. Age at maturity and the spawning mark on the scale.

Xenotis megalotis in Michigan appears to mature at a definite age rather than at a definite size. In both the southern and northern part of the state, the great majority of individuals mature first at the age of two years, that is, in their third summer. This is true despite the circumstance that the immature yearlings in the south are of about the same size as the mature two-year old fish in the north (Table I).

We find little variation in the age at maturity of long-eared sunfish in Michigan. Occasional large yearlings at scattered localities were found to be

mature, or maturing so as to spawn in their second year. Similarly a few two-year old (third summer) fish were immature, and a few scales show no trace of a spawning mark on their scales inside the third winter line.

This spawning mark of the long-eared sunfish is usually associated with and lies just within each winter annulus, from the third to the last one shown on the scale. Several of us who have worked on the life history of centrarchid fishes have noted "double annuli" which we have thought might reflect checks in growth to both winter and breeding. Now we feel justified in stating, for the long-eared sunfish at least, that spawning usually is registered on the scale by a definite mark (Plate II).

The spawning mark is most clearly evident across the anterior or concealed field of the scale, and in the anterior portion of the lateral fields. Here it is often more conspicuous than the true winter line. It often appears as a definite clear break across the anterior field, caused largely by the straightening out of the ridges (circuli) between the radii. From the spawning mark inward to the preceding annulus the ridges are usually strongly curved inward between each pair of radii, while from the spawning mark outward to the following annulus, the ridges are usually straight. Furthermore, the ridges representing the spring growth out to the spawning check are widely spaced, while those representing the fall growth outside the spawning mark are often though by no means always more densely crowded, so as to form a dark band. This dark band of crowded ridges when developed is usually apparent around and just back of the anterolateral axes. Rarely the breeding mark may be traced into or even across the posterior or exposed field of the scale, though usually the two marks seem to run together backward. More complete spawning marks may well have been occasionally mistaken for winter annuli. A thorough understanding of the features of the two marks should however make such errors in age determination very rare.

Although the spawning season of the long-eared sunfish in Michigan centers in July, extending from late June to early August, the spawning mark is usually much nearer the following annulus than the preceding one. This indicates that a very rapid spring growth and a more sluggish late summer and fall growth is the rule.

The formation of the spawning mark is clearly coincident with breeding. Scales from fish taken in the late spring prior to spawning show the widely spaced ridges characteristic of spring growth, without a trace of a spawning mark near the margin. Scales from males taken on their redds in the Huron River, Michigan, on June 28 show little indication of a spawning mark, while almost all of those taken on their nest in the same river on July 7 and 9 showed a spawning mark forming or completely formed, at or very near the margin of the scale. Autumn fish have scales showing the spawning mark well inside the margin.

VI. Relation of size and growth to legal limit

The laws of Michigan as they now stand list the long-eared sunfish (Xenotis megalotis peltastes) as a game fish, and place the legal size limit of this species at 6 inches. A glance at Table VIII will show that not one of the 727 specimens available for the present research was that large. It is doubtful if one long-eared sunfish per thousand mature fish in Michigan is of legal size. Less than 1% of our 727 examples are more than 5 inches long. Less than 1 in 10 is more than 3 1/2 inches long. This species is clearly not in need of any protection in the way of a legal size limit. Placing a legal size limit of 6 inches, or of 5 or even of 4 inches on this species can serve only to give it complete or almost complete protection.

Protecting this sunfish apparently has no beneficial effects, and may be decidedly harmful to fishing conditions, for panfish, in certain inland lakes. The long-eared sunfish must to a considerable degree compete with the

IX

Table ~~VIII.~~ Distribution of specimens of long-eared sunfish according to total length in inches, maturity and legal size.

Total length including caudal fin in inches

Summer of Life	Growing Season, days	1.2-1.4	1.5-1.7	1.8-2.0	2.1-2.3	2.4-2.6	2.7-2.9	3.0-3.2	3.3-3.5	3.6-3.8	3.9-4.1	4.2-4.4	4.5-4.7	4.8-5.0	5.1-5.3	5.4-5.6	Total
	110-130	5	26	28	1	-	-	-	-	-	-	-	-	-	-	-	60
Second	130-150	2	23	22	9	2	1	-	-	-	-	-	-	-	-	-	59
	150-180	4	2	14	26	9	1	2	1	-	-	-	-	-	-	-	59
	110-130	-	10	23	34	30	21	8	-	-	-	-	-	-	-	-	126
Third	130-150	-	-	-	5	11	6	1	1	1	1	-	-	-	-	-	26
	150-180	-	-	-	28	48	19	21	19	3	4	-	-	-	-	-	142
	110-130	-	-	2	11	14	24	8	10	1	-	-	-	-	-	-	70
Fourth	130-150	-	-	-	-	5	3	4	2	1	-	-	-	-	-	-	15
	150-180	-	-	-	-	-	3	4	11	5	9	3	-	-	-	-	35
	110-130	-	-	-	-	7	26	21	15	2	1	-	-	-	-	-	72
Fifth	130-150	-	-	-	-	1	2	3	5	-	-	-	-	-	-	-	11
	150-180	-	-	-	-	-	-	1	12	3	5	5	1	1	-	-	28
	110-130	-	-	-	2	4	1	2	1	-	-	1	-	-	-	1	12
Sixth	130-150	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	2
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	110-130	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	3
Seventh	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2
	110-130	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	2
Eighth	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	110-130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ninth	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	110-130	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Tenth	130-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	150-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	110-130	5	36	53	48	55	72	39	26	6	3	2	-	-	-	1	346
ALL	130-150	2	23	22	14	19	12	9	8	3	1	-	-	-	1	-	114
AGES	150-180	4	2	14	54	57	23	28	43	11	18	8	1	2	2	-	267
TOTALS	ALL	11	61	89	116	131	107	76	77	20	22	10	1	2	3	1	727

Almost all immature

Almost all mature

pumpkinseed and bluegills sunfishes for food and for spawning grounds. The competition for food between the adults of the long-eared sunfish and the half-grown of the larger species must be rather severe, especially when the long-eared sunfish becomes abundant. It does in fact tend to swarm in certain inland lakes. In all probability the complete protection accorded this species by the law has been conducive to its increase. The larger and better sunfish species have suffered a drain and depletion, while the dwarf species has been favored.

It is true that the longeeared sunfish is not generally distinguished from the larger species by the public. It is claimed that a special size limit on this fish would lead to confusion in the enforcement of the law. Our recommendation is that it be removed from the list of game fish entirely, and that the legal limit for sunfish be specified as applying to the pumpkinseed and the bluegill. This would allow cottagers (and their children) to remove the excess of the long-eared sunfish when it becomes over-abundant, after they have learned the identity of the dwarfed species.

Preliminary studies indicate that the green sunfish (Apomotis cyanellus) is very similarly dwarfed in Michigan. We recommend that it also be removed from the list of game fish as defined by law, and that it be made clear that no legal size limit applies to it. The green sunfish, on account of its large mouth and voracious feeding habits, is obviously a dangerous competitor of the larger species.

VII. Summary

1. This study was based on the examination of the scales of 727 long-eared sunfish (*Xenotis megalotis peltastes*) from Michigan, using methods becoming standard.

2. This species becomes progressively more dwarfed toward the north in Michigan, in good correlation with a shortened growing season and lower mean temperature. Greatest age is probably attained in the region of greatest dwarfing.

3. There is no evidence for "growth compensation". In 3 genera of Centrarchidae, a positive correlation exists between the growth of the first and of the second year.

4. In *Xenotis* as in other centrarchids the male grows faster than the female. This unusual relation may be an adaptation, as larger size would be of advantage to these nest guarding fishes. In the Cyprinidae males grew larger than the females in the species in which the male guards the eggs.

5. Attainment of maturity is related to age (usually just two years) rather than size. A definite spawning mark is produced on the scale. Spine growth (prior to spawning) is usually more vigorous than late summer and fall growth.

6. As the long-eared sunfish does not attain its designated legal size in Michigan, and does not usually reach even 4 inches in total length, it is not in need of protection. The legal protection may be harmful, as this species is protected at the expense of the better larger panfish, and tends to become over-abundant.

Literature Cited

Barney, R. L., and Anson, B. J. 1923. Life History and Ecology of the Orange-spotted Sunfish Lepomis humilis. Rep. U. S. Comm. Fish., 1922, App. 15: 1-16, figs. 1-6.

Bolen, Homer R. 1924. The Relation of Size to Age in Some Common Fresh-water Fishes. Proc. Ind. Acad. Sci., 33, 1923: 307-309, figs. 1-4.

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.

Greeley, John R. [1930] A contribution to the biology of the Horned Dace, Semotilus atromaculatus Mitchill. Abstract of Thesis, Cornell Univ.: 4 pp.

Hile, Ralph. 1931. The Rate of Growth of Fishes in Indiana. Investigations of Indiana Lakes, 2: 7-55, figs. 1-4.

Hubbs, Carl L. 1926. A Check-List of the Fishes of the Great Lakes and Tributary Waters, with Nomenclatorial Notes and Analytical Keys. Univ. Mich. Mus. Zool. Misc. Publ. 15: 1-77, pl. 1-4.

————and Hubbs, Laura C. 1931. Increased Growth in Hybrid Sunfishes. Pap. Mich. Acad. Sci., Arts and Letters, 13, for 1930: 291-301, figs. 45-46.

———— ———— 1933. The Increased Growth, Predominant Maleness and Apparent I_n fertility of Hybrid Sunfishes. Ibid., 17, for 1932: 613-641, figs. 69-71, pls. 64-65.

Potter, George E. 1925. Scales of the Bluegill, Lepomis pallidus (Mitchell). Tran. Am. Micro. Soc., 44: 31-37, fig. 1, pl. 3.

Seeley, Dewey A. 1922. Michigan Agriculture. 3. Climate: 1-46, charts 1-16.

Tester, Albert L. 1932. Rate of Growth of the Small-mouthed Black Bass (Micropterus dolomieu) in Some Ontario Waters. Publ. Ont. Fish. Res. Lab., 47: 205-221, fig. 1, 2, pl. 1.

Van Cleave, Harley J., and Markus, Henry C. 1929. Studies on the Life History of the Blunt-nosed Minnow. Am. Nat., 63: 530-539, figs. 1-3.

Wright, Stillman. 1929. A Preliminary Report on the Growth of the Rock Bass, Ambloplites rupestris (Rafinesque), in Two Lakes of Northern Wisconsin. Trans. Wisc. Acad. Sci., Arts, and Letters, 24: 581-595, fig. 1.