THE EFFECT OF SELECTION ON THE LENGTH OF SPINE IN DAPHNIA LONGISPINA

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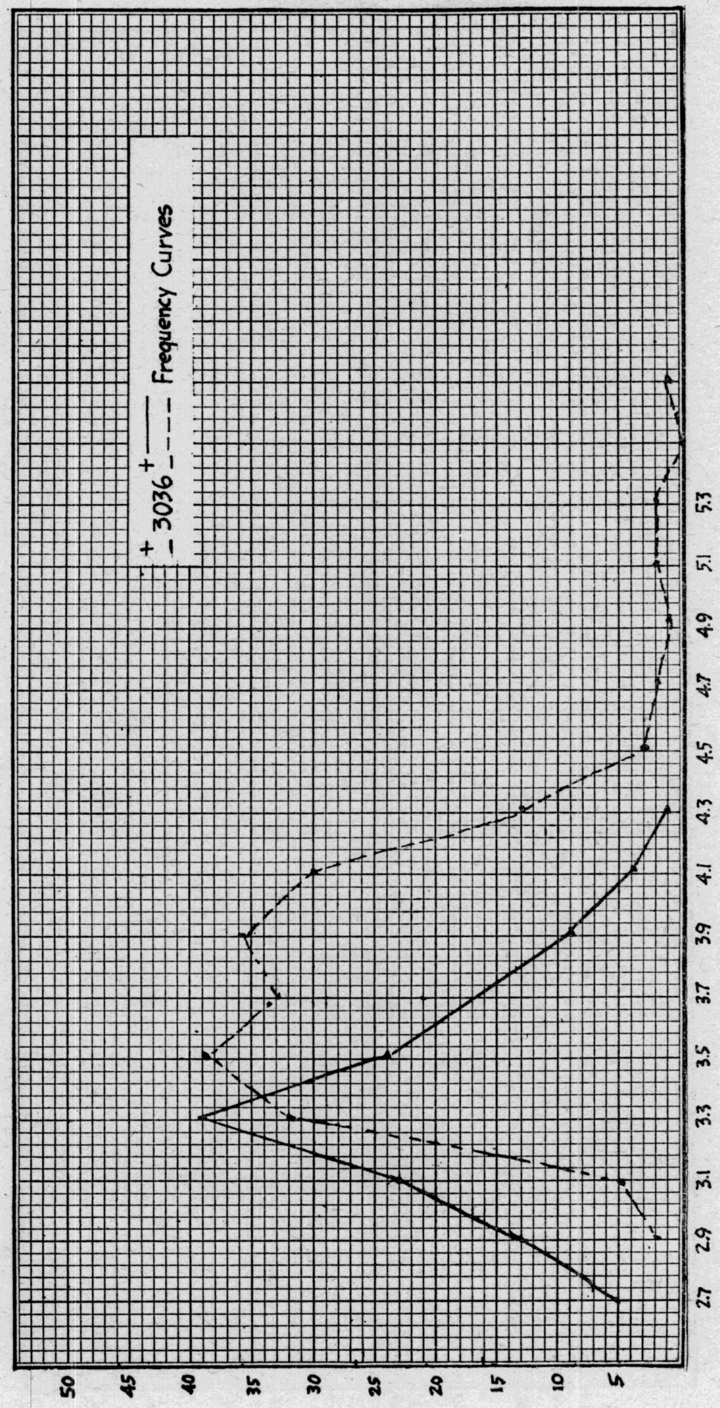
The work was started Dec. 27, 1922, and so far there have been ten generations. This paper is, therefore, merely a preliminary one.

The Daphnia stock was obtained from the Laboratory of the University of Chicago where the work was carried on. The stock came originally from a fish fancier and had been kept in the laboratory for about a year before this experiment was begun.

A parthenogenetic female (3027) was selected to start the first (3028)[1] generation. A brood is produced about every other day. The stock is kept in fingerbowls under greenhouse conditions, and temperature, food and other environmental conditions kept as nearly uniform as possible. The food consists of a coccus (Chlamyda monas) which causes the water to look green. Successive broods are termed A, B and C, and broods A, B and C are used as a basis for all the mathematical calculation. From brood A of 3028[1] an individual was selected to start the minus strain, and another to start the plus strain of 3029[2]. The difference in length of spine between the two was not great and was taken without measuring. After this the length of body, divided by the length of spine and called "Index", was made the basis of all calculations. The plus or long spine strain will therefore have a smaller index than the minus or short spine strain.

Selection was made from the A brood of ±3029[2] for the ±3030[3] generation, the indices being respectively .3 and .4.

In order to have better proof of the hereditary quality of the character, the A broods of ±3030[3] were measured alive and the five most favorable animals respectively were used to start five plus lines and five minus lines of 3031[4]. It was then thought best to use the method of selecting in each generation five individuals of the plus strain and five from the minus strain of the B brood belonging to the most favorable A brood. This was done to start generation 3032[5]. The curves of this generation


+ 3036 +
Frequency Curves
50
45
40
35
30
25
20
15
10
5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
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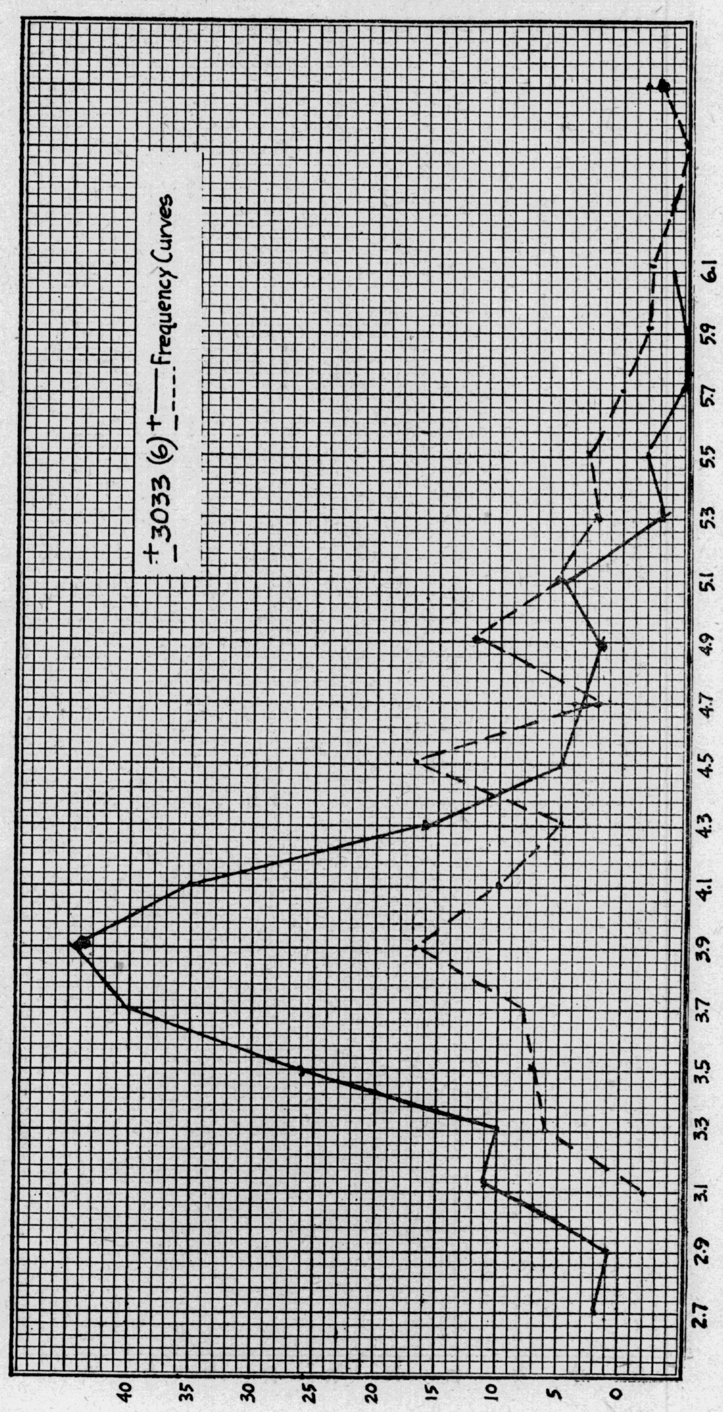
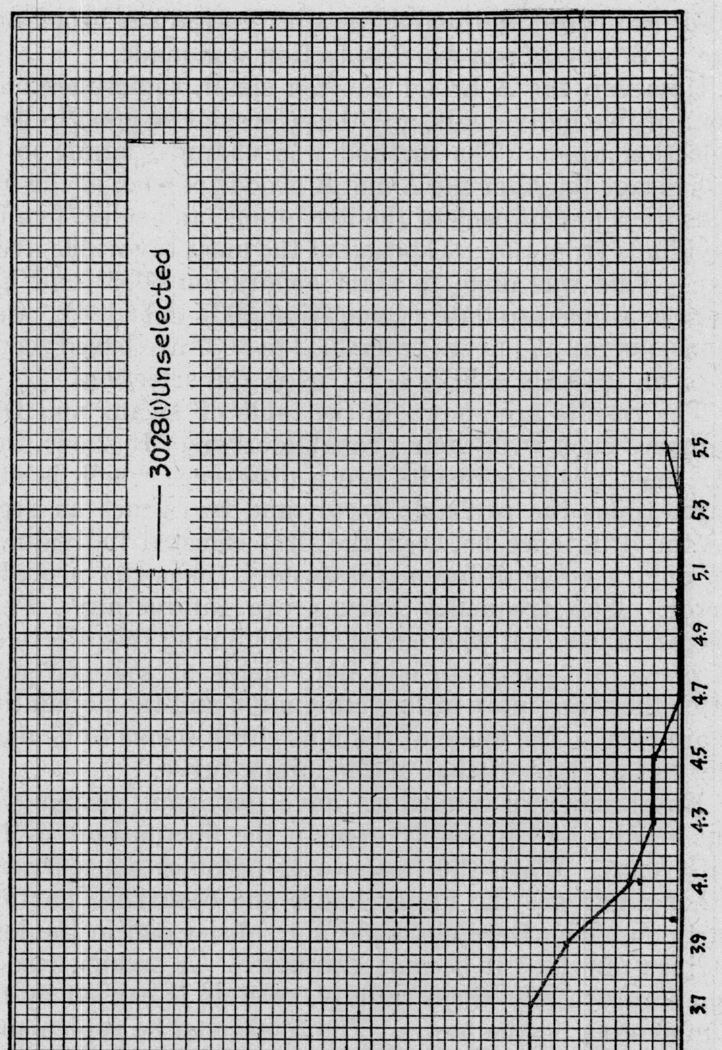

+ 3033 (6) + ——
— - - - -
Frequency Curves
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
40
35
30
25
20
15
10
5
0


3028(1) Unselected
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5
10
15
20
25
30
35

3031[4] are based on the five lines of ± strain A brood and the ± B brood from which selection was made.

However, the A brood is often small, sometimes only four or five individuals, and therefore not so good to base selection upon. The method was changed again so as to average together the A and B broods of each of the five plus lines and of each of the five minus, and select five individuals from the ± C brood of the most favorable average. This was done to start generation 3033[6] and has been continued to date (generation 3037 included). Calculations for all curves from 3032 to 3037 are based therefore on ±(5A's + 5B's + C) used for selection.

The results are shown in the table of Means and Differences each with their probable errors. It shows that the least positive results are a difference which is still three times the probable error, and two times as great as the difference between the first selected individuals. In one case the difference is twenty times the probable error. The frequency curves are interesting. They seem to show that whereas at the beginning the difference is often due partly to odd individuals at the extremes, later these are more or less eliminated and the population more even. The mode of the plus curve seems to be moving to the right of that of the minus curve.

Environmental conditions have important bearing on the results and probably explain the fluctuations of the difference. When the food water becomes concentrated other algae get the upper hand, one occurring particularly on which Daphnia could not subsist and in the long strings of which it became entangled. A sudden rise in temperature kills them rapidly, such as is caused by the sun shining on the bowls. The food must be replenished continually or they do not thrive. The writer has looked for indications that size of brood or size and vigor of animal causes a difference, but has been unable to find any signs of this. The vigorous animal is larger both ± but the length of spine has the same relation to body length. All individuals were measured at about seven days old. One cannot tell exact date of birth unless material is under constant surveillance. The size at the same age varies considerably, but not so the index.

The work was done entirely with parthenogenetic females, no males appearing; hence the results are entirely in a pure line. Whether similar results will continue or whether the difference will persist when selection is discontinued remains to be seen. The full significance of the experiment can not be gauged in so early and preliminary a stage.

What the causes are which may produce selection in a pure line if such should prove possible in the long run, is still an open question. A. M. Banta in his interesting work on "Selections in Cladecera on the Basis of a Physiological Character" takes up the question. He was slightly successful in selecting Daphnia longispina for its reaction to light. In one line he got a difference 4.05 times the probable error. He thinks selection may be due to (1) general physiological changes or (2) direct genetic changes. The first consists of materials carried over by cyloptasm, lide bacteria or protozoa or dye, which fed to fowls appears in egg yolk (Riddle 1908). But if the genetic basis be assumed, then he thinks that selection in a pure line altho it cannot cause genetic changes "may seize upon modifications of the character used in selection as they occur and in the case of plural genetic changes may build up differences between selected strains" and may be "the means of utilizing the variations in accomplishing the end sought." There is no way in Daphnia by which there could be any recombination of nuclear material, since there is only one maturation division without reduction in the parthenogentic egg.

Banta also discusses the mutation theory. In connection with such small genetic changes he would not call them mutations, but calls the point immaterial. He would not call them segregations or larger mutations because they occur too often and because there is no chromatic reduction involved. Sturtevant, in his work on Dichaet flies, was able to select plus and minus strain for a number of bristles. Dichaets vary more in bristle number than non Dichaets. In his final discussion he raises three questions.

1. "Does selection use germinal differences already present or such as arise during experiment, or both?" He thinks that, assuming the factors are Mendelian, selection in a group heterozygous for many minor factors will be effective in isolating favorable combinations of such modifying genes or multiple factors. Since mutations take place at all times, selection may make use of variations arising during the experiment.

2. "In case it uses new differences does it cause them to occur more frequently and does it influence their directions?" He finds nothing to show that favorable variations occur oftener on account of selection.

3. "Are differences new or otherwise more likely to occur in the locus of the gene under observation or in other loci?" He thinks variations appear more often in other factors since there are so many, but only in one that is responsible for the difference under observation.

TABLE OF MEANS AND DIFFERENCES WITH P. E.

Generation	— Means	+ Means	Difference
3029 (2)	4.6 ± .098	3.7 ± .13	.9 ± .016
3030 (3)	3.76 ± .046	3.6 ± .04	.11 ± .062
3031 (4)	4.7 ± .094	4.1 ± .074	.6 ± .011
3032 (5)	4.6 ± .034	4.0 ± .042	.6 ± .054
3033 (6)	4.8 ± .056	3.6 ± .035	1.2 ± .066
3034 (7)	4.2 ± .05	3.98 ± .051	.22 ± .055
3035 (8)	3.8 ± .039	3.3 ± .011	.5 ± .05
3036 (9)	3.8 ± .02	3.3 ± .017	.5 ± .025
3037 (10)	3.6 ± .028	3.1 ± .018	.5 ± .02