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AGE, GROWTH, AND SUITABILITY FOR PROPAGATION OF THE GOLDEN SHINER (Notemigonus crysoleucas auratus)

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Growth rate studies were made by the scale method on Golden Shiners (Notemigonus crysoleucas auratus) from several Michigan localities. The localities, dates on which the collections were made, and the average sizes of the specimens of each age group, are indicated in Table I. The variation in growth rate within the state is marked. As Hubbs and Cooper (1935) found for the Longeared Sunfish (Xenotis megalotis peltastes) and the Green Sunfish (Apomotis cyanellus) in Michigan, there is a correlation between the growth rate of the Golden Shiners and two climatic gradients indicated by Seeley (1922), namely: (1) the average number of days in the growing season (from the last killing frost in spring to the first killing frost in autumn), and (2) the mean annual temperature. Golden Shiners grow faster in the warmer lakes of southern Michigan than they do in the colder lakes in the northern part of the state (Table I and Figure 1).

The Huron River series of May 19, 1934, obtained by the writer with the aid of Dr. Henry Vander Schalie, proved especially adequate for growth rate studies. At the time this collection was obtained there was a great concentration of this minnow in the Huron River just below the power dam at Ypsilanti. One haul with a 25' seine yielded the 541 specimens of Golden Shiners together with several hundred sunfish, crappie, carp, etc. Since the entire lot was preserved, the group of shiners used in this study represents a random sample of the crowded population.

The growth rate of this Huron River series is summarized in Table II and Figs. 2 and 3. The scales of only two specimens of this series (one each of the I and II year

Table I. Growth rate of Golden Shiners from Michigan localities.

The collections are grouped according to the length of growing season and to the mean annual temperature. The average standard length in millimeters for each age group is given for each locality. The inferior number appended to each average is the number of specimens upon which the average is based.

Growing season; Mean Temp., County Lake or Stream; Date	Winter marks 0	I	II	III	IV	V	VI	VII
110-140 days; 39°-45°F.								
Luce Co.:								
Killhain L.; VI:23	....	32.3_{7}	53.8_{11}	61.5_{34}	65.8_{9}	....	....	....
Kalkaska Co.:								
Perch L.; VII:5	....	....	....	105.7_{6}	107.6_{5}	116.0_{1}	....	....
Indian L.; VII:13	....	....	88.0_{1}	110.1_{12}	122.5_{2}	120.0_{1}	....	....
Bass L.; IX:4	....	....	....	....	101.0_{1}	125.3_{4}	....	....
Bass L.; VII:27	....	....	....	....	116.0_{1}	126.0_{1}	123.5_{2}	....
East L.; IX:1	....	....	....	107.0_{2}	....	120.5_{4}	125.5_{2}	133.5_{2}
Manistee Co.:								
Manistee R.; IV:14	....	34.4_{26}	54.3_{40}	65.3_{7}	75.2_{6}	93.5_{2}	....	....
Iosco Co.:								
Cooks Dam; VI:11	....	....	....	98.0_{10}	102.0_{4}	113.3_{3}	....	....
Alcona Co.:								
Alcona Dam; VI:6,7	....	57.2_{4}	70.3_{9}	82.9_{8}	90.0_{2}	....	....	....
Gladwin Co.:								
Ross L.; VI:26	....	48.1_{49}	69.5_{4}	....	....	....	....	....
140-180 days; 45°-50°F.								
Newaygo Co.								
Nichols L.; IX:16	....	....	....	121.1_{8}	....	....	....	....
Ingham Co.:								
Jones L.; VI:24	....	....	....	114.0_{1}	....	131.0_{1}	....	....
Kent Co.								
Hatchery; Spring	....	....	....	....	....	....	192.0_{1}	....
Jackson Co.:								
Watkins L.; IX:29	41.1_{48}	69.4_{62}	95.0_{10}	111.0_{1}	....	....	....	....
Washtenaw Co.:								
Third Sister L.; VI:21	....	55.3_{3}	....	129.3_{3}	133.7_{3}	....	....	....
Huron R.; V:8	....	56.3_{79}	101.7_{3}	....	....	....	....	....
Huron R.; V: 19	....	71.0_{302}	91.6_{170}	101.9_{53}	115.7_{14}	126.5_{2}	....	....
Wayne Co.								
Edison L.; VI:24	....	.....	121.2_{6}	117.0_{1}	....	....	....	....
Van Buren Co.:								
Eagle L.; V:14	....	....	....	....	....	....	183.0_{1}	....
Lenawee Co.:								
Dewey L.; IV:29	....	....	....	....	172.0_{1}	170.0_{2}	177.0_{1}	....
110-140 days; 39°-45°F.								
Summary	....	43.1_{86}	57.9_{65}	80.5_{79}	87.7_{30}	117.0_{16}	124.5_{4}	133.5_{2}
140-180 days; 45°-50°F.								
Summary	41.1_{48}	68.1_{446}	92.9_{189}	105.9_{67}	121.8_{18}	137.0_{5}	184.0_{3}	....
All localities								
Grand summary	41.1_{48}	64.0_{532}	83.9_{254}	92.2_{146}	100.5_{48}	121.8_{21}	150.0_{7}	133.5_{2}

Table II. Size frequencies for each age group of Golden Shiners taken from the Huron River at Ypsilanti on May 19, 1934

Standard length, in mm.	Winter marks I ♂	I ♀	II ♂	II ♀	III ♂	III ♀	IV ♂	IV ♀	V ♂	V ♀
46-48	...	2	...	...	...	...	...	...	...	...
49-51	1	...	...	...	...	...	...	...	...	...
52-54	1	1	...	...	...	...	...	...	...	...
55-57	...	5	...	...	...	...	...	...	...	...
58-60	8	7	...	...	...	...	...	...	...	...
61-63	20	11	...	...	...	...	...	...	...	...
64-66	17	16	...	...	...	...	...	...	...	...
67-69	27	15	...	...	...	...	...	...	...	...
70-72	21	18	...	...	...	...	...	...	...	...
73-75	28	10	...	...	...	...	...	...	...	...
76-78	24	15	2	...	...	...	...	...	...	...
79-81	18	15	3	...	...	...	...	...	...	...
82-84	6	7	9	4	...	...	1	...	...	...
85-87	3	4	11	10	2	...	...	...	...	...
88-90	1	1	23	14	3	1	...	...	...	...
91-93	...	...	21	16	4	1	...	...	...	...
94-96	...	...	12	17	1	6	...	...	...	...
97-99	...	...	2	9	1	3	...	...	...	...
100-102	...	...	2	10	1	3	...	...	...	...
103-105	...	...	1	1	1	6	1	...	...	...
106-108	...	...	...	1	1	6	...	1	...	...
109-111	...	...	...	...	1	5	1	2	...	...
112-114	...	...	...	...	...	3	1	1	...	...
115-117	...	...	1	1	1	2	...	...	...	...
118-120	...	...	...	...	...	1	...	1	...	...
121-123	...	...	...	...	...	...	...	2	...	1
124-126	...	...	...	...	...	...	...	...	...	...
127-129	...	...	...	...	...	...	...	...	...	...
130-132	...	...	...	...	...	...	...	1	...	1
133-135	...	...	...	...	...	...	...	1	...	1
136-138	...	...	...	...	...	...	...	...	...	...
139-141	...	...	...	...	...	...	...	...	...	...
142-144	...	...	...	...	...	...	...	1	...	...
Average length in mm.[1]	71.2	70.7	89.9	93.4	96.3	104.3	102.8	120.8	...	126.5
No. specimens	175	127	87	83	16	37	4	10	...	2

[1] The average lengths were calculated from the frequencies for each millimeters size group, not from the frequency classes given in this table.

groups) show growth in the 1934 growing season. Thus the last growing season of each age group can be considered as finished and the designated ages refer to completed growing seasons. Compared to the growth in other localities, this Huron River series of young Golden Shiners had an excellent growth during the summer of 1933. In general, scales of the two-year-old fish indicated a large growth in 1933, but their growth as young in 1932 was much less than growth of the young of 1933. This seems to indicate that conditions were better for this species during the summer of 1933 than during 1932. Maturity and the growth rate of the first year appear to be closely related; that is, in any one locality, maturity is determined by size rather than age[1]. The larger young are the first to reach maturity, which is accompanied by a noticeable slackening in growth rate. In this large Huron River series, scales of the two-year-old specimens indicated that those ~~shiner~~ shiners which attained a large size in their first year and which apparently reached maturity early in their second summer, made a small growth in their second year. Conversely those shiners which attained a small growth during their first summer (as was true of most of this II year class), were apparently immature during most, if not all of their second summer, during which they made a rapid growth. This species therefore appears to show the phenomenon of growth compensation.

All of the specimens of this Huron River series in the II to V year groups were mature and would have spawned during the season in which they were collected. The ova in all of the females of these four year groups were approximately of the same size (about 0.5 mm. in diameter). If the size of eggs contained in the ovaries is an indication of the stage of maturity, then all of the one-year-old females, with the exception of a few of the smaller individuals, would have spawned in their second summer. These deductions relative to maturity hold, in a similar way, for the males. The big difference between the various age groups of females was in the size of the ovaries and the number of eggs which they contained rather than in the size of the eggs.

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[1] This principle, however, does not appear to be of universal application to the species. Hubbs (1921) mentioned that most of the greatly dwarfed Golden Shiners of San Diego River, California, become mature at the end of their first year of life.

Table III. Average standard lengths in millimeters of the two sexes of Golden Shiners in those age groups containing both sexes.

The inferior number appended to each average is the number of specimens upon which the average is based.

Locality	Date	Winters of life I ♂	I ♀	II ♂	II ♀	III ♂	III ♀	IV ♂	IV ♀	V ♂	V ♀
Killhain L.	VI:23	41.5_{2}	29.7_{3}	54.0_{9}	53.0_{2}	57.0_{1}	61.6_{33}	....	....	....	....
Manistee R.	IV:14	....	....	55.3_{21}	53.2_{19}	68.0_{2}	64.2_{5}	....	....	....	....
Alcona Dam	VI:6,7	57.3_{3}	57.0_{1}	68.5_{2}	70.8_{7}	....	....	....	....	....	....
Ross L.	VI:26	47.2_{24}	49.0_{25}	68.0_{1}	70.0_{3}	....	....	....	....	....	....
Nichols L.	IX:16	....	....	....	....	125.8_{4}	116.3_{4}	....	....	....	....
Jones L.	VI:24	....	....	....	....	....	....	....	....	135.0_{1}	127.0_{1}
Watkins L.	IX:29	69.1_{33}	69.7_{29}	96.8_{5}	93.2_{5}	....	....	....	....	....	....
Third Sister L.	VI:21	....	....	....	....	123.0_{1}	132.5_{2}	124.0_{1}	138.5_{2}	....	....
Huron Rφ.	V:8	56.2_{28}	56.4_{51}	....	....	....	....	....	....	....	....
Huron R.	V:19	71.2_{175}	70.7_{127}	89.9_{87}	93.4_{83}	96.3_{16}	104.3_{37}	102.8_{4}	120.8_{10}	....	....
Edison L.	VI:24	....	....	116.0_{2}	123.8_{4}	....	....	....	....	....	....

In the warmer waters of the southern part of the state most Golden Shiners reach maturity early in their second summer. In the colder waters of the northern part of the state, maturity is usually delayed until the third summer. The approximate size at which maturity is reached is 50 to 70 millimeters standard length or 2 1/2 to 3 1/2 inches in total length.

This species exhibits a sexual dimorphism in growth rate. The females grow faster than the males (see Tables II and III, and figs. 2 and 3). Although the Huron River series was the only one large enough to demonstrate this difference in the growth rate of the sexes, it is assumed that the dimorphic growth rate is characteristic of the species. Since this difference in growth rate first manifests itself in the second year of life, coincident with the first year of maturity, it is probable that these two phenomena are related.

Female Golden Shiners are distinctly more viable than the male (see Table IV). The aberant sex ratio in the older age groups is not due to ease in catching spawning females, for the two sexes are represented in equal numbers in the two-year-group (third summer), of which practically all females are mature. A sudden drop in the number of males occurs following the third summer, and males older than four summers (three winters) are rare.

Table IV. The numbers of each sex of Golden Shiners in each age group, from all Michigan localities.

	Winters of life						
	I	II	III	IV	V	VI	VII
Males	263	127	24	5	1	..	..
Females	236	127	121	42	21	6	2

This minnow, in the light of present knowledge, is one of the best suited for pond propagation, to furnish forage fish at hatcheries and to provide bait minnows. One drawback of the western form as a bait minnow for propagation is that it seldom reaches a large enough size (4 inches or more) for bass and pike bait during its first year of life. Therefore the hatch of one year would generally need to be carried over a winter to reach

this desired size during the second summer, in the southern part of Michigan. Farther north it would often require holding the fish over two winters to produce this size, unless faster growth can be induced by bettered conditions or by selective breeding.

II

Growth studies were made on four collections of the eastern subspecies of the Golden Shiner (Notemigonus crysoleucas crysoleucas), to determine if this eastern form is an appreciably faster growing, hence a better forage and bait minnow species than the western subspecies auratus. The dates and localities of these New York collections, and the average standard length in millimeters for each age group are indicated in Table V. The Cooper's Pond collection was made with a 100 ft. seine; the Bachus pond collection with a short seine and a gill net; and the Knickerbocker Lake and Snyder Lake collections with gill nets. Because of the size-selectivity of the methods of collecting, and because of the small number of specimens in these collections, no extensive generalizations on the life-history of this eastern subspecies will be made at this time. These data are given solely to show the general trend in growth rate.

On the basis of the data presented in this paper a summary of the growth of these two subspecies is given at the end of Table V. These data indicate that the two forms grow at approximately the same rate for the first four summers, after which the growth of the eastern subspecies (crysoleucas) is somewhat faster than that of the western subspecies (auratus). One of the chief advantages of the eastern form over the western form, as a forage species, would be that larger breeders could be used. Since the eastern subspecies is markedly a heavier-bodied fish, it might be expected to give a greater production in weight, in pond culture, than the western subspecies.

Table V. Growth of the eastern form of the Golden Shiner (*Notemigonus crysoleucas crysoleucas*).

The four localities listed in this table are in the Hudson River drainage in New York State. These New York specimens were obtained during 1934. The average standard length in millimeters is given for each sex in each age group for these localities. A summary of the New York localities (eastern subspecies *crysoleucas*) and the Michigan localities (western subspecies *auratus*) is given for each age group, at the bottom of the table.

County Pond or Lake; Date	Winters of life 0		I		II		III		IV		V		VI		VII		IX	
	♂+♀		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Columbia																		
Bachus Pond, VIII:6	38.5		....	....	....	....	....	149.0	....	....	....	168.4	140.0	187.0	....	....	207.0	....
No. specimens	24		....	....	....	....	....	1	....	....	....	5	1	1	....	....	1	....
Knickerbocker L.,IX:10	....		....	....	....	....	....	....	....	....	168.8	171.0	....	....	....	....	....	....
No. specimens	....		....	....	....	....	....	....	....	....	4	4	....	....	....	....	....	....
Rensselaer																		
Cooper's Pond, IX:9	....		73.0	....	85.0	....	83.0	92.1	....	....	....	....	....	....	....	....	....	....
No. specimens	....		1	....	2	....	6	12	....	....	....	....	....	....	....	....	....	....
Snyder's L., VIII:28	....		....	....	....	....	151.0	....	....	....	166.0	167.4	....	169.0	....	....	....	....
No. specimens	....		....	....	....	....	1	....	....	....	4	7	....	1	....	....	....	....
All New York localities	38.5		73.0	....	85.0	....	92.7	96.5	....	....	167.4	168.6	140.0	178.0	....	....	207.0	....
No. specimens	24		1	....	2	....	7	13	....	....	8	16	1	2	....	....	1	....
	♂+♀		♂+♀		♂+♀		♂+♀		♂+♀		♂+♀		♂+♀		♂+♀		♂+♀	
All New York localities	38.5		73.0		85.0		95.2		....		168.2		165.3		....		207.0	
No. specimens	24		1		2		20		....		24		3		....		1	
All Michigan localities	41.1		64.0		83.9		92.2		100.5		121.8		150.0		133.5		....	
No. specimens	48		532		254		146		48		21		7		2		....	

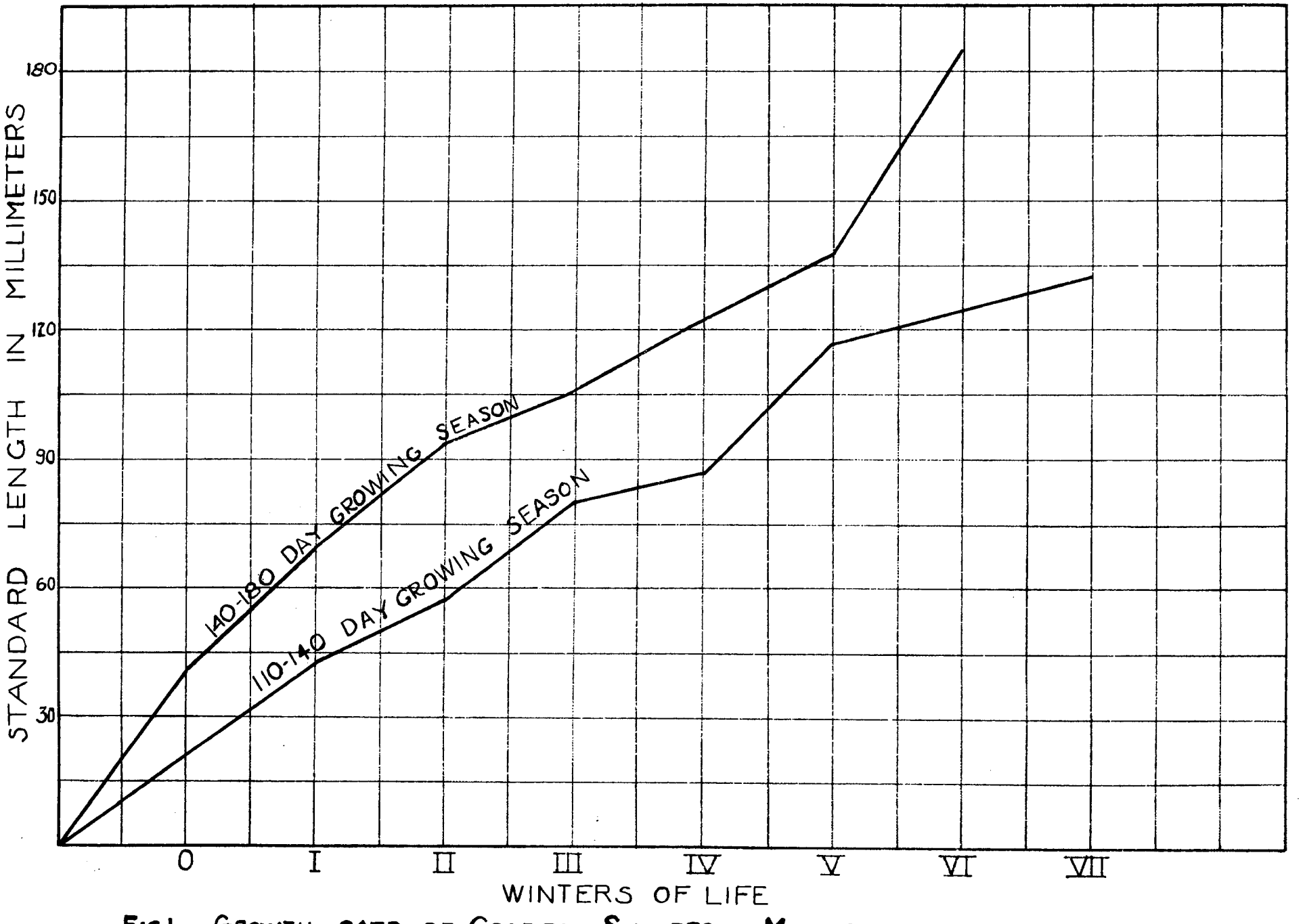

FIG. 1. GROWTH RATE OF GOLDEN SHINERS IN MICHIGAN, CORRELATED WITH THE AVERAGE NUMBER OF DAYS IN THE GROWING SEASON.

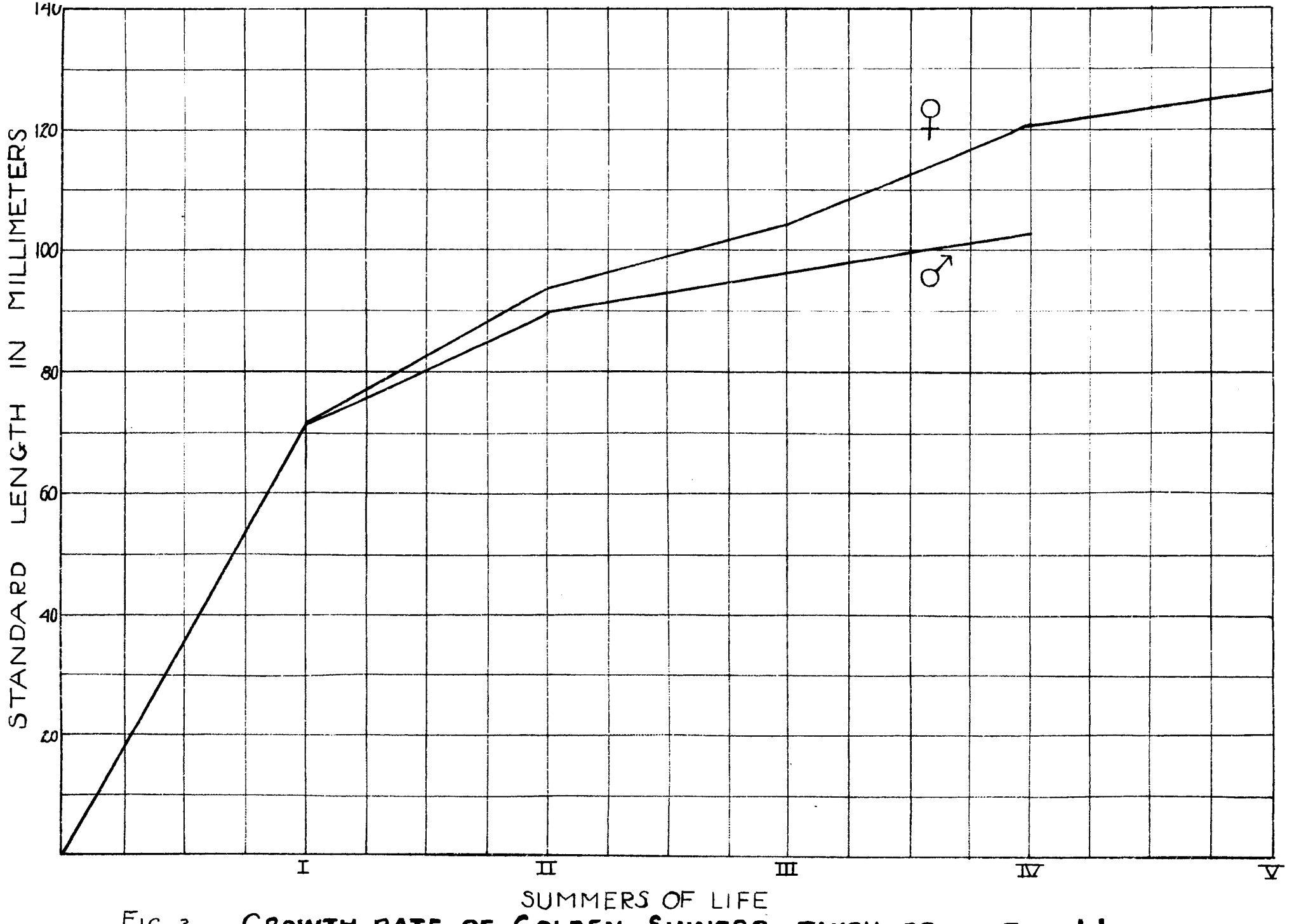

FIG. 2. GROWTH RATE OF GOLDEN SHINERS TAKEN FROM THE HURON RIVER AT YPSILANTI ON MAY 19, 1934. THE AVERAGE SIZE OF EACH AGE GROUP FOR EACH SEX IS PLOTTED.

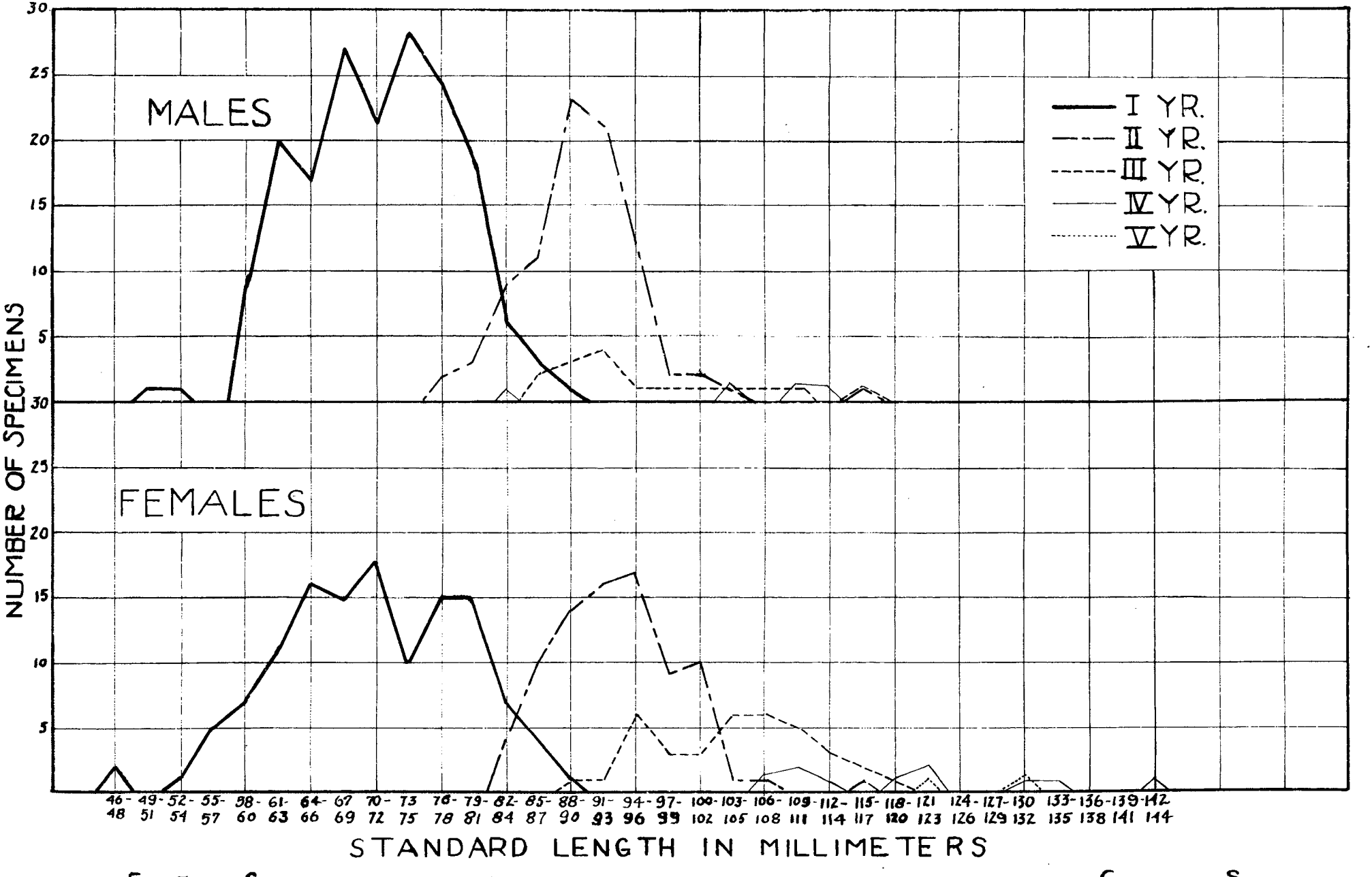

FIG. 3 SIZE FREQUENCY GRAPHS OF THE AGE GROUPS IN EACH SEX OF GOLDEN SHINERS TAKEN FROM THE HURON RIVER AT YPSILANTI ON MAY 19, 1934. DATA GIVEN IN TABLE IV.