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LES COMPTES-RENDUS
DES TRAVAUX DU LABORATOIRE CARLSBERG

paraissent par livraisons à des époques indéterminées. A mesure qu'il en paraîtra un nombre suffisant pour faire un volume, les abonnés recevront un titre en même temps qu'une table des matières, avec l'indication de la période qu'embrasse le volume.

JOHS. SCHMIDT:
RACIAL INVESTIGATIONS.

VIII. THE NUMERICAL SIGNIFICATION OF FUSED VERTEBRAE.

BY

JOHS. SCHMIDT.

Investigation of the vertebral column in fishes not unfrequently discloses vertebrae that give the impression of being double i. e. formed through the fusion of two single vertebrae. In endeavouring to aseertain the number of vertebrae — e. g. for statistical or genetic purposes — one is therefore confronted with the question as to how such fused vertebrae should be counted. Are they to be regarded as two vertebrae or as only one? Or are both views erroneous?

In previous works of a statistical nature I have evaded the difficulty by rejecting altogether specimens with fused vertebrae, as I considered that in such works no error of importance could occur when the material under investigation was large and the number of specimens with fused vertebrae small.

When dealing with genetic works, however, investigating the inheritance of the number of vertebrae, the case is more doubtful. By ignoring individuals with fused vertebrae one is running the risk of committing a serious error.

The question has been raised during the investigation regarding the inheritance of vertebrae in the trout, on the basis of which I described the so-called diallel crossing's method (1919, 1 and 2). To avoid overloading the essay I did not on that occasion enter into the question of the significance of the fused vertebrae. I shall now therefore discuss the matter briefly.

In the table are given the results of the first experiment in diallel crossings, wherein 4 female specimens were crossed with 2 male specimens, so that 8 offspring-combinations resulted. These are distinguished by the parents' symbols, the males being

Diallel Crossings with Trout (*Salmo trutta*), Number of vertebrae.

1) Individuals with single, 2) Individuals with double hæmal arch at the 5-last vertebrae.

No. of vertebrae	x a	x b	x c	x d	y a	y b	y c	y d
1) 61	»	»	»	»	»	3	»	»
60	»	»	»	»	46	90	»	6
59	30	95	»	4	280	153	7	160
58	193	98	81	211	90	9	33	193
57	23	»	147	85	»	»	1	9
56	»	»	1	»	»	»	»	»
a_1	58.028	58.492	57.349	57.730	58.894	59.341	58.146	58.443
2) 61-60 ($60^1/_2$)	»	»	»	»	»	2	»	»
60-59 ($59^1/_2$)	»	»	»	»	23	15	»	7
59-58 ($58^1/_2$)	5	19	1	5	28	4	1	37
58-57 ($57^1/_2$)	9	2	27	18	»	»	1	4
a_2	57.857	58.455	57.536	57.717	58.951	59.405	58.000	58.563
1) + 2) a_{1+2}	57.109	58.488	57.370	57.729	58.900	59.346	58.140	58.457.

1) Total average... **58.303**. 2) Total average... **58.310**.

marked *x* and *y*, the females *a*, *b*, *c* and *d*. The table thus shows the number of vertebrae in the 8 offspring-combinations.

It is a striking fact (e. g. in comparison with *Zoarces*) that each sample contains very few variates indeed. Thus the combination *xb* has only 2 variates, both occurring with almost equal frequency, namely 58 and 59. In none of the samples do we find more than 4 variates. In *Zoarces* as a rule the individual-offspring samples had 6—8, and even 12, variates as regards the number of vertebrae (*vide* Johs. Schmidt, 1917, p. 317—319).

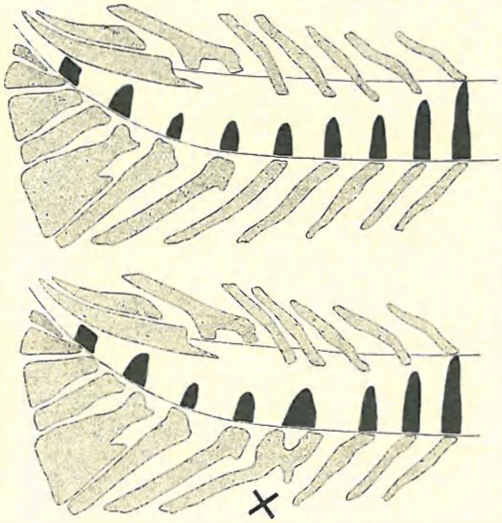

Fig. 1. — End of tail of two trout young (*Salmo trutta*), length ca. 22 mm.; alizarine-staining. — In the lower specimen the fifth vertebra (marked ×) from the end is fused. Notice the longer body, the partly double hæmal and the double neural arch. Drawing by Vilh. Ege.

The trout then is remarkable for the fact that its individual offspring samples have very narrow limits of variation.

It must however be added that in all 8 samples was found a small number of individuals (average ca. 10 %) whose 5-last vertebra shows a peculiarity impossible to ignore and which places one in doubt as to whether one is dealing with a single or a double vertebra.

In the accompanying figures are depicted the ends of the vertebral column in a specimen of this nature and in a "normal" specimen.

Whilst apparently there is not here, as in other cases of fusion of vertebrae, anything to remark in the body itself, apart from its being longer than usual, the hæmal arch proves to be double in its proximal part, being thus bifurcated (*vide* Fig.); the neural arch is double. The question is now: What value in counting the vertebrae shall be allowed to such a 5-last vertebra with double arch? Is it to be reckoned as 2 or only as 1, or does the truth lie between? This question is obviously of considerable importance when a sample contains many specimens with double hæmal arch.

In order to examine the matter more closely let us imagine two individuals, a male and a female, both homozygous as regards numbers of vertebrae. Let us further imagine that the one has an even, the other an uneven number of vertebrae, e. g. 58 and 59. In such a case one might expect that their offspring would have $58^{1}/_{2}$ vertebrae. Reasoning thus one might be allowed to regard it as probable that the 5-last vertebra in question with double hæmal arch would have a value lying between 1 (single vertebra) and 2 (double vertebra).

To test this theory I have experimentally counted it as $1^{1}/_{2}$, so that a specimen with 58 normal vertebrae besides the 5-last with double arch, is counted as having $59^{1}/_{2}$ vertebrae, etc. etc. A test regarding the accuracy of this assumption is possible in the following manner. If within each of the 8 offspring samples we ascertain the average number of vertebrae in specimens having double arches at the 5-last vertebra, counting this vertebra as $1^{1}/_{2}$, the average must coincide with the average for the normal individuals, provided our theory be correct.

Proceeding on this principle we find that the two averages coincide closely, the average of the 8 samples of individuals with double arches being 58.310 and that of the 8 samples of normal individuals 58.303.

Thus it seems evident that our assumption that the vertebra in question has a numerical value of $1^{1}/_{2}$ is correct. Hence it follows that it would be just as incorrect to count it as 1 as to reckon it as 2 complete vertebrae. On the other hand we are apparently justified in completely ignoring individuals with double hæmal arch at the 5-last vertebra, provided we are dealing with groups consisting of a large number of individuals.

Our investigation thus shows that vertebrate animals can realize fractional parts of vertebrae, but it is evident from the table that such individuals are numerically inferior to what we above called "normal" individuals. In reality the former are just as "normal" as the latter. In both cases it is the individual's genetic structure in connection with its environment in the sensitive period, which is deciding the total realized; but it seems as if whole numbers in such organs as vertebrae are more easily realized than fractional parts.

I must here recall that, based on the results of the diallel crossings with trout, I had to distinguish between the two notions personal and generative value (1919, 1 and 1919, 2) and that I found thatan individual's generative vertebral number could have any value whatever between two whole numbers e. g. 58.57 or 62.72 Taking this into consideration the proof that fractions of vertebrae can actually be realized — in other words that also the personal values can be broken numbers — is of interest.

Finally I desire to emphasize that there exist other categories of fused vertebrae than those mentioned here. Thus one of our experiments, which I hope to find an opportunity of discussing later, proves that the vertebral column under the influence of extreme external conditions can develop quite abnormally, with irregular fusions of a greater or a smaller number of vertebrae.

Carlsberg Laboratory, April 15, 1921.

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