

MATERIAL FOR THE STUDY OF THE VARIATION OF *PIMEPHALES NOTATUS* (RAFINESQUE), IN TURKEY LAKE AND IN SHOE AND TIPPECANOE LAKES.* BY J. H. VORIS.

As a part of the general plan of the Indiana University Biological Station to study the variation of the same vertebrates in two contiguous lakes belonging to different water systems, I collected during the summer of 1895 a large series of *Pimephales notatus* in Turkey Lake and the Shoe and Tippecanoe Lakes. Shoe Lake is a small body of water perfectly land locked, but which has but recently become cut off from communication with Tippecanoe Lake. Tippecanoe Lake is a long narrow sheet of water near the head waters of the Tippecanoe River, a tributary of the Wabash. Turkey Lake occupies a corresponding position in the St. Lawrence system. At different points in Turkey Lake 536 specimens were collected in the months of June, July and August. In Tippecanoe, seventy-two specimens were taken, and in Shoe Lake, forty-three.

The species is much more abundant in Turkey Lake than in the other two lakes. Many individuals are found along the shallow rocky shores, and their eggs are found in abundance plastered on the under surface of boards and other submerged objects near the margin of the lake where the water is not more than one or two feet deep. The fry were seen in quiet, warm weather along the shores by the laboratory.

A large number of characters were examined at the beginning of the study, but as many of these, for one reason or another, were found not available for the purposes in hand, the data were finally limited to the number of dorsal and anal rays and to the scales of the lateral line. While this fish has the reputation of being very variable, the characters examined are remarkably constant, and in the number of dorsal and anal rays the species may be said to have reached a stage of stable equilibrium, as the following pages will demonstrate. Since it was not possible in every case to determine absolutely those scales in the lateral line which had and those which had not spores, this character is omitted from the paper.

A miscellaneous lot of 536 specimens from Turkey Lake range in length from 25 mm. to 73 mm. The largest number of individuals of a given length is 37 and these have a length of 47 mm. A curve constructed to show the relative number of specimens of a given length shows that they do not fall into distinct groups of different ages.

* Contributions from the Biological Laboratory of the Indiana University, No. 19.

The dorsal fin has one spine-like ray, eight rays, the last one of which is double, and one very small or rudimentary ray before the spine. The variation from this is very small indeed. Of the 536 specimens from Turkey Lake, 97 per cent. have this number of rays, which may be designated thus: II $8\frac{1}{2}$, the "II" standing for the rudimentary ray and spine, the "8" for the eight rays, and the " $\frac{1}{2}$ " for the double of the last ray. The average number of rays is 8.0037. The table shows the results obtained.

DORSAL FIN.

<i>No. of Rays.</i>	<i>No. of Specimens.</i>	<i>No. of Rays.</i>	<i>No. of Specimens.</i>
II $8\frac{1}{2}$	519	I $9\frac{1}{2}$	1
II $9\frac{1}{2}$	4	I $7\frac{1}{2}$	1
I $8\frac{1}{2}$	9	II 6.....	1
II 8.....	1		

It will be seen from the table that over one-half of those that vary from II $8\frac{1}{2}$ are different only in the absence of the very small rudimentary ray. This is so small and lies so close to the base of the spine that it cannot be seen unless especially looked for. Only five specimens have nine full rays, one with seven and one with six, making in all but six specimens that have a variation of one full ray, and one a variation of two rays from II $8\frac{1}{2}$.

The variation in the anal fin is a little more than in the dorsal, 92.91 per cent. have II $7\frac{1}{2}$ rays. The anal fin has one less ray than the dorsal, and the average for the whole is 7.0037. The greater per cent. of variation in this fin is due to the absence of the rudimentary ray. Only four specimens have one complete ray more, and two one less than II $7\frac{1}{2}$. The table shows the results obtained.

ANAL FIN.

<i>No. of Rays.</i>	<i>No. of Specimens.</i>	<i>No. of Rays.</i>	<i>No. of Specimens.</i>
II $7\frac{1}{2}$	498	II $6\frac{1}{2}$	1
II $8\frac{1}{2}$	3	I $6\frac{1}{2}$	1
I $7\frac{1}{2}$	30	I $8\frac{1}{2}$	1
II 7.....	2		

The following table shows the dorsal and anal fins, together with the number of specimens that each combination contains. It will be seen from this table that there are but three specimens in which there is a variation from the prevailing number in both the dorsal and anal fins. Each of these has the small rudimentary ray absent, and one specimen has one complete ray more than the prevailing number. It seems that

there is no co-ordination in the variation of these two fins. The per cent. of variation above or below the prevailing number in each case is so small that it may be regarded as purely accidental. At least it can be said that this fish in Turkey Lake has reached a stage of stable equilibrium as regards this character.

DORSAL AND ANAL FINS.

<i>Dorsal.</i>	<i>Anal.</i>	<i>No.</i>	<i>Dorsal.</i>	<i>Anal.</i>	<i>No.</i>
II 8½.....	II 7½.....	484	II 9½.....	II 7½.....	4
II 8½.....	I 7½.....	28	II 6.....	II 7½.....	1
I 8½.....	II 7½.....	7	II 8½.....	II 8½.....	3
I 8½.....	I 7.....	2	II 8½.....	I 6½.....	1
I 7½.....	II 7½.....	1	II 8.....	II 7½.....	1
I 9½.....	I 8½.....	1	II 8½.....	II 6¼.....	1
II 8½.....	II 7.....	2			

The dorsal and anal fins of seventy-two specimens from Tippecanoe Lake were examined and the results obtained are shown in the following tables:

DORSAL AND ANAL FINS.

<i>Dorsal Fin.</i>	<i>No. Specimens.</i>	<i>Anal Fin.</i>	<i>No. Specimens.</i>
II 8½.....	64	II 7½.....	69
II 9½.....	3	II 8½.....	2
II 7½.....	2	I 7½.....	1
I 8½.....	3		

DORSAL AND ANAL FINS COMBINED.

<i>Dorsal Fin.</i>	<i>Anal Fin.</i>	<i>No. Specimens.</i>	<i>Dorsal Fin.</i>	<i>Anal Fin.</i>	<i>No. Specimens.</i>
II 8½.....	II 7½.....	62	I 8½.....	II 7½.....	2
II 9½.....	II 7½.....	3	I 8½.....	I 7½.....	1
II 7½.....	II 7½.....	2	II 8½.....	II 8½.....	2

A comparison of these tables with the preceding ones shows that the per cent. of variation in the Tippecanoe specimens is much larger than in those from Turkey Lake. However, the number in the one case is not sufficient for a definite conclusion. Leaving out of consideration the small rudimentary ray, which would not be noticed in an ordinary examination, and considering only those cases in which there is a variation of at least one complete ray from the prevailing number, the per cent. in the dorsal fin of the Turkey Lake specimens is 1.3, while in those from Tippecanoe, it is 7. The per cent. of Turkey Lake specimens, that have a variation of at least one ray from the prevailing number in the anal fin, is 1.1, while in the Tippecanoe specimens it is 2.8.

Forty-three specimens from Shoe Lake were examined, and the results obtained are shown in the tables below:

DORSAL AND ANAL FINS.

<i>Dorsal Fin.</i>	<i>No. Specimens.</i>	<i>Anal Fin.</i>	<i>No. Specimens.</i>
II 8½.....	41	II 7½.....	40
I 8½.....	2	I 7½.....	2
		II 6½.....	1

DORSAL AND ANAL FINS COMBINED.

<i>Dorsal Fin.</i>	<i>Anal Fin.</i>	<i>No. Specimens.</i>	<i>Dorsal Fin.</i>	<i>Anal Fin.</i>	<i>No. Specimens.</i>
II 8½.....	II 7½.....	38	II 8½.....	I 7½.....	2
I 8½.....	II 7½.....	2	II 8½.....	II 7½.....	1

The number of specimens here is too small to draw any definite conclusions in comparison with the others. It is to be noticed, however, that there is but one case in which the variation from the prevailing number is one complete ray, and that occurs in the anal fin.

The scales in the lateral line of each side of 500 specimens from Turkey Lake were counted. They range from 40 to 48 in number, and the largest number of individuals have 44. The table below shows the number of individuals which have a given number of scales on each side. The striking thing shown by this table is the regularity of the variation on the right side. The largest number of individuals has 44 scales, and there is a range of four both above and below this.

<i>No. Scales</i> <i>Right Side.</i>	<i>No. Specimens.</i>	<i>No. Scales</i> <i>Left Side.</i>	<i>No. Specimens.</i>
40.....	3.....	40.....	1
41.....	7.....	41.....	8
42.....	36.....	42.....	45
43.....	126.....	43.....	136
44.....	157.....	44.....	168
45.....	121.....	45.....	90
46.....	37.....	46.....	40
47.....	11.....	47.....	8
48.....	2.....	48.....	4
Average.....	44.01.....	43.912.....	

On the right side the variation is nearly symmetrical. On the left side there is not such a marked symmetry. The number of specimens that have fewer than 44 scales on the right side is but one more than those that have more. On the left side, there are 190 that have fewer than 44 scales, and 142 that have more, a difference of 48.

The average deviation, or index of variability for the right is .9369, for the left, .94916.

In the following table every possible combination of scales for the two sides is given with the actual number of specimens for each combination in one column, and the number according to the laws of probability in a parallel column:

Scales.		Actual Number of Specimens.	Calculated Number.	Scales.		Actual Number of Specimens.	Calculated Number.	Scales.		Actual Number of Specimens.	Calculated Number.
Right.	Left.			Right.	Left.			Right.	Left.		
40	40	1	0	43	40	0	0	46	40	0	0
40	41	0	0	43	41	3	2	46	41	0	1
40	42	1	0	43	42	15	11	46	42	0	3
40	43	1	1	43	43	56	34	46	43	4	10
40	44	0	1	43	44	37	42	46	44	9	12
40	45	0	1	43	45	13	23	46	45	9	7
40	46	0	0	43	46	2	10	46	46	13	3
40	47	0	0	43	47	0	2	46	47	0	1
40	48	0	0	43	48	0	1	46	48	2	0
41	40	0	0	44	40	0	0	47	40	0	0
41	41	2	0	44	41	1	2	47	41	0	0
41	42	2	1	44	42	14	14	47	42	0	1
41	43	2	2	44	43	37	43	47	43	0	3
41	44	1	2	44	44	69	58	47	44	2	4
41	45	0	1	44	45	31	28	47	45	2	2
41	46	0	1	44	46	4	13	47	46	3	2
41	47	0	0	44	47	1	3	47	47	3	0
41	48	0	0	44	48	0	1	47	48	1	0
42	40	0	0	45	40	0	0	48	40	0	0
42	41	2	1	45	41	0	2	48	41	0	0
42	42	10	3	45	42	3	11	48	42	0	0
42	43	14	10	45	43	22	33	48	43	0	1
42	44	9	13	45	44	41	41	48	44	0	1
42	45	1	6	45	45	33	22	48	45	1	0
42	46	0	2	45	46	17	10	48	46	1	0
42	47	0	1	45	47	4	2	48	47	0	0
42	48	0	0	45	48	1	1	48	48	0	0

The two columns show that there is a striking deviation from the calculated results, the result of a marked correlation in the variation or tendency to or toward bilateral symmetry. As calculated, the chance association of the same number of scales on the two sides would occur 115 times for all combinations, it actually occurs 187 times. The specimens fall into several definite groups in which the same number of scales on each side forms the center of a group. This is not quite true at the extremes, but is especially marked in the central groups into which the large majority of the specimens fall. There are three specimens in the first group, each of which has 40 scales on the right side. One has 40 scales on the left side, one 42, and one 43. The greatest difference in the number on the two sides is three. There are three specimens in the first group of the calculated column. Each has 40 scales on the right side, one has 43 on the left, one 44 and one 45. The greatest difference in this case is five, and none have the same number on both sides. In the second group of the actual column there are seven specimens, two with 41 scales on each side, two with 41 on the right side and 42 on the left, two with 41 on the right and 43 on the left, and one with 41 on the right and 44 on the left. The greatest difference in the number of scales on the two sides is three. There are seven specimens in the second group of the calculated column. Each has 41 scales on the right side and on the left side one has 42, two have 43, two 44, one 45, and one 46. As in the first group of this column, none have the same number on both sides, and the greatest difference is five. The number of specimens in the fourth group of the actual column is 126. Each has 43 scales on the right side, and on the left three have 41, fifteen 42, fifty-six 43, thirty-seven 44, thirteen 45 and two 46. The largest number of individuals in this group which have the same combination, have the same number of scales on both sides, and the greatest difference in the number on the two sides as in the other cases is three. The calculated column of the same group contains 125 specimens, each of which has 43 scales on the right side. On the left side, two have 41, eleven have 42, thirty-four 43, forty-two 44, twenty-three 45, ten 46, two 47 and one 48. The largest number in this case with the same combination has 43 scales on the right side and 44 on the left, and the greatest difference, as before, is five.

The number of specimens in the same groups of the two columns is the same in most cases, and in no case is there a difference of more than one. This difference is perhaps due to the dropping and adding of frac-

tions. In the calculations fractions of less value than one-half were dropped and those of a value of one-half or more were called one. It will be observed from the groups described—and the same is true of the other groups—that when the number of scales is the same on each side or not more than a difference of one, the actual column exceeds the calculated, and as the difference increases, the calculated column exceeds the actual. A comparison of the corresponding groups in the two columns in every case gives the same results as in those described, all of which demonstrates the tendency to bilateral symmetry or a marked correlation in the variation of the two sides.

PRELIMINARY NOTE UPON THE ARRANGEMENT OF RODS AND CONES IN THE
RETINA OF FISHES. BY C. H. EIGENMANN AND GEORGE HANSELL.

[Abstract.]

A variety of fish eyes were examined, and it was found that in most cases the rods and cones are arranged in a regular pattern. This pattern is either that described by Hannover and Ryder for fishes or a slight modification of this pattern.

DEGENERATION IN THE EYES OF THE AMBLYOPSIDÆ, ITS PLAN, PROCESS AND
CAUSES. BY CARL H. EIGENMANN.

[Summary only.]

1. There are at least six species of "blind fishes," Amblyopsidæ, inhabiting North America, three with well-developed eyes and three with mere vestiges.

2. The three species with vestigial eyes are descended from generically distinct ancestors with well-developed eyes.

3. These species can be more readily distinguished by the structure of their eyes than by any other characteristic.

4. The most highly-developed eye is much smaller and simpler than the eye of normal-eyed fishes.

5. The structure of their eyes may be represented by the following key to the genera and species.

a. Vitreous body and lens normal, the eye functional. No scleral cartilages. Eye permanently connected with the brain by the optic nerve. Eye muscles normal. No optic fibre layer. Minimum diameter of the eye $.700 \mu$.

* Chologaster.