'95. The influence of the environment on the early stages of embryonic development. Science, I, 36.

Wilson, W. P., '94. The influence of external conditions on plant life. Biological Lectures, 1893, pp. 163–185. Boston, 1894.

Windle, B. C., '89. Report on a discussion on the transmission of acquired characters. Nature, XL, 609.

'89a. A note on the *musculus sternalis*. Anat. Anz., IV, pp. 715–719.

'90. On some cranial and dental characters of the domestic dog. Proc. Zoöl. Soc , Jan. 1890.

'90a. Terratological evidence as to the heredity of acquired conditions. J. Linn. Soc. Zoöl., XXIII, pp. 448–502.

Wortman, J. L., '93. A new theory of the mechanical evolution of the metapodial keels of Diplarthra. Am. Nat., XXVII, p. 421.

Zenneck, J., '94. Die Anlage der Zeichnung u. deren physiologische Ursachen bei Ringelnatterembryonen. Zeitsch. W. Zoöl., LVIII, pp. 364–393.

VARIATION OF NORTH AMERICAN FISHES. II.

The Variation of Etheostoma Caprodes Rafinesque in Turkey Lake and Tippecanoe Lake.* By W. J. Moenkhaus.

Introduction.—In a former paper on the "Variation of *Etheostoma caprodes* Rafinesque" (Am. Nat., Aug., 1894), I determined the geographical distribution of this fish and the geographical variation of its color-pattern and fins.

It was found that this species inhabits practically all the fresh waters of the Atlantic slope east of the 100th meridian and west of the Alleghany Mountains. Its northern and eastern limits are the Great Lakes and Lake Champlain; its southwestern, the Rio Grande in the extreme southern part of Texas.

The following conclusions were reached among others:

1. Each river system from which specimens were examined possesses a peculiar variety. This peculiarity is most striking in the color-pattern.

2. All the variations are continuous.

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*Contributions from the Zoölogical Laboratory of the Indiana University under the direction of C. H. Eigenmann, No. 18.

3. The variation in the anal rays and dorsal spines are determinate with the latitude, the southern specimens having a slightly larger number of rays and spines.

4. The color-pattern variations are determinate, varying through definite stages from a simple to more complex pattern.

In Table A and B are given the data on the anal rays and dorsal spines. The localities are arranged in the order of their latitude from north to south. From these we see that there is both an increase in the average number of rays and spines and in the number that prevails in each case from north to south. In the anal fin 10 is the prevailing number north, and 11 and 12 south, of the Ohio River. Fourteen and fifteen are the prevailing number of dorsal spines in the north and 15, 16 and 17 in the south.

TABLE A.

LOCALITY.	Number of Specimens.	Average Number of Anal Rays.	Number of Specimens with 10 Rays.	Number of Specimens with 11 Rays.	Number of Specimens with 12 Rays.
Torch Lake, Mich	7	$10\frac{1}{7}$	6	1	.....
Cedar Rapids, Iowa	1	12	.....	.....	1
White River, at Indianapolis	1	10	1	.....	.....
Gosport, Ind	5	10	5	.....	.....
Bean Blossom, Ind	17	$10\frac{9}{17}$	8	9	.....
Rushville, Ind	1	10	1	.....	.....
Wild Cat Creek, Ind	1	11	.....	1	.....
Pike Creek, Ind	2	11	.....	2	.....
Illinois	1	10	1	.....	.....
Nipisink Lake, Ill	2	$10\frac{1}{2}$	1	1	.....
Monongahela River	1	10	1	.....	.....
Hartford, Ky	4	$10\frac{1}{4}$	3	1	.....
Green River, Greensburg, Ky	3	$10\frac{2}{3}$	1	2	.....
Little Barren River, Osceola, Ky	4	11	.....	4	.....
Little South Fork Cumberland River, Wayne County, Ky	1	11	.....	1	.....
Eagle Creek, Olympus, Tenn	2	11	.....	2	.....
Obeys River, Elizabethtown, Tenn	13	$11\frac{6}{13}$	1	5	7
Watauga River, Elizabethtown, Tenn	2	$10\frac{1}{2}$	1	1	.....
North Fork Holston River, Saltville, Va	1	12	.....	.....	1
Eureka Springs, Ark	1	.....	.....	.....	.....
Chocola Creek, Oxford, Ala	4	$11\frac{1}{4}$	.....	3	1
San Marcos Springs, Tex	2	11	.....	2	.....

TABLE B.

LOCALITY.	Number of Specimens.	Average Number of Dorsal Spines.	Number of Specimens with 13 Rays.	Number of Specimens with 14 Rays.	Number of Specimens with 15 Rays.	Number of Specimens with 16 Rays.	Number of Specimens with 17 Rays.
Torch Lake, Mich.	7	$14\frac{1}{7}$	....	3	4	....	....
Cedar Rapids, Iowa	1	14	....	1	....	....	....
White River, at Indianapolis	1	14	....	1	....	....	....
Gosport, Ind.	5	$14\frac{4}{5}$	....	1	4	....	....
Bean Blossom, Ind.	17	$14\frac{6}{17}$	1	9	7	....	....
Rushville, Ind.	1	14	....	1	....	....	....
Wild Cat Creek, Ind	1	15	....	....	1	....	....
Pike Creek, Ind	2	$14\frac{1}{2}$	....	1	1	....	....
Illinois	1	15	....	....	1	....	....
Nipinsik Lake, Ill.	2	$14\frac{1}{2}$	....	1	1	....	....
Monongahela River	1	15	....	....	1	....	....
Hartford, Ky.	4	15	....	1	2	1	....
Green River, Greensburg, Ky	3	15	....	....	3	....	....
Little Barren River, Osceola, Ky.	4	15	....	1	2	1	....
Little South Fork Cumberland River, Wayne County, Ky	1	16	....	....	....	1	....
Eagle Creek, Olympus, Tenn	2	$16\frac{1}{2}$	....	....	....	1	1
Obeys River, Elizabethtown, Tenn.	13	$16\frac{6}{13}$	....	....	2	3	8
Watauga River, Elizabethtown, Tenn	2	$15\frac{1}{2}$	....	....	1	1	....
North Fork Holsten River, Saltville, Va	1	16	....	....	....	1	....
Eureka Springs, Ark	1	16	....	....	....	1	....
Chocola Creek, Oxford, Ala.	4	$15\frac{1}{2}$	....	....	2	2	....
San Marcos Springs, Tex	2	$13\frac{1}{2}$	1	1	....	....	....

The color-pattern varies from a probably primitive, simple pattern consisting of alternate whole and half cross-bars distributed along the entire length of the body through the pattern consisting of whole, half and quarter bars, having an incomplete longitudinal series of lateral spots to a pattern having a very prominent longitudinal series of dark lateral blotches with fine reticulations on the back. Between these different patterns all stages exist, so that they can be connected by regular steps. Those specimens inhabiting the lakes were found to possess a peculiar color-pattern. This was derived from the primitive, simple pattern by supposing the lower part of the whole bars to have become much broader than the upper part, and then to have shifted backwards slightly.

This lake variety (*manitou*, Jordan) is one of the most abundant of the fishes in Turkey and Tippecanoe Lakes, and upon it the results given in the following pages are based.

Six hundred specimens, all that were collected from Turkey Lake, and three hundred of those collected from Tippecanoe Lake, have been examined with a view, first, of making a comparison of this species in the two lakes, and second, of determining the range and character of its variation within Turkey Lake itself. The number of species collected from Tippecanoe Lake is much greater than 300, but this number was thought sufficient to give fairly good results. The effect of natural selection will be taken up at a later time.

Etheostoma caprodes has two dorsal fins, the first, a spinous one, well separated from the second, which is composed of soft rays. The anal fin is composed of two rather strong spines followed by a number of soft rays. The scales are very regularly arranged, so that they can be definitely counted along the complete lateral lines. The number of spines and rays in these fins, and the number of scales in the lateral line of both sides of the body have been determined. Besides these characters the presence or absence of scales on the nape has been determined. These structures have been taken because, with the exception of the last, they present definite, countable elements, so that in the results the personal factor is entirely eliminated.

Curves have been constructed to represent the variation in these structures. In all the curves the horizontal distances represent the countable elements, and the vertical distances the per cent. of specimens possessing these varying elements.

COMPARISON OF TURKEY LAKE AND TIPPECANOE SPECIMENS.

COLORATION.—The coloration of these fishes in the two lakes will be taken up in detail later. The color-pattern of Turkey Lake specimens is, on the whole, of a more blotched character than that of Tippecanoe Lake specimens, and shows a slighter affinity to the simple, primitive coloration characteristic of the Wabash River forms. The connection of Tippecanoe Lake with the Wabash River may account for this greater affinity.

SQUAMATION OF NAPE.—In Turkey Lake the nape is as a rule naked, while in Tippecanoe Lake it is usually scaled. Table I will bring out the difference.

TABLE I.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having no scales on nape	88.00	19.32
Per cent. of specimens having few scales on nape	8.00	23.87
Per cent. of specimens having several scales on nape	4.00	28.32
Per cent. of specimens having nape thinly scaled	0.20	16.67
Per cent. of specimens having nape closely scaled	0.00	11.74

Lateral Line.—The specimens of Turkey Lake have on an average two more scales in the lateral line. The average number for Turkey Lake is 89.46 for the left side, 89.74 for the right side; for Tippecanoe Lake, 87.69 for the left side, 87.45 for the right side. Fig. 1 represents the curves for the scales of the right side. The continuous line represents the conditions in Turkey Lake, and the broken line those of Tippecanoe Lake. It should be noticed that the entire curve for Turkey Lake is two units to the right of that of Tippecanoe Lake, showing that practically all the Turkey Lake specimens have a greater number of scales. Table II contains the summary of the counts for the scales in the lateral line.

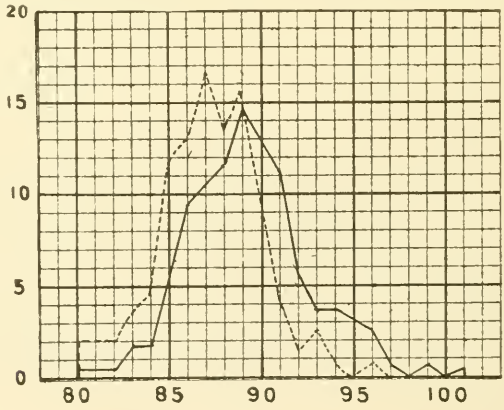

Fig. 1.

TABLE II.

	Turkey Lake.		Tipp'canoe Lake	
	Left Side.	Right Side.	Left Side.	Right Side.
Per cent. of specimens having 78 scales....	0.17	.....	.....	.....
Per cent. of specimens having 79 scales....	.....	.....	.....	.....
Per cent. of specimens having 80 scales....	0.17	0.34	.....	.....
Per cent. of specimens having 81 scales....	.....	0.34	0.50	.....
Per cent. of specimens having 82 scales....	0.17	0.34	1.00	2.00
Per cent. of specimens having 83 scales....	1.37	1.55	2.50	3.50
Per cent. of specimens having 84 scales....	3.44	1.89	7.00	4.50
Per cent. of specimens having 85 scales....	3.78	5.17	8.50	11.50
Per cent. of specimens having 86 scales....	6.88	9.30	11.50	13.00
Per cent. of specimens having 87 scales....	11.02	10.68	15.00	16.50
Per cent. of specimens having 88 scales....	12.56	11.55	15.00	13.50
Per cent. of specimens having 89 scales....	17.72	14.82	16.00	16.00
Per cent. of specimens having 90 scales....	12.39	12.93	11.50	10.50
Per cent. of specimens having 91 scales....	8.08	11.03	7.50	4.00
Per cent. of specimens having 92 scales....	6.53	5.67	1.50	1.50
Per cent. of specimens having 93 scales....	5.16	3.62	1.00	2.50
Per cent. of specimens having 94 scales....	3.61	3.78	0.50	0.50
Per cent. of specimens having 95 scales....	2.58	3.27	0.50	.....
Per cent. of specimens having 96 scales....	1.37	2.41	0.50	0.50
Per cent. of specimens having 97 scales....	1.03	0.51	.....	.....
Per cent. of specimens having 98 scales....	0.17	.....	.....	.....
Per cent. of specimens having 99 scales....	0.34	0.34	.....	.....
Per cent. of specimens having 100 scales....	.....	.....	.....	.....
Per cent. of specimens having 101 scales....	0.17	0.17	.....	.....
Per cent. of specimens having 102 scales....	0.17	.....	.....	.....
Per cent. of specimens having 103 scales....	0.17	.....	.....	.....

Anal fin.—The number of spines in the anal fin varies from the normal in only nine specimens from Turkey Lake and in six from Tippecanoe Lake. This variation is always toward a lower number, and extends only through one spine.

Turkey Lake specimens have on an average fewer rays in the anal than Tippecanoe Lake specimens. The averages are 10.87 for the former, 11.15 for the latter. Fig. 2 represents the curves for the anal rays. Here again, and also in the succeeding curves for the comparison of the two lakes, the continuous line represents Turkey Lake and the broken line Tippecanoe Lake. Table III gives the summary of the anal rays for both lakes.

The prevailing number of rays in both lakes is 11; 53 per cent. from Turkey lake, and 56 per cent. from Tippecanoe Lake having that number. The number of rays in the next highest per cent. is 10 for Turkey Lake and 12 for Tippecanoe Lake, about 27 per cent. in each case.

The range of variation is two greater in Turkey Lake. This may be due t the greater number of specimens from this lake.

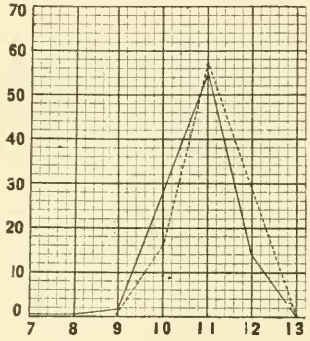

Fig. 2.

TABLE III.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 7 anal rays	0.16	.....
Per cent. of specimens having 8 anal rays	0.16	.....
Per cent. of specimens having 9 anal rays	1.48	0.77
Per cent. of specimens having 10 anal rays	26.80	15.50
Per cent. of specimens having 11 anal rays	53.43	56.21
Per cent. of specimens having 12 anal rays	14.13	27.13
Per cent. of specimens having 13 anal rays	0.49	0.35

Dorsal Spines.—Turkey Lake has on an average more dorsal spines, the average being 14.52 for Turkey Lake and 14.23 for Tippecanoe Lakes. Fig. 3 represents the curves for this structure. The range of variation is the same, from 12 to 17. Although the average number of spines differs but slightly in the two

lakes, the preferences shown for a given number of spines are quite different. In the Tippecanoe Lake specimens the preference is decidedly for 14. In the Turkey Lake specimens the preference is for 15, although not so decided. From Table IV and the curves, it will be seen that the number of individuals in Turkey Lake having 14 spines and 15 spines are about the same, 41 per cent. having 14 and 44 per cent., 15, while in Tippecanoe Lake this is not the case, 60 per cent. having 14, and only 25 per cent. having 15.

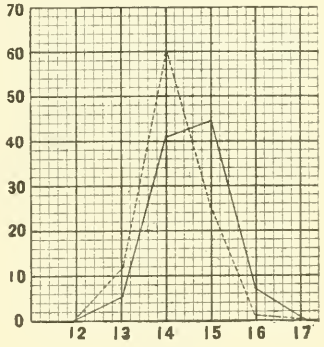

Fig. 3.

TABLE IV.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 12 dorsal spines	0.32	0.38
Per cent. of specimens having 13 dorsal spines	5.09	11.24
Per cent. of specimens having 14 dorsal spines	41.26	60.85
Per cent. of specimens having 15 dorsal spines	44.22	25.96
Per cent. of specimens having 16 dorsal spines	6.90	1.16
Per cent. of specimens having 17 dorsal spines	0.65	0.38

Dorsal Rays.—The average number of dorsal rays for Turkey Lake is 14.87, for Tippecanoe Lake, 16.40, the latter having on an average almost two more. The curves are given in Fig. 4. From this and Table V it will be seen that Turkey Lake specimens show a decided preference for 15 rays, while the Tippecanoe Lake specimens show just as decided a preference for 16 rays, 52 per cent. of the

specimens having these numbers in both lakes. The range of variation is two greater in Turkey Lake, from 12 to 18 as compared from 14 to 18 in Tippecanoe Lake. This again may be due to the greater number of specimens.

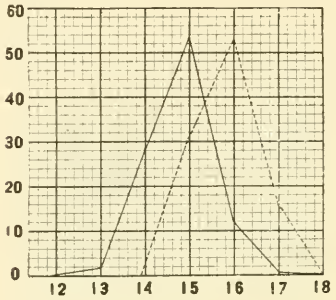

Fig. 4.

TABLE V.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 12 dorsal rays	0.32	.....
Per cent. of specimens having 13 dorsal rays	1.48	.....
Per cent. of specimens having 14 dorsal rays	28.77	3.48
Per cent. of specimens having 15 dorsal rays	52.26	31.78
Per cent. of specimens having 16 dorsal rays	12.16	52.32
Per cent. of specimens having 17 dorsal rays	1.64	15.11
Per cent. of specimens having 18 dorsal rays	0.16	0.77

Table VI presents all the combinations of dorsal spines and dorsal rays from both lakes. The spines are represented by Roman numbers and the rays by Arabic numbers. The commonest combination in Turkey Lake is XIV–15 and XV–15; XIV, XV, occurring most frequently in the spinous dorsal, and 15 most frequently in the soft dorsal. The per cent. of specimens having these combinations is 22.46 and 24.49 respectively. In Tippecanoe Lake, XIV–16 is the commonest combination, XIV being the prevailing number in the spinous dorsal and 16 in the soft dorsal. 32.11 per cent. of the specimens have this combination.

TABLE VI.

		From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having the combination	XII–14.....	0.16	.....
Per cent. of specimens having the combination	XII–15.....	0.16	.....
Per cent. of specimens having the combination	XII–16.....	.....	0.37
Per cent. of specimens having the combination	XIII–14.....	0.84	0.37
Per cent. of specimens having the combination	XIII–15.....	3.71	2.22
Per cent. of specimens having the combination	XIII–16.....	0.67	5.92
Per cent. of specimens having the combination	XIII–17.....	.....	2.59
Per cent. of specimens having the combination	XIV–12.....	0.16	.....
Per cent. of specimens having the combination	XIV–13.....	1.01	.....
Per cent. of specimens having the combination	XIV–14.....	11.99	1.48
Per cent. of specimens having the combination	XIV–15.....	**22.46**	20.37
Per cent. of specimens having the combination	XIV–16.....	5.74	**32.11**
Per cent. of specimens having the combination	XIV–17.....	0.33	6.66
Per cent. of specimens having the combination	XIV–18.....	.....	1.11
Per cent. of specimens having the combination	XV–13.....	0.67	.....
Per cent. of specimens having the combination	XV–14.....	13.51	1.85
Per cent. of specimens having the combination	XV–15.....	**24.49**	8.14
Per cent. of specimens having the combination	XV–16.....	5.40	14.44
Per cent. of specimens having the combination	XV–17.....	0.84	1.48
Per cent. of specimens having the combination	XV–18.....	0.16	.....
Per cent. of specimens having the combination	XVI–12.....	0.16	.....
Per cent. of specimens having the combination	XVI–13.....	0.16	.....
Per cent. of specimens having the combination	XVI–14.....	2.36	.....
Per cent. of specimens having the combination	XVI–15.....	3.04	1.11
Per cent. of specimens having the combination	XVI–16.....	0.84	0.37
Per cent. of specimens having the combination	XVI–17.....	0.33	.....
Per cent. of specimens having the combination	XVII–14.....	0.50	.....
Per cent. of specimens having the combination	XVII–15.....	.....	0.37
Per cent. of specimens having the combination	XVII–16.....	0.16	.....
Per cent. of specimens having the combination	XVIII–14.....	0.16	.....

In Table VII is given the variation in the two dorsal fins taken together. The average number for the two fins is 29.21 for Turkey Lake and 30 for Tippecanoe Lake. In Turkey Lake 36.82 per cent. have the average number; in Tippecanoe Lake, 41.8 per cent. The range of variation in the fins separately is six for the spinous dorsal and five for the soft dorsal in Tippecanoe Lake, and seven in each dorsal fin in Turkey Lake. With an exception in the spinous dorsal in Tippecanoe Lake the range of variation is, in each case, one greater for the two fins taken together, than for the fins separately. Although the extent of variation is only one greater for the two fins together, the per cent. of specimens having the average number is much smaller than the per cent. of specimens having the average

number in the fins separately. In Turkey Lake nearly 37 per cent. have the average number of the fins taken together, while 44 per cent. and 52 per cent. have the average number in the spinous and soft dorsal respectively. In Tippecanoe Lake 41 per cent. have the average number for both fins, while 52 per cent. and 61 per cent. have the average number in the spinous and soft dorsals respectively.

TABLE VII.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 26 rays in the dorsals	0.33	.....
Per cent. of specimens having 27 rays in the dorsals	2.02	0.37
Per cent. of specimens having 28 rays in the dorsals	16.38	4.07
Per cent. of specimens having 29 rays in the dorsals	36.82	28.15
Per cent. of specimens having 30 rays in the dorsals	32.59	41.80
Per cent. of specimens having 31 rays in the dorsals	9.28	22.22
Per cent. of specimens having 32 rays in the dorsals	1.85	3.33
Per cent. of specimens having 33 rays in the dorsals	0.67	.....

SUMMARY.

1. This species is equally abundant in the two lakes.

2. The color pattern of Tippecanoe Lake specimens shows a greater affinity for the primitive, simple Wabash River pattern than does that of Turkey Lake specimens.

3. In Turkey Lake the nape is usually naked; in Tippecanoe Lake the nape is usually scaled.

4. Tippecanoe Lake specimens have a smaller number of scales in the lateral line.

5. The anal spines vary but little, and show the same variation in the two lakes.

6. The anal fin is somewhat larger in the Tippecanoe Lake specimens.

7. Turkey Lake specimens have one more dorsal spine.

8. Tippecanoe Lake specimens have one more dorsal ray, 16 rays is the mean in Tippecanoe Lake and 15 in Turkey Lake.

9. The combinations of the dorsal spines and rays are determined by the numbers that prevail in the fins separately.

10. The range of variation in the total number of dorsal spines and rays combined is one greater than the variation in the fins separately.

11. The number occurring most frequently is 29 in Turkey Lake and 30 in Tippecanoe Lake.

12. The preference shown for a given number is less decided for the two dorsal fins taken together than for the dorsal fins taken separately.

13. The variation is in all cases continuous.

THE VARIATION IN TURKEY LAKE.

Many of the facts on the extent and character of the variation of the 600 specimens from Turkey Lake, taken as a whole, have been given in the preceeding.

The lengths of the 660 specimens from Turkey Lake were measured and upon comparison were found to fall into three quite distinct groups. Fig. 5 represents the curve for all. Each of the smaller horizontal distances represents one mm. and each of the larger verticle distances one per cent. The sizes ranged from 27 mm. to 102 mm. The first group ranges from 27 mm. to 60 mm.; the second from 60 mm. to 80 mm., and the third from 79 mm. to 103 mm. The three curves of Fig. 5 represent these three groups. I have watched the growth during the first summer, and know the first curve to represent the first summer's fish. The second curve in all probability represents the second year's fish, and the third curve, those three years old and over. The growth, thus, is most rapid during the first summer, the rate of growth decreasing each year after. The fish reaches practically its full size the third year, though the more gradual slope to the right of the last curve shows that it does not cease growing entirely.

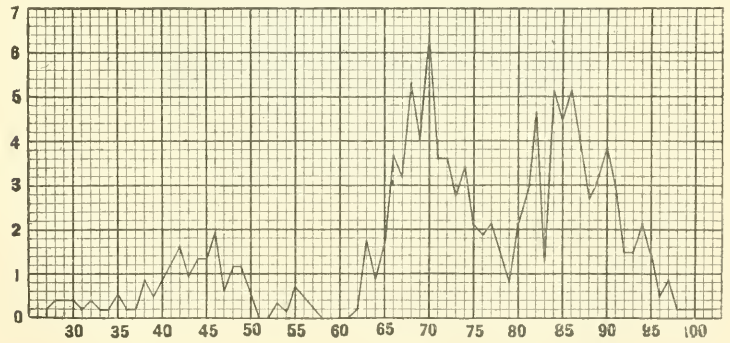

FIG. 5.

Having grouped them into three definite ages, a summary of the characters for each was made, and curves constructed. Figs. 6, 7, 8 and 9 represent the curves for these characters. In all the curves constructed for these ages, the continuous line is for the third year specimens, the broken line for the second year specimens and the dotted line for the first year specimens.

Lateral Line.—Below is the table of the average number of scales in the lateral line of the three ages.

	1st year.	*2d year.*	*3d year.*
Right side	87.84	90.80	88.39
Left side	88.00	89.80	88.78

From this it is seen that the first and third year specimens are most nearly alike. The second year specimens have about two scales more. By reference to the curves, Fig. 6, and Table VIII below, it will be seen that the great bulk of the specimens of all three ages have from 85 to 92 scales. The increased average in the second year is due to a larger per cent. having 93, 94, 95 and 96 scales than in the first and second years.

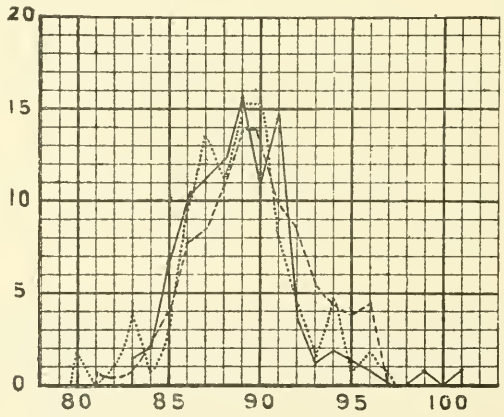

Fig. 6.

TABLE VIII.

	Per Cent. of Specimens Having 80 Scales.	Per Cent. of Specimens Having 81 Scales.	Per Cent. of Specimens Having 82 Scales.	Per Cent. of Specimens Having 83 Scales.	Per Cent. of Specimens Having 84 Scales.	Per Cent. of Specimens Having 85 Scales.	Per Cent. of Specimens Having 86 Scales.	Per Cent. of Specimens Having 87 Scales.	Per Cent. of Specimens Having 88 Scales.	Per Cent. of Specimens Having 89 Scales.	Per Cent. of Specimens Having 90 Scales.	Per Cent. of Specimens Having 91 Scales.	Per Cent. of Specimens Having 92 Scales.	Per Cent. of Specimens Having 93 Scales.	Per Cent. of Specimens Having 94 Scales.	Per Cent. of Specimens Having 95 Scales.	Per Cent. of Specimens Having 96 Scales.	Per Cent. of Specimens Having 97 Scales.	Per Cent. of Specimens Having 98 Scales.	Per Cent. of Specimens Having 99 Scales.	Per Cent. of Specimens Having 100 Scales.	Per Cent. of Specimens Having 101 Scales.
First year specimens	1.99	....	.96	3.84	.96	3.84	9.97	13.45	11.52	15.38	15.38	5.69	4.50	1.99	4.50	.96	1.92	.96	......	......	......	......
Second year specimens	....	.85	.42	.85	2.14	4.29	7.72	8.58	10.73	13.73	13.73	9.87	8.58	5.57	4.29	3.86	4.29	4.29	......	......	......	......
Third year specimens	....	....	....	1.22	2.04	7.35	10.24	11.47	12.28	15.57	11.06	14.34	3.67	2.47	2.86	3.68	.81	.40	......	.81	......	.40

Anal Fin.—Five out of 116 first year specimens have one anal spine; 6 out of 236 of the second year, and 3 out of 246 of the oldest specimens.

The average number of anal rays are 10.56 for the first year, 10.74 for the second year and 11.00 for the third year specimens.

The curves in Fig. 7 and Table IX, below, show that the anal fins of the first and second year specimens more nearly resemble each other. All three ages show a preference for 11.00 rays. The per cent. of specimens having this number are 51.69, 52.53 and 61.60 for the first, second and third year specimens respectively. The per cent. of specimens having 10 rays is reduced from 36.43 in the first year to 20.57 in the third year, and the per cent. of those having 12 rays is increased from 5.09 in the first year to 20.16 in the third year. There is a very evident increase in the number of spines with the age.

The extent of variation of the second and third year specimens is the same. The first year specimens, although only half as many, exceed the other ages two rays in the extent of variation.

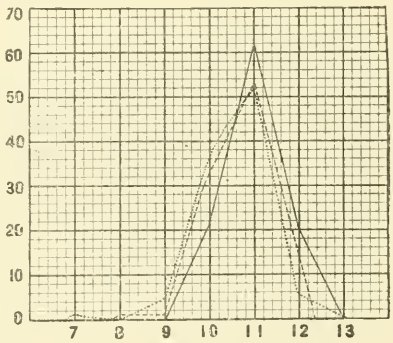

Fig. 7.

TABLE IX.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 7 anal rays	0.84	.....	.....
Per cent. of specimens having 8 anal rays	.....	0.42	.....
Per cent. of specimens having 9 anal rays	5.09	1.69	0.82
Per cent. of specimens having 10 anal rays	36.43	32.19	20.57
Per cent. of specimens having 11 anal rays	51.69	52.53	61.60
Per cent. of specimens having 12 anal says	5.09	13.12	20.16
Per cent. of specimens having 13 anal rays	0.84	.....	0.82

Several important facts brought out by the preceding comparison are worth consideration.

1. No two of the ages here compared are alike in all the characters.

2. In the anal fin and soft dorsal there is a definite increase in the number of rays with the age.

3. Variation of this nature is not present in the other structures.

4. The extent of variation in the different ages is about the same.

Dorsal Rays.—The average number of dorsal rays are 14.57, 14.76 and 14.98 for the first, second and third year specimens, respectively. There is a slight increase with age. The summaries for this structure are given below in Table XI, and the curves in Fig. 8. The prevailing number of rays is 15 for all three ages, the per cents. being 53.39, 52 53 and 55.69 for the first, second and third year specimens, respectively. The per cent. of specimens having 14 rays decreases from 40.72 in the first year to 22.35 in the third year specimens, while the per cent. of specimens having 16 rays increases from 3.38 in the first year specimens to 16.73 in the third year specimens. The extent of variation is from 12 to 16 in the first year, from 12 to 17 in the second year and from 13 to 18 in the third year specimens. As in the anal fin there is a tendency toward a greater number of rays as the fish grows older.

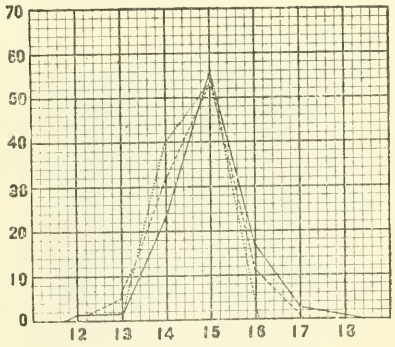

Fig. 8.

TABLE XI.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 12 dorsal rays	0.84	0.42	.....
Per cent. of specimens having 13 dorsal rays	1.69	2.96	1.21
Per cent. of specimens having 14 dorsal rays	40.72	30.50	22.35
Per cent. of specimens having 15 dorsal rays	53.39	52.53	55.69
Per cent. of specimens having 16 dorsal rays	3.38	11.48	16.73
Per cent. of specimens having 17 dorsal rays	.....	0.84	3.25
Per cent. of specimens having 18 dorsal rays	.....	.....	0.40

Dorsal Spines.—The averages for this structure are 14.69 for the first year, 14.39 for the second and 14.65 for the third year, the first and third years being almost identical, and the second year having a fewer number. Fig. 9 represents the curves for this structure. The curves of the first and third years are almost identical, both showing a preference for 15, with about 35 per cent. for 14. The second year shows as decided a preference for 14, about 35 per cent. for 15. This structure varies from 13 to 16 in the first year specimens, from 12 to 17 in the second year specimens and from 13 to 17 in the third year specimens. Table X contains the summaries for this structure.

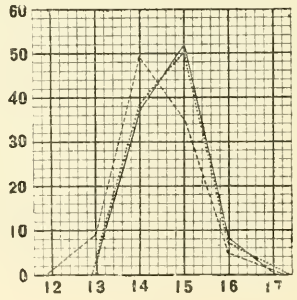

Fig. 9.

TABLE X.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 12 dorsal spines....	.....	0.84	.....
Per cent. of specimens having 13 dorsal spines....	1.69	8.47	3.65
Per cent. of specimens having 14 dorsal spines....	38.98	49.14	36.17
Per cent. of specimens having 15 dorsal spines....	50.00	35.16	51.62
Per cent. of specimens having 16 dorsal spines....	7.62	5.50	8.13
Per cent. of specimens having 17 dorsal spines....	.....	0.42	0.40

The first and third year specimens resemble each other very closely in regard to the scales in the lateral line and the dorsal spines. In these characters the second year specimens show a decided difference. These have on an average two more scales in the lateral line, and have 14 as the prevailing number of dorsal spines instead of 15, the number in the first and third year specimens.

Several explanations might be suggested to account for a part or all of these differences.

The explanation suggesting itself most readily is that an additional spine and ray are added during the life of the individual. I have gone over all the specimens carefully with this point in view, but find no evidence either of the splitting of a ray or spine, or of the new growth of these, except at the anterior of the dorsal fins. Here may be found numerous instances of shorter spines and rays from two-thirds to one-fourth the normal length. But among so many specimens it is entirely probable that these spines and rays would be found in every possible stage of growth. But this is not the case. The spines and rays, although sometimes only one-fourth the full length, are always strong and suggest aborted rather than immature structures. Besides, if this were the case, we would expect to find the tendency toward a lower number of spines, and rays very decided in the first year specimens. While this condition is true in the dorsal and anal rays, it is decidedly not true in the dorsal spines, where the characters in the first years are almost identical with those of the third year.

Natural Selection.—The principle of natural selection, the influence of which upon this species I hoped in the onset of this work to find, can not be applied in explanation of the difference in the number of scales and dorsal spines without serious objections. If natural selection were the determining factor in producing these differences, we should expect all the variations graduated with the age. We would expect to have a narrower range of variation as the specimens

grow older. Neither of these conditions obtain. There are neither 18 dorsal rays nor 13 anal rays represented in the second year specimens; and in the first year specimens 17 dorsal rays are not represented. In the dorsal spines where the difference is most pronounced we have in the first year specimens the exact duplicate of that of the third year specimens, while the second year specimens are quite different. The scales in the lateral line present the same difficulty.

Annual Variation.—The explanation that seems to meet all the conditions most satisfactory is that the species varies with the varying conditions of successive years.

The difference in the dorsal spines of the different ages accounts thus for the abnormality of the curve for the dorsal spines of all the Turkey Lake specimens, Fig. 4. The 600 specimens for which the curve is constructed is a composite lot of three age varieties.

This conclusion, however, should be held with some reservation. It will be noticed that nearly all the curves of Figs. 7, 8 and 9 are abnormal curves, which may possibly be due to the presence of local races in the lake. While this may possibly be the case, it is not at all probable, because, in the first place, the curve constructed for the dorsal spines of 100 specimens of three year olds, taken within a distance of 100 yards along the shores where the conditions were undoubtedly uniform, gave a curve identical with that for all the three year olds. In the second place, the second and third year specimens are found in about equal abundance together, and since these were promiscuously preserved it is altogether probable that from any given locality, an equal number of each age was taken.

The sex has been determined in all, and a summary shows that the sexes do not differ in the characters entering into the above considerations.