THE EFFECT OF SELECTION FOR EYE FACET NUMBER IN THE WHITE BAR-EYE RACE OF *DROSOPHILA MELANOGASTER*[1]

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INTRODUCTION

The present report is one phase of an intensive study of the germinal and environmental factors affecting eye-facet number in Drosophila.[2] It gives the results of forty-two generations of selection for high facet number on the one hand and low facet number on the other. The objects in view are the determination of (1) the character of the germinal diversity present in the stock at the beginning of selection, and (2) the manner of appearance of germinal changes during the course of selection. The results obtained are to be considered not only for their independent value, but also because they form a necessary link in the solution of the general problem of the explanation of the character differences. The general viewpoint of the writer has been that an analysis of a single character with a view to the correlation of the different processes involved in its production is of the greatest importance at the present time. There is no attempt to deny that there has been a need for the emphasis on a clear distinction between the problem of the mechanism of transmission of "genes" and the problem of the ontogenetic development of characters. On the other hand, it seems to the writer that at present there has developed a greater need for the attempt to understand each of these processes in relation to the other. There can be no full understanding of the mechanism of transmission unless there is an understanding of the sort of thing that is being transmitted, and the reverse is equally true.

In some earlier work started in 1914 (ZELENY and MATTOON 1915) it was shown that bar eye, which at that time was a recent mutation from

[2] The reports already published are given in the list of cited literature at the end of the paper.

full eye, possessed germinal diversity as regards the factors affecting facet number. Three successive selections for high facet number increased the mean number from 98.0 to 139.5 and three similar selections for low facet number decreased it to 83.7. Significant progress was noted in each of the three selections in both high and low lines. While the selections were not carried on long enough to make possible a clear demonstration, the fact that regression toward the mean of the parental generation increased with successive selections made it seem probable that a limit to the progress of selection would eventually be reached. The same fact made it seem probable that the effectiveness of the selection was due to the sorting out of original differences in germinal composition.

H. G. MAY (1917) continued the study in this laboratory during the academic year 1915–1916. His first series, with vestigial-winged bar, died out at the end of three generations on account of high sterility. Selection was effective for one generation but failed to produce further effects in the second and third generations. Reverse selections in low lines were not effective. In a second series long-winged bar flies were used. Selection was effective for the six generations during which it was carried on, though in the low line most of the high flies were eliminated by the first three selections. Crosses between the high and low lines indicated that the hereditary factors involved in the difference between the two were not sex-linked. Outside of the selection results an important demonstration of reverse mutation of bar to full was made.

MAY's data on the effects of selection were not as conclusive as one might wish because of sterility and the high variability in facet number due to uncontrolled environmental factors. His results indicated the probability that temperature is an important factor in this connection. Accordingly the working out of this problem was suggested to E. W. SEYSTER in 1916. His work was incomplete at the time he left for war service, but the results were published in 1919. In the meantime, JOSEPH KRAFKA, JR., took up the problem, and his more complete analysis of the temperature effect was published in 1920. It is clearly demonstrated by these experiments that temperature has a pronounced and definite effect upon facet number. Stated very generally, there is approximately an increase of 10 percent in facet number for each *decrease* of one degree centigrade in temperature except near the temperature limits, where complicating factors enter.

At the same time that these temperature experiments were begun, it was decided to carry on the other phases of the study under as accurate temperature control as possible. Under such conditions a series of selection experiments on a red bar-eye stock, in which all individuals were derived from a single mating containing a single bar gene was started in 1916, and in 1917 a series on white bar eye. The first of these will be reported in a separate paper. The latter is the subject of the present report. White bar was used because it was desired to duplicate an experiment which had previously been carried on by one of the students in the laboratory with results strikingly different from those in our other selection series. The data he obtained, however, have since that time not stood the test of critical analysis.

The experiments recorded in the present paper demonstrate clearly that selection, by taking advantage of the large mutations, rapidly effects an upward change to full eye and a downward change to ultra-bar. The presence of selection and its direction, however, have no effect on the character or rate of the mutations. Selection merely preserves them if they happen to be in the proper direction. Since these mutations to full eye and to ultra-bar are discussed elsewhere (ZELENY 1920 a, 1921 a) the present report will be confined to a discussion of other germinal differences unless the former are specifically mentioned.

If full eye and ultra-bar are set aside as they appear and attention is confined to the remaining individuals, the results demonstrate the existence of distinct germinal differences in the original unselected population. The low-facet factors of pronounced effect are rapidly eliminated in the high line and the high-facet factors in the low line. Factors of smaller degree are protected for a time from the action of selection by non-heritable fluctuations, but eventually they also are eliminated. Such eliminations take place in the low line following the 12th generation and in the high line following the 25th generation. A sex-linked lethal factor affecting facet number in single dose appears in the 21st generation of the high line and persists for several generations. It causes a rise in the mean facet value of the females in these generations.

Selection thus merely exercises a sorting effect and further progress after the preliminary sorting is completed is confined to new mutations whose origin is independent of selection.

MATERIAL

Full eye

Normal wild *Drosophila melanogaster* has a large oval, so-called "full eye" (figure 1 F). The average number of ommatidia as indicated by ten facet counts of each sex in stock number 345 is 810.6 in the females and 849.8 in the males at a temperature of 27° C. The data are given in table 1 under "full eye."

TABLE 1

Eye-facet number in full-eye stock number 345 and white bar unselected stock number 133-7.

	FULL EYE		WHITE BAR EYE	
	Females	Males	Females	Males
Number of counts	10	10	488	441
Mean of facets	810.6	849.8	58.8	111.4
Lowest facet number	632	700	21	35
Highest facet number	924	980	134	314
Mean in factorial units[3]	+26.67±0.24	+21.15±0.17	0.00±0.10	0.00±0.13
Standard deviation in factorial units	1.11±0.17	1.12±0.17	3.12±0.07	3.91±0.09
Lowest individual in factorial units	+24.22	+19.12	−9.68	−10.72
Highest individual in factorial units	+28.02	+22.49	+8.75	+11.11

Origin of bar eye

In an experiment involving rudimentary- and long-winged flies and not concerned with eye characteristics, TICE (1914) found a single male with a reduced number of ommatidia. The eye facets were restricted to a vertical band or bar of irregular outline (figure 1 B). This male was crossed to a normal full-eyed fly, and the daughters were back-crossed to their father. From the offspring of this back-cross there were derived individuals like the original mutant male and they constitute the so-called "bar-eye" race. Bar eye is a sex-linked character, and it is evident from its origin in a single male that all the future bar-eye genes are derived from the single original one. The gene is located at 57.0 on the chromosomal scale developed by MORGAN and his co-workers. It is spoken of as a dominant mutant in the original paper, but the heterozygotes are intermediate in facet number between bar and full eye (figure 1 Z). Using the factorial scale as applied in the present paper, the heterozygote is nearer to full eye than to bar. The facets of bar eye are divided into an upper and a lower group by a constriction slightly below the middle of the eye. It is more pronounced in low than in high bar, and in some cases the two parts of the eye are completely separated.

Bar-eye stocks

A few months after the establishment of the stock, Professor MORGAN kindly sent me some individuals which served as the basis of my stock.

[3] For the meaning of factorial units see page 13 and following.

In September 1914, less than a year after the appearance of the original mutant, this stock was used as the starting point of the selection series described by ZELENY and MATTOON (1915). The facet counts in the unselected stock at this time averaged 65.06 in the females and 98.04 in the males. In factorial units, according to the system and scale used in the present paper, these values are +1.50 for the females and −0.50 for the males. The sexual dimorphism indicated in the facet counts was noted throughout the various series of experiments, but it has been shown to vary so much in degree that the method of reduction of the

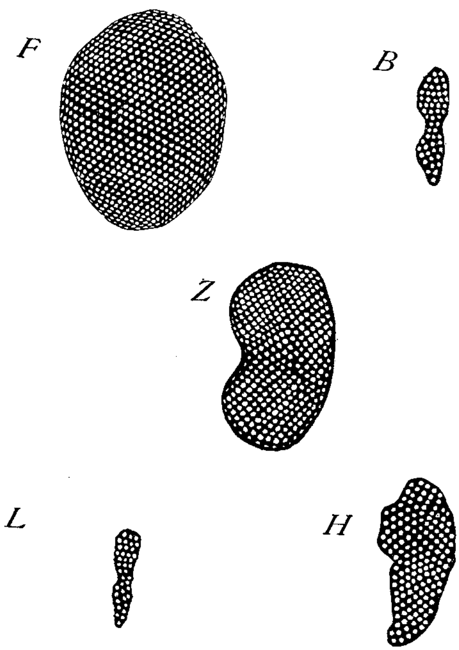


FIGURE 1.—Full and bar eyes. Females. F = full eye. B = bar eye of white unselected stock number 127. Z = heterozygote of full × bar. L = selected low-bar eye. H = selected high-bar eye.

female and male values to a common basis by the use of a constant factor, which was employed in the first paper, has not been followed in the later tabulations. The values for the two sexes in factorial units as given above show that the sexual dimorphism at the given time was different from that in the unselected white bar stock which is used as the standard of reference. The females are relatively higher, and the males relatively lower. As described in a paper now in press, there is also a pronounced decrease in the dimorphism during the course of selection with inbreeding (ZELENY 1921 b).

The vestigial bar used by MAY (1917) in one of his selection series was obtained from the same stock by crossing with a vestigial-winged full-eyed race. In MAY'S other series the bar stock was used directly.

In 1916 my stock was divided into parts, each of which received a distinct designation. They were carried on separately with a view to determining any divergence of the mean values that might occur under the conditions. One of these stocks, number 31, was later used as the starting point of red-bar selection lines A and B, which are to be described in a separate paper. Another one, number 23, was used in producing the white bar stock which served as the basis of the experiments about to be described.

It was desired in the present selection series to duplicate as nearly as possible the material used in a previous set of experiments. Red bar, number 23, and white full-eye stocks were carried in the laboratory without selection or contamination. During the summer of 1917 they were kept in a constant-temperature room at about 25.6° C. Males of red bar, number 23, were mated to females of white full-eye on August 6. The F_1 offspring were the expected red heterozygous females and white full males. These gave in F_2 the expected non-crossover and crossover classes. The white heterozygous bar crossover females and white bar crossover males were mated in mass, and their offspring (F_3) were treated as follows. The two lowest pairs, a 19-facet female and 31-facet male, and a 21-facet female and 39-facet male, and the two highest pairs, a 141-facet female and a 202-facet male, and a 177-facet female and a 211-facet male, were eliminated and used for a separate test. Of the remaining individuals a random sample was preserved for a count and the rest were mated in mass, giving the pure white bar stock (F_4) which served as the starting point of the selection series.

It is to be noted that several red bar males were used in the original cross with white full, so that several bar genes were present at the start. This condition is to be contrasted with that in another series, described in a separate paper, in which a single bar gene was introduced.

METHOD

Food

The banana was put into an Arnold sterilizer for 45 minutes, sealed in air-tight Mason jars and inoculated with yeast as needed. Uniformity in food conditions was by no means obtained, and some of the variability in facet number is undoubtedly due to this source. A technique making possible a better food control is highly desirable in future work of this character.

Contamination

A special effort was made to avoid contamination, because the study involved the origin of mutations as well as the effect of selection. The evidence that no contamination occurred is similar to that given by MAY (1917), and need not be repeated here except to state that the precautions observed were even more rigid than his, and that no case of contamination was discovered.

Temperature control

In view of the marked dependence of facet number upon temperature as demonstrated by SEYSTER (1919) and KRAFKA (1920), great care was taken to keep the material at a constant temperature throughout the experiment. The departure from 27.0° C did not exceed 0.5° during the whole course of the selection. The details of the temperature control as given by ZELENY (1920 a, pp. 294–296) apply to the present data.

Selection procedure

Brother-and-sister matings were made as consistently as possible. In a few cases death or lack of fertility compelled a resort to cousin matings to insure the continuity of the experiment. Figures 2 and 3 give the pedigrees for the low- and high-selection lines respectively. The selection generations are given in the first column and the catalog numbers of individual matings in the succeeding columns. The original selections naturally came from the mass stock culture. In the low direct line the only exceptions to brother-and-sister matings were in the first generation, which had a cousin mating, and in the fifth, which was a mass culture. In the high direct line the only exception is in the 21st generation. Among the matings not in the direct line, one in the 20th generation of the low selection, and one each in the 27th, 28th and 36th generations of the high line are not brother-and-sister matings.

As a matter of general routine, it was planned to mate the lowest (or highest) male in each generation with the lowest (or highest) female. The next-lowest (or highest) were then mated, and so on. If the highest pair gave a considerable number of offspring, these were used for the next selection. If they were sterile, or gave only a few offspring, the next-highest pair was chosen, and so on. While "performance" did not enter into the plan of the procedure as originally outlined, it did enter as an element in selection in a few places because in case the offspring of the lowest (or highest) pair were only few in number, they were more frequently chosen for the continuation of the line when their values were in the direction of the selection than when they were strikingly in the other direction.

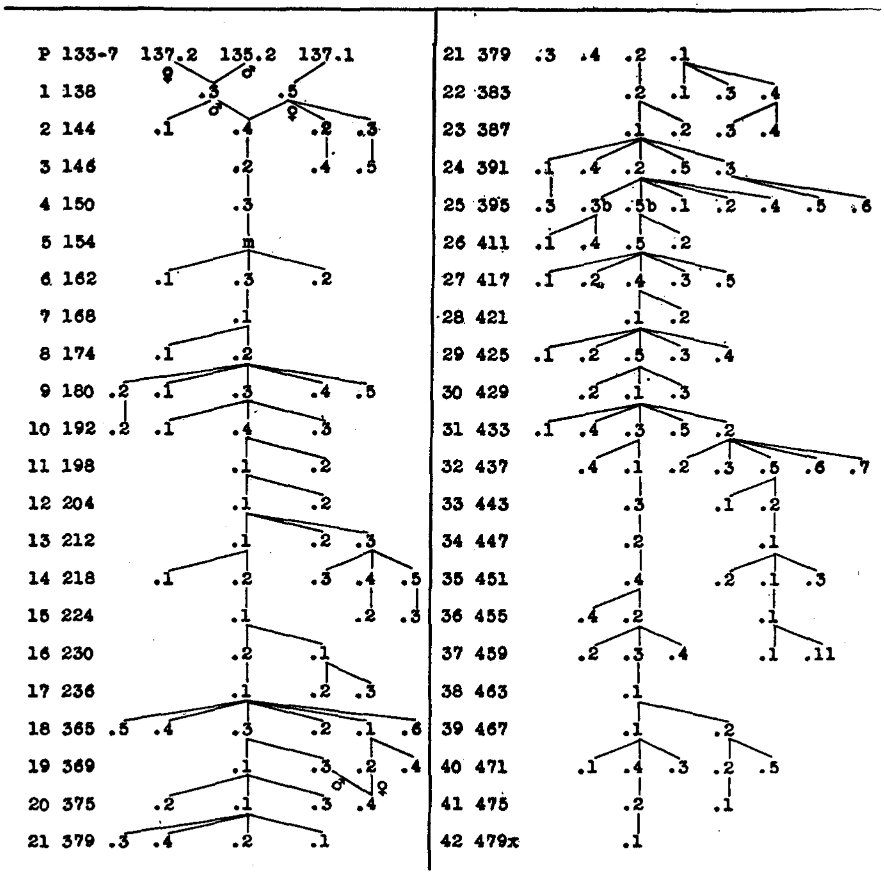


FIGURE 2.—Pedigrees in low line. The generations and culture numbers are given. The direct line is the continuous vertical one. All matings are of brothers with sisters except where male and female parents are indicated as coming from two sources.

At times the fertility was low, and it was necessary to mate as many as twelve or even more pairs to insure continuity of the lines. The offspring of the sib-matings were recorded, and the data are included in the tables labeled "all matings." In every case, however, the "direct-line" matings are separately tabulated.

Recording of the data

The data were recorded in notebooks paged consecutively, and entries were made in day book fashion. All the records are referred to by page number with a decimal corresponding to position on the page. For instance, number 144.2 refers to the data recorded on page 144 in the second column from the left. The bottles of flies had the same numbers. Each bottle and each corresponding entry in the notebook had attached to it the source of the parents, their facet numbers, date of mating, food-

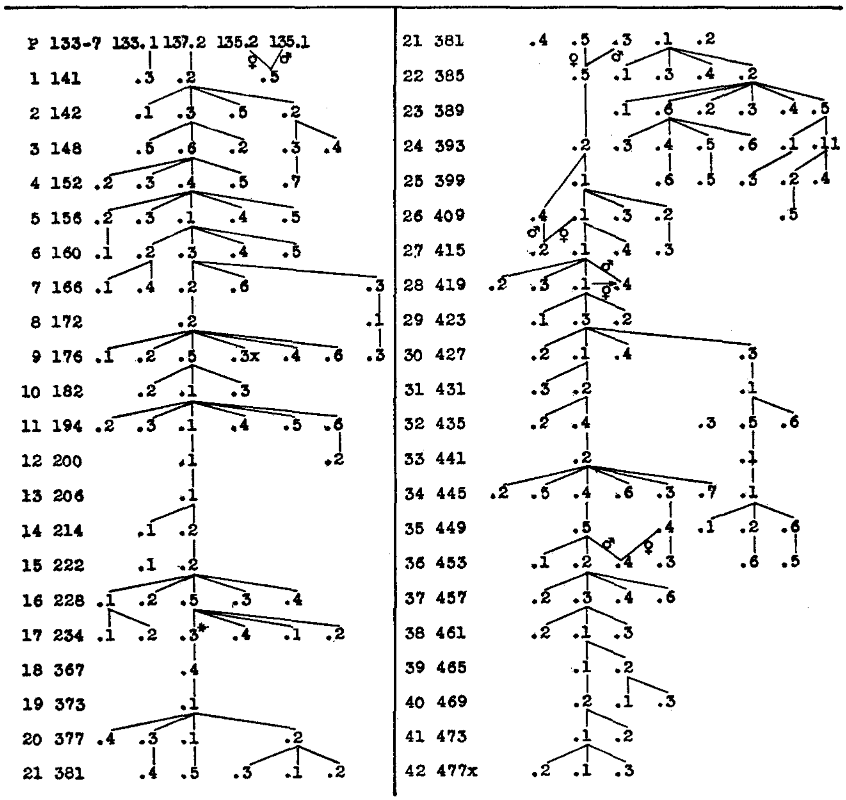


FIGURE 3.—Pedigrees in high line. Arrangement as in figure 2.

culture number, date of removal of parents, temperature, and bottle sequence in case more than one bottle was used for the same pair. After a considerable experience with both cards and bound notebooks, the writer favors the latter if a tendency to crowding can be avoided. It is his experience that the day-book scheme for the original data causes the recording of more details than do other systems because there is no need of hunting for the proper place of entry.

The degree of selection

In the low direct line the average difference between the means of the selected parents and the means of the populations of which they were a part was -1.71 factorial units. Including the sib-matings, the average was -1.79.[3] Due to the exigencies of the experiment, largely a matter of low viability, five of the matings in the direct line and one generation when all matings are included, were actually high selections, the means of the selected pairs being higher than the mean of the population. In one generation, also in both direct and all matings, there was a resort to a mass selection. In the remaining 36 generations of the direct line and 40 generations of all matings (those having a minus selection) the average degree of selection was -2.02 factorial units for the direct line, and -1.87 for all matings. The values for the individual generations are given in tables 26 and 27 and figures 122 and 123.

In the high direct line, the average difference between averages of the grades of the selected parents and the means of the populations of which they were a part was $+2.16$ factorial units. Including the sibs, the average was $+2.10$. In three of the generations of the direct line and in two of "all matings," there was a minus selection. The average degree of the remaining 38 or plus generations of the direct line, was $+2.41$ factorial units, and of the 39 plus generations of all matings, $+2.30$. The values for the individual generations are given in tables 28 and 29 and figures 124 and 125.

Synchrony between low and high lines

It was deemed desirable to keep the low and high lines of any generation as nearly synchronous as possible. This was done with the object of aiding in the elimination of differences due to food or other factors not otherwise controllable. The degree of success of the attempt at synchrony is shown in table 2 which gives the dates of the matings for all the generations in both low and high lines. It will be noted that the 23rd generation of the high line is skipped in order to bring the two lines to equal dates of mating. A reference to the pedigree chart (figure 3) shows the necessity for this procedure. It was due to the loss of the prospective direct line and the substitution of a prospective sib-mating for the lost one. In the discussion of the experiments, as well as in the tables, it seems best to call the high-selection generations beginning with the 23rd by generation numbers one higher than the actual so as to make them agree in time with the coördinate low-selection generations.

[3] For the meaning of factorial units see p. 13 and following.

TABLE 2

Synchrony between low and high generations. White bar selection, 27° C.

	LOW			HIGH				LOW			HIGH		
P	1917	IX	26	1917	IX	26	22	1918	VIII	13	1918	IX	11
1		X	9		X	13	23		VIII	26			
2		X	23		X	25	24		IX	25		IX	24
3		XI	3		XI	6	25		X	11		X	11
4		XII	1		XI	17	26		X	22		X	22
5		XII	14		XII	17	27		XI	2		XI	2
6	1918	I	1		XII	28	28		XI	14		XI	21
7		I	15	1918	I	14	29		XII	5		XII	5
8		II	12		I	26	30		XII	20		XII	20
9		III	1		II	8	31	1919	I	1	1919	I	8
10		III	13		II	22	32		I	23		I	25
11		III	22		III	7	33		II	6		II	11
12		IV	5		III	23	34		II	25		II	27
13		IV	16		IV	10	35		III	11		III	11
14		IV	26		IV	25	36		III	25		III	27
15		V	11		V	11	37		IV	8		IV	8
16		V	24		VI	4	38		IV	22		IV	24
17		VI	4		VI	15	39		V	14		V	7
18		VI	19		VII	4	40		V	26		V	21
19		VII	4		VII	16	41		VI	5		VI	12
20		VII	16		VII VIII	26 2	42		VI	20		VI	25
21		VIII	1		VIII	26							

Times of first matings in the direct line in each generation, except the last in which the dates of the facet counts are given.
Average length of generation in days, low line = 12.7, high line = 12.8.
Total period in days, low line = 533, high line = 538.

Accuracy of facet counts

The accuracy of the facet counts was tested at various times to see if it was sufficient for the purposes of the experiment. Most of the facets are arranged in rows, and it is easy for the eye to follow them. Some are irregular in arrangement, and occasionally one or two facets are of small size. The counts cannot, therefore, be absolutely correct under the conditions of the experiment which involved the handling of such large numbers of individuals. They are, however, of sufficient accuracy for the purpose in view, as shown in table 3, which includes an ordinary routine count and a recount made several weeks later by JOSEPH KRAFKA, JR., who is responsible for nearly all of the counts made in connection with the present experiment.

TABLE 3

Accuracy of counts. Test by JOSEPH KRAFKA, *Jr.*

	FEMALES		MALES	
	Original	Recount	Original	Recount
	1918 I 21	1918 III 3	1918 I 21	1918 III 3
	34	35	32	33
	37	36	39	37
	38	38	40	40
	41	40	40	41
	41	41	40	41
	42	42	41	43
	42	42	41	43
	43	42	47	45
	43	43	49	48
	45	45	52	51
Average	40.6	40.4	42.1	42.2

THE TABULATION OF FACTORIAL VALUES FOR FACET NUMBERS[4]

General statement

In working up the data, it became evident that the demands of the biological analysis were not adequately met by the system of arrangement in classes with equal facet numbers. It seemed desirable in so far as is possible, to express relations directly in terms of factorial units affecting facet number rather than in facet numbers. Direct experiment with one factor, temperature, had demonstrated that its action is not one of accretion, as this system demands, but one of proportionate action. The result depends upon the amount of material acted upon as well as upon the temperature. Assuming that the action of other factors follows the same principle, the geometric or logarithmic mean and the dispersion of the logarithms of the facet numbers should form the basis of the biological analysis. That this is a proper procedure is further indicated by the marked positive skewness of the variation curves of facet number as plotted on the arithmetic basis and the normal form of the logarithmic curves.

The particular form which the analysis takes in the present paper was determined primarily by the need of a procedure which would enable one to visualize the biological significance at all points. The following discussion has that object in view.

[4] A brief statement of this method of tabulation is given in a previous paper (ZELENY 1920 b).

For reasons to be stated presently, in dealing with a stock averaging 30 facets as compared with one averaging 300 facets, it seemed that the unit value should not be one facet for both but rather that a change of one facet at the mean in a 30-facet stock should be recognized as representing the same factorial value as a change of ten facets at the mean in the 300-facet stock, and a corresponding principle should apply within the range of a single stock. In the ordinary determination of variation constants this principle is, of course, recognized in the formula for the the coefficient of variation in which C.V. $= \frac{\sigma}{M} \times 100$, or the standard deviation per unit of the mean multiplied by 100. The formula, however, makes the reduction only for the population as a whole. It does not make any provision for comparisons within the range of a single population and therefore does not meet the demands of graphic representation.

In the tabulation with equal facet values for the different classes, the difficulties connected with the comparison of stocks with greatly different means can be met for purposes of tabulation of the data by use of the coefficient of variation as given above. In graphic representation, the different populations can be brought to a comparable basis by using class ranges differing for the different stocks and equal for any stock to a certain definite percent of the mean of that stock. Thus for a stock with a mean of 30 facets, classes each of which has a range of 33 facets or 10 percent of the mean of that stock, might be used. Within the population of each race, however, there would still be a discrepancy between the individuals with high and those with low values, because the class range in each stock is too low for the individuals with high facet number and too high for those with low facet number.

As given later, biological considerations in connection with eye-facet formation, and the same undoubtedly hold for many other similar organs, lead to the belief that environmental and presumably germinal factors do not act by accretion, but that the effect is upon the rudiment of the organ as a whole. A unit factorial change in a 300-facet race yields ten times as much facet change as in a 30-facet race, because it has ten times as much material to act upon.

Considering this hypothesis of the proportionate relation of factors to somatic characters to be correct, a population which has a normal variability curve as regards factors will have a positive skewness as regards the eye-facet characters. The obvious correction for this condition is to make the class ranges vary in accordance with the hypothesis. If each class range is a definite fixed percent of the mean of *its* class, then throughout the whole range of variation the class ranges are comparable, and each class has the same factorial value.

The variation data are thus put into factorial units and not eye-facet units, and the various constants can be determined in the ordinary way. Suppose that the class facet ranges are in every case equal to ten percent of the mean class facet values, which is the amount produced by a change of one degree centigrade, and a factorial unit is one that produces a ten percent change in the facet value of a class; then, according to the hypothesis, all the factorial units have the same factorial value though their facet values vary with the means of the classes. Starting with some arbitrary point, for instance the mean facet value of the unselected stock in a selection experiment, and calling this point zero, then every facet value has a definite factorial value equal to plus or minus a certain definite number of factorial units from the zero point. Five units above the mean is equal to five units below the mean, and similarly everywhere in the scale, while a departure of +5 or +50 facets under the ordinary system of tabulation does not have the same factorial value as −5 or −50 facets. The standard deviation, as determined by this method, is expressed in factorial units and serves directly as a coefficient of variation strictly comparable in all cases, regardless of the mean values of the different stocks that may be compared.

Validity of the method

The validity of the method is, of course, dependent upon the biological assumption that eye-facet value is such a function of factorial value as is indicated. The evidence in favor of this view will now be considered.

Proportionate action *versus* accretion

It is a common principle of embryology that a changed condition does not act by accretion, i.e., by the addition or subtraction of individual parts without affecting the rest. On the contrary, the action is upon all the pre-existing parts of the organ. The result then depends not only upon the strength of the new agent, but also upon the reaction capacity of these pre-existing parts. Since a new factor, f, acts upon the whole complex, the value of the pre-existing mechanism, m, is a factor in the result as well as f. This general statement applies to both germinal and environmental factors. For instance, it is clear that any particular factor affecting facet number is not something which can of itself produce facets, nor is it a certain amount of substance with a capacity limited to the production of a fixed number of facets.

Germinal factors

As regards germinal factors, it is clear that the chromosomal mechanism distributes them equally to all the cells of the body. Limiting the consideration to a single effect of a particular factor, if at the stage at which this factor can function there are eight cells in the reacting region in one individual and only four in another, the resultant effect is twice as great in the first as in the second. This is a crude statement of the case because the action of the different factors is no doubt to a large extent simultaneous, but it makes clear the principle involved.

Environmental factors

That the theory of proportionate action is a closer approximation for the temperature effect than the theory of action by accretion is demonstrated by the experiments of SEYSTER and of KRAFKA. SEYSTER (1919) has shown that in the bar eye, facet number decreases with increase in the temperature at which the larvae of Drosophila are reared. This decrease follows VAN'T HOFF'S law if an inhibitor of facet number is assumed as the effective agent upon which the temperature acts. KRAFKA (1920) has demonstrated that this law applies to ultra-bar as well as to bar eye, and that for the different stocks the effect of a degree of change in temperature is roughly proportional to the mean facet value of the stock, and the same is approximately true for the effect throughout the range of a single stock. Table 4 gives the results of one of his experiments

TABLE 4

Facet values and factorial values at 15° and 25° in ultra-bar, low bar and unselected bar.

STOCKS	FACET VALUES				FACTORIAL VALUES			
	15°	25°	Differences	Ratios $=\frac{X}{B'U}$	15°	25°	Differences	Ratios $=\frac{X}{B'U}$
Ultra-bar $=B'U$	51.5	25.2	26.3	1.0	− 0.83	−7.86	7.03	1.0
Low bar	189.0	74.2	114.8	4.4	+12.17	+2.79	9.38	1.3
Unselected bar	269.8	120.5	149.3	5.7	+15.72	+7.73	7.99	1.1

with ultra-bar, low-selected bar and unselected bar. The facet numbers for 15° and 25° are given, and the facet differences for the three stocks are respectively 26.3, 114.8 and 149.3. Representing the effect of a ten-degree difference for ultra-bar as unity, low-selected bar has 4.4 times and unselected bar 5.7 times this difference. It is obvious that difference in facet value is not a good measure of the value of the temperature factor.

On the other hand, if the facet values are reduced to factorial values, the differences between the 15° and 25° values are 7.03 factorial units for ultra-bar, 9.38 for low bar and 7.99 for unselected bar. The last two values are respectively 1.3 and 1.1 times the first, while the corresponding facet values are respectively 4.4 and 5.7 times the facet difference for ultra-bar. The factorial units, therefore, give a much closer approximation than the facet numbers.

A change of one facet is, therefore, not of equal factorial value at different points in the variation scale as far as temperature is concerned. A plotting of the data using facets as the units does not give a uniform factorial scale. Suppose temperature to be the only factor causing variation in the facet number of a particular stock, and knowledge of the actual temperatures involved in the production of a particular population to be lacking, and it is desired to derive the value of the temperatures from the facet values. Obviously the closer approximation would be obtained by the tabulation in which each class has a range equal to a definite percent of the mean of the class. KRAFKA'S data show that even in this case the values are not exact, but certainly the error is of a much lower order than that involved in using facets as the units.

Skewness

When eye-facet numbers are plotted on the basis of classes with equal facet ranges, they usually show a very distinct positive skewness, i.e., the mean is higher than the mode (figure 4). Such a skewness may be due to any one or more of a number of causes, but it is not the intention to discuss them here in detail. One evident explanation is that the facet values on that system of plotting do not correspond with factorial values. If we employ the method of factorial units, this skewness disappears in large part and the curve shown in figure 5 is obtained. If the factorial values fluctuate evenly around the mean, the curve should be without skewness when plotted on the basis of those values, but should have a positive skewness if plotted on the basis of classes with equal facet ranges.

If this explanation applies to eye-facet numbers, it is very probable that it applies to similar cases elsewhere. In this connection it is interesting to note that positive skewness is very common in variation data as tabulated by the ordinary method. Some, at least, of these cases may be explained on the same basis as the one under discussion. Separate proof, however, is required in each case.

Zero point

The location of the point of reference or zero point in the factorial determinations at the mean of the unselected population has the additional value of being itself in the zone of normal factorial action. The same can not be said of zero facet number, for it is obvious that the factorial action involved in producing a change from zero to any value above zero is of a different order from that involved in any other change whatsoever within the range of variation.

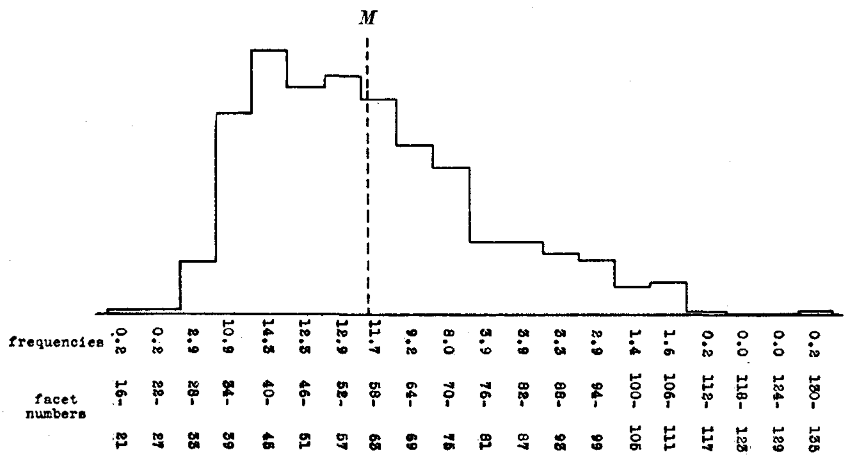


FIGURE 4.—Unselected white bar females arranged in classes each with a range of six facets. 488 individuals. M = mean. There is a striking positive skewness.

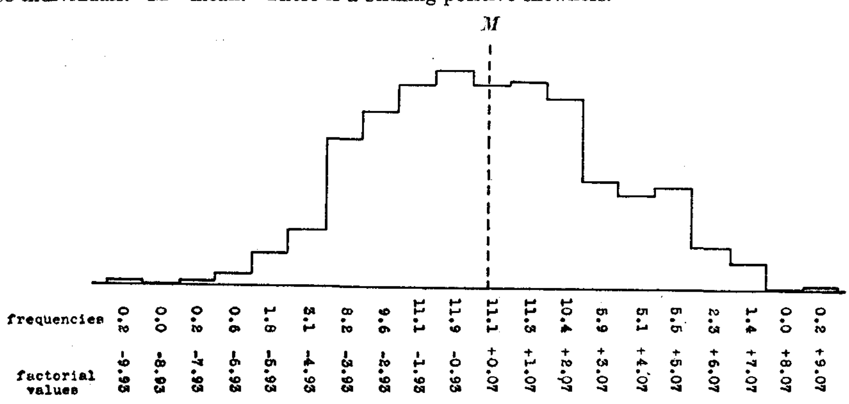


FIGURE 5.—Unselected white bar females arranged in classes each of which has a range of ten percent of the mean facet value of the class. 488 individuals. M = mean. The lower row of figures gives the departures in "ten-percent" factorial units from the mean.

Application to white bar selection

The scale of factorial classes with corresponding facet values as used in the white bar selection lines is given in table 5. The first column gives the mean factorial values of the classes in the females and the third column those in the males. The middle columns give the corresponding facet ranges. The bases of reference or the zero points of the factorial scales are respectively the mean facet value of the females and of the males of the unselected population. For females this value of the zero point is 58.8 ± 0.58 facets and for the males 111.4 ± 1.44 facets. If the facet ratio between the sexes were a constant, it would be possible to reduce the male to the female values or *vice versa*, according to the method followed by ZELENY and MATTOON (1914). The great variation in the ratio in the present material, however, makes it desirable to use separate male and female scales.

Each class has a range in facet value equal approximately to 10 percent of the facet mean of its class. An exact relation of 10 percent would have involved dividing individuals with the same facet value between two classes, but the demands of the analysis are met by the approximation which allows all individuals of a single facet value to be grouped in the same class. An exception was made for individuals with 14 facets which are divided equally between two classes, as part of the procedure in making the departures of the lower classes from the mean as nearly accurate as possible.

Since on the average in the bar-eye races a decrease of one degree centigrade in temperature causes an increase of 10 percent in facet number, the factorial scale may be read as a temperature scale. In other words its units of value are equivalent to degrees centigrade and the difference between any two points may be expressed as so many degrees of temperature. Thus the difference in facet number between ultra-bar and bar eye may be expressed as equal to approximately twelve degrees of temperature or in other words ultra-bar may be changed to the bar level by decreasing the temperature by that amount.

It will be noted that each facet value may be represented as plus or minus a definite number of factorial units from the point of reference, the mean facet value of the unselected population. The determination in factorial units of the mean, standard deviation and other constants is readily accomplished directly as in the ordinary methods. For example, the mean of the males of the 25th generation of upward selection is $+4.60 \pm 0.16$ factorial units, and the corresponding mean of the males of the

TABLE 5

Factorial scales in the white bar selection lines for females (first column) and males (third column) using the means of the unselected population as the zero points and arranging the classes so that each will have a range approximating ten percent of its mean facet value. The corresponding facet values of the classes are given in the middle columns.

CLASS FACTORIAL VALUES FEMALES	CLASS FACET VALUES	CLASS FACTORIAL VALUES MALES
−16.93	10	−23.05
−15.93	11	−22.05
−14.93	12	−21.05
−13.93	13 and 14 (part)	−20.05
−12.93	15 and 14 (part)	−19.05
−11.93	16−17	−18.05
−10.93	18−19	−17.05
− 9.93	20−21	−16.05
− 8.93	22−23	−15.05
− 7.93	24−26	−14.05
− 6.93	27−29	−13.05
− 5.93	30−32	−12.05
− 4.93	33−35	−11.05
− 3.93	36−39	−10.05
− 2.93	40−43	− 9.05
− 1.93	44−48	− 8.05
− 0.93	49−53	− 7.05
+ 0.07	54−59	− 6.05
+ 1.07	60−65	− 5.05
+ 2.07	66−72	− 4.05
+ 3.07	73−80	− 3.05
+ 4.07	81−88	− 2.05
+ 5.07	89−97	− 1.05
+ 6.07	98−107	− 0.05
+ 7.07	108−118	+ 0.95
+ 8.07	119−131	+ 1.95
+ 9.07	132−145	+ 2.95
+10.07	146−160	+ 3.95
+11.07	161−177	+ 4.95
+12.07	178−196	+ 5.95
+13.07	197−217	+ 6.95
+14.07	218−240	+ 7.95
+15.07	241−265	+ 8.95
+16.07	266−293	+ 9.95
+17.07	294−324	+10.95
+18.07	325−358	+11.95
+19.07	359−396	+12.95
+20.07	397−438	+13.95
+21.07	439−484	+14.95
+22.07	485−535	+15.95
+23.07	536−591	+16.95
+24.07	592−653	+17.95
+25.07	654−722	+18.95
+26.07	723−798	+19.95
+27.07	799−882	+20.95
+28.07	883−975	+21.95
+29.07	976−1078	+22.95
+30.07	1079−1191	+23.95

25th generation of downward selection is -7.76 ± 0.11. The effectiveness of the selection is represented by the difference between the two, which is 12.36 ± 0.19. The standard deviations are 1.81 ± 0.09 for the high males and 1.77 ± 0.08 for the low males of this generation. They may be used directly as the coefficients of variation since no correction for mean facet values needs to be made. In the case cited, the difference between the two standard deviations is obviously not significant. As compared with the standard deviation of the unselected males, which is 3.91 ± 0.09 factorial units, there has been a significant decrease in variability.

Other examples

The advantages of the factorial basis for purposes of calculation and tabulation may be illustrated by some further examples.

The determination of a coefficient of dominance

As shown in table 6, the mean facet number of low-bar females in the twenty-fourth generation of selection is 35.1, that of full-eyed females

TABLE 6

Dominance of bar and full.

FEMALES	CATALOG NUMBERS	NUMBERS OF INDIVIDUALS	MEAN FACET VALUES	MEAN IN FACTORIAL UNITS	FACTORIAL UNITS FROM HETEROZYGOTES	DOMINANCE IN PER-CENTS
Low-selected bar (F24)	391.2	129	35.1	− 4.45	+23.89	23.2
Full stock	345	10	810.6	+26.67	− 7.23	76.8
Heterozygotes	769	19	399.9	+19.44		

810.6 and that of the heterozygotes between the two, 399.9. Since the facet values between 35.1 and 399.9 do not have the same factorial value as those between 399.9 and 810.6, the relative strengths of bar and full in determining the value of the heterozygotes cannot be obtained directly. However, by putting these facet values in terms of factorial units of equal value throughout the scale, it is possible to get such coefficients by use of the formulae

$$\text{C.D. of bar eye} = \frac{F-H}{F-B} \times 100, \text{ and}$$

$$\text{C.D. of full eye} = \frac{B-H}{B-F} \times 100$$

in which B is the factorial value of bar eye, F of full eye and H of the heterozygote. Assuming uniformity of action throughout the whole range, these determinations give a value of 23.2 percent for the dominance of low bar, and 76.8 percent for that of full eye on a scale in which 100 percent represents complete dominance and 0.0 percent complete recessiveness.

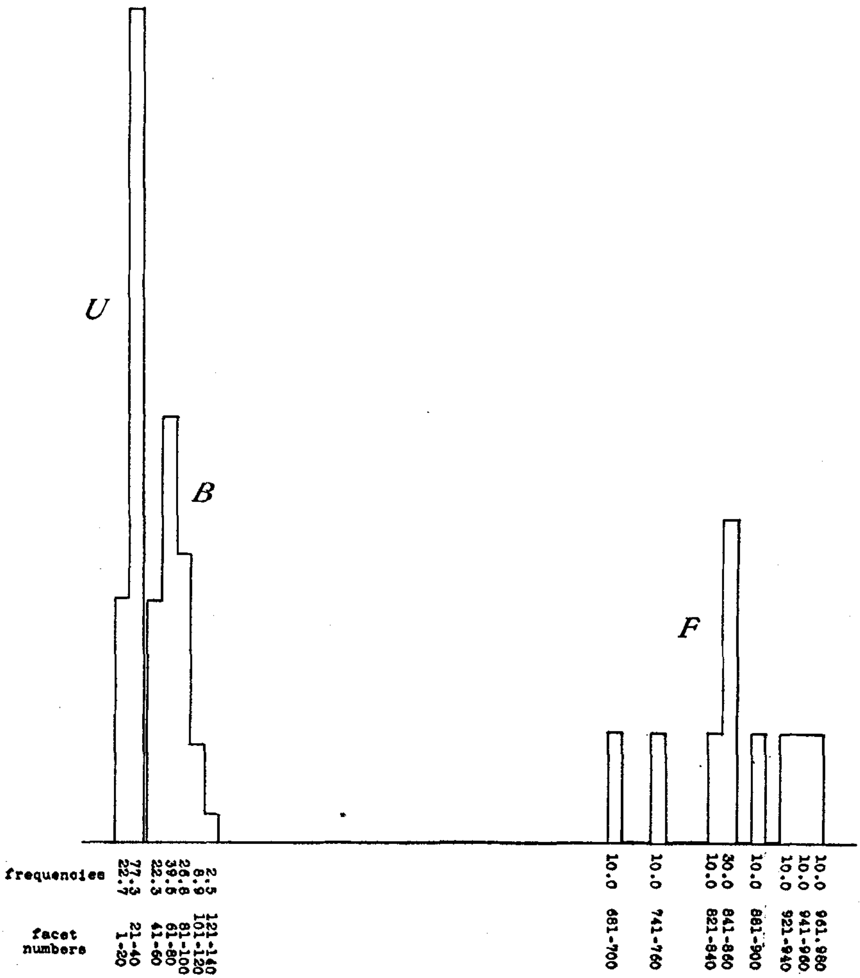


FIGURE 6.—Males of ultra-bar (U), low-bar of the second generation (B) and full eye (F) arranged in classes each of which has twenty facets. All raised at 27° C. Compare with figure 7 which shows the same data arranged in factorial classes.

The comparison of variability in ultra-bar, bar and full eye

Figures 6 and 7 represent variability in ultra-bar (U), bar of the second low-selected generation from which ultra-bar was derived (B), and full

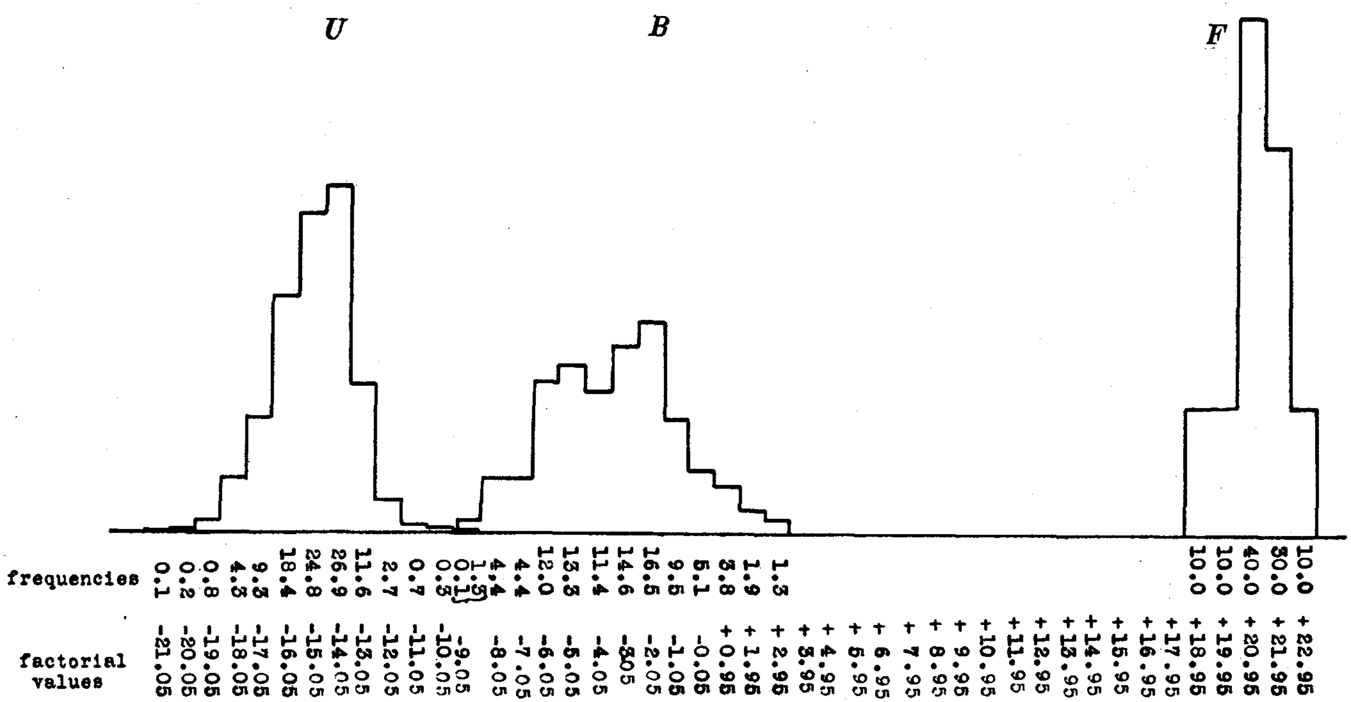


FIGURE 7.—Males of ultra-bar (U), low-bar of the second generation (B), and full eye (F), arranged in classes each of which has a range equal to ten percent of its mean facet value. The lower row of figures gives the departures in "ten-percent" factorial units from the mean of unselected bar.

eye (F). In figure 6 the classes are arranged in the ordinary way so that each has the same facet range. In figure 7, each of the classes has a facet range equal to 10 percent of its mean facet value. The superiority of figure 7 over figure 6 as a true representation of factorial values is apparent.

The comparison of low and high selection lines

Figures 8 and 9 represent the low and high lines of white bar eye after 25 generations of selection. Figure 8 is based on equal facet values for all the classes, and figure 9 has classes each of which has a facet range equal to 10 percent of its mean facet value. Again the superiority of the second representation is apparent.

The representation of mixed populations

Figures 9 and 10 give the variability among daughters of a heterozygous female (from ultra-bar × bar) by a bar male. Heterozygous and bar females are expected. Other crosses show that the two classes overlap, and the same fact is indicated by the distribution in this case. Figure 10 gives the data as arranged in classes of equal facet value. Figure 11 gives them as arranged in classes of equal factorial value. The latter representation is obviously superior for purposes of biological analysis.

DATA

Original data

The importance of the manipulations to which the data are subjected has been emphasized in the last section. The original data before analysis should therefore be available. They have been collected for this purpose in a series of tables, of which one is published here (table 7). The complete tables are on file in the Zoölogical Laboratory of the University of Illinois where they are available for study or for photographic reproduction. In each table there are given all the facet counts for the particular generations with which it deals. The uppermost horizontal column gives the generations of selection. The second column contains the catalog numbers of the individual matings as applied to the offspring, the third the catalog numbers of the matings from which the parents were derived, the fourth the facet counts of the female parents and the fifth the facet counts of the male parents. Under each mating the daughters and sons are listed in separate columns. The vertical column at the left gives the facet counts and in their proper places are listed

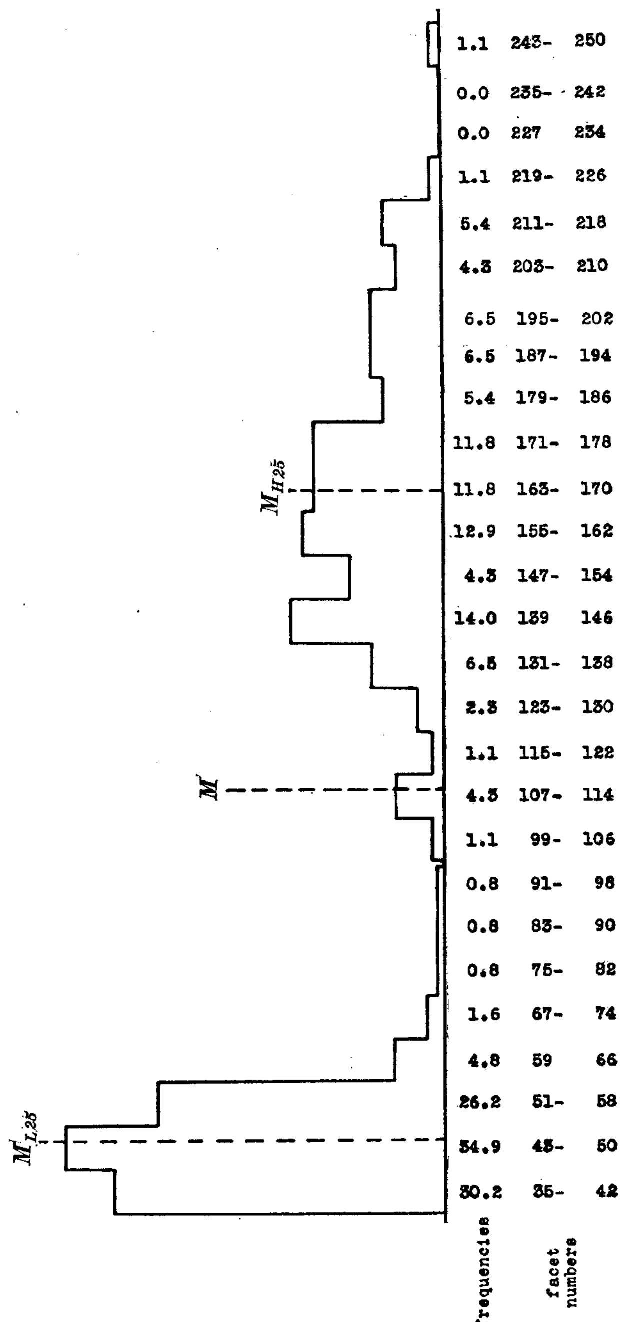


FIGURE 8.—Low-selection and high-selection males of the 25th generation arranged in classes each of which has a range of eight facets. 126 individuals in low-selection line and 93 in high-selection line. M_{L25}= mean of low-selection line=48.2 facets. M_{H25}=mean of high-selection line=166.1 facets. M=mean of the unselected males=111.4.

TABLE 7

Tabulation of original data. Eye-facet numbers. White bar selection. Low line. Temperature =27° C. Banana yeast food. September 12, 1917 to July 15, 1919. (Sample table.)

GENERATION	F 37												F 38		F 39					
Mating	459.3		459.1		459.11		459.2		459.4		Total		463.1		467.1		467.2		Total	
Parents from:	455.2		455.1		455.1		455.2		455.2				459.3		463.1		463.1			
Facets ♀	34, 34		33		35		34		33				33		35		38			
Facets ♂	42		34		35		39		41				40		36		43, 43			
Offspring	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
25															1				1	
26																				
27															2				2	
28															2				2	
29																				
30	1										1									
31	1										1				1				1	
32													1		5				5	
33	1				1				1		3				4				4	
34															4				4	
35	1				1						2		1				2	1	2	1
36					1						1		1	1	5			1	5	1
37	2				2	1		1	1	1	5	3	2		5	3			5	3
38	2								1	2	3	2	1	1	3	2	2	1	5	3
39	3		1		1						5				8	4	1	1	9	5
40	2	3	2		1			2			5	5	1	3	2	3	2	1	4	4
41	2	1			4			3		1	6	5	5	4	2	1	1	4	3	5
42	1					2	2	1	1		4	3	3	3	1	3	1	4	2	7
43	1	1	1			1					2	2	6	4		5	1	2	1	7
44	2	2						2			2	4	2	1	2	4	4	2	6	6
45					3	1	1			1	4	2	1	1		1	1	2	1	3
46	3	1	1		1	3		1			5	5	5		1	1		4	1	5
47	2	1			1	1		1	1		4	2	2	1	1	1	1	2	2	3
48	1	1					1	3			2	4		2		2	2	1	2	3
49	1							1			1	1	1	1			1		1	
50		3			1	1		1			1	5				1				1
51	1	1				1					1	2		1		3				3
52	1	4									1	4		1		4				4
53	2	2						1			2	3				1	2	1	2	2
54	1	1						1			1	2	1			2				2
55		2										2		1						
56	1	3									1	3		1		3		1		4
57		2				1						3				1				1
58						1						1				1				1
59		1										1		1						
60		1		1		2						4	1							
61		1										1								
62		2				1						3				1				1
63		4										4		1		1				1
64		1										1		2						
65																				
66																				
67																1				1
Total	32	38	5	1	17	16	4	17	5	5	63	77	34	30	49	49	21	28	70	77

the numbers of daughters and of sons from each mating for each facet count. Under each generation the first vertical column gives the mating in the direct line. The others are sib-matings. The few exceptions to this rule are noted in the pedigree charts of tables 2 and 3.

When the mating is not of brother with sister, the fact is indicated by the presence of two catalog numbers in the third horizontal column, the upper one giving the origin of the female parent and the lower of the male parent. When more than a single male or female is included in a bottle that fact is indicated by the presence of more than one facet count under "female or male parent."

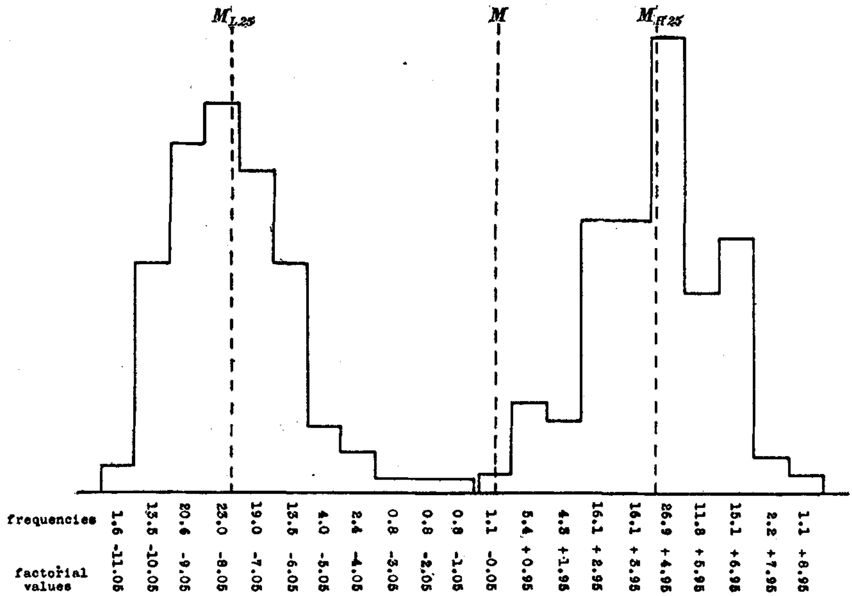


FIGURE 9.—Low-selection and high-selection males of the 25th generation arranged in classes each of which has a range equal to ten percent of its mean facet value. 126 individuals in low-selection line and 93 in high. M_{L25} = mean of low-selection line = -7.76 factorial units. M_{H25} = mean of high-selection line = $+4.60$ factorial units. M = mean of the unselected males = 0.00.

With very few exceptions only one of the two eyes was observed, and in the few cases in which facet counts of both eyes were made, in every instance only the eye first observed is included in the record.

Parents of direct-line offspring

The values of the parents in each generation of the direct line are given in table 8 for the low line and table 9 for the high line. The vertical

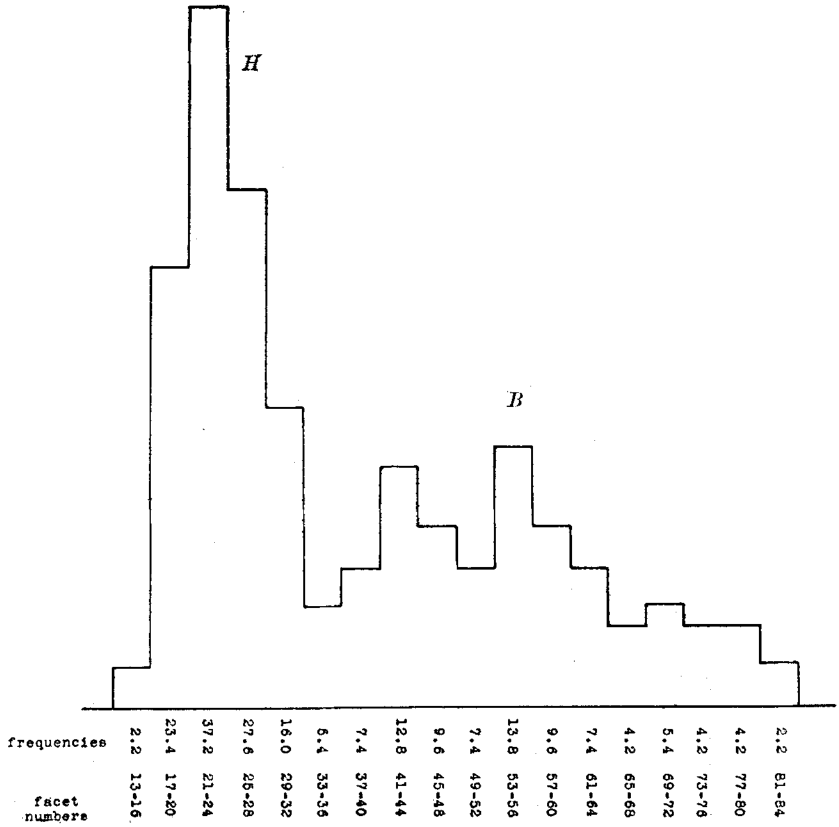


FIGURE 10.—Daughters of heterozygous female (from ultra-bar × bar) × bar male arranged in classes each with a range equal to four facets. 188 individuals. From experiment number 740. The heterozygotes (H) and bars (B) are not as well brought out as in the other method of tabulation.

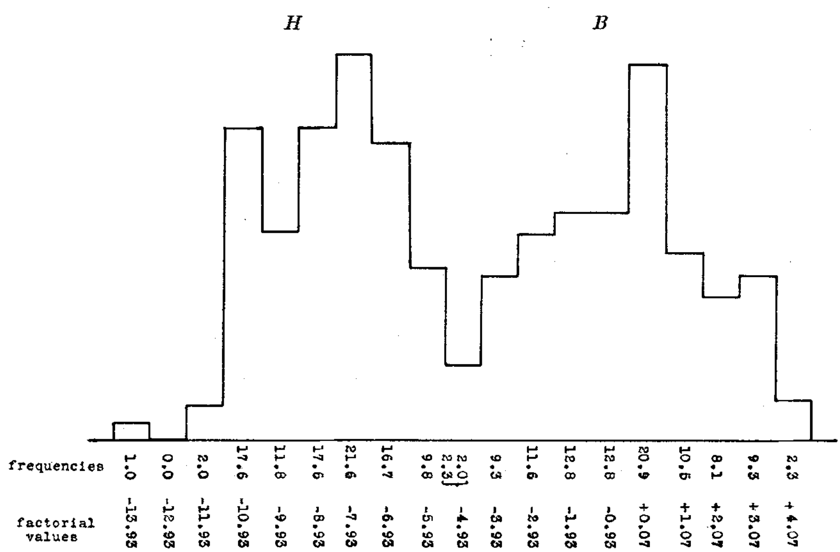


FIGURE 11.—Daughters of heterozygous female (from ultra bar × bar) × bar male arranged in classes each with a range equal to 10 percent of its mean facet value. 188 individuals. From experiment number 740. The two expected groups, heterozygotes (H) and bars (B) are well shown and agree in value with the controls.

TABLE 8

White bar selection. Low line. Direct. Parents.

GENERATION	ATALOG NUMBER	FEMALES		MALES		AVERAGE OF FACTORIAL UNITS
		Facets	Factorial units	Facets	Factorial units	
P	133−7					
1	138.3, 5	35, 30	−5.43	67, 54	− 5.40	− 5.41
2	144.4	34	−4.93	33	−11.38	− 8.15
3	146.2	44	−2.33	48	− 7.65	− 4.99
4	150.3	33	−5.26	39	− 9.67	− 7.46
5	154.m		−1.03		− 6.03	− 3.53
6	162.3	43	−2.55	51	− 7.05	− 4.80
7	168.1	37	−4.05	43	− 8.67	− 6.36
8	174.2	31, 39	−4.74	44	− 8.45	− 6.59
9	180.3	57	+0.15	51	− 7.05	− 3.45
10	192.4	50	−1.13	64	− 4.80	− 2.96
11	198.1	39	−3.55	41	− 9.17	− 6.36
12	204.1	37	−4.05	42	− 8.92	− 6.48
13	212.1	33	−5.26	41	− 9.17	− 7.21
14	218.2	37	−4.05	41	− 9.17	− 6.61
15	224.1	38	−3.80	40	− 9.42	− 6.61
16	230.2	32	−5.60	35	−10.72	− 8.16
17	236.1	30	−6.26	31	−12.05	− 9.15
18	365.3	35	−4.60	39	− 9.67	− 7.13
19	369.1	39	−3.55	44	− 8.45	− 6.00
20	375.1	30	−6.26	33	−11.38	− 8.82
21	379.2	40	−3.30	39	− 9.67	− 6.48
22	383.2	33	−5.26	43	− 8.67	− 6.96
23	387.1	40	−3.30	41	− 9.17	− 6.23
24	391.2	30	−6.26	36	−10.42	− 8.34
25	395.5b	23	−8.68	41	− 9.17	− 8.92
26	411.5	43	−2.55	45	− 8.25	− 5.40
27	417.4	41	−3.05	44	− 8.45	− 5.75
28	421.1	39	−3.55	43	− 8.67	− 6.11
29	425.5	30	−6.26	36	−10.42	− 8.34
30	429.1	32	−5.60	37	−10.17	− 7.88
31	433.3	33	−5.26	38	− 9.92	− 7.59
32	437.1	36, 36	−4.30	48	− 7.65	− 5.97
33	443.3	36	−4.30	37	−10.17	− 7.23
34	447.2	34	−4.93	38	− 9.92	− 7.42
35	451.4	34	−4.93	37	−10.17	− 7.55
36	455.2	{32 / 33, 33}	−5.26	39	− 9.67	− 7.46
37	459.3	34, 34	−4.93	42	− 8.92	− 6.92
38	463.1	33	−5.26	40	− 9.42	− 7.34
39	467.1	35	−4.60	36	−10.42	− 7.51
40	471.4	25	−7.93	34	−11.05	− 9.49
41	475.2	39	−3.55	42	− 8.92	− 6.23
42	479.x	34	−4.93	36	−10.42	− 7.67

TABLE 9

White bar selection. High line. Direct. Parents.

GENERATION	CATALOG NUMBER	FEMALES Facets	FEMALES Factorial units	MALES Facets	MALES Factorial units	AVERAGE OF FACTORIAL UNITS	DIFFERENCE BETWEEN HIGH AND LOW LINES
P	137.2						
1	141.2	110	+ 6.80	243	+ 8.55	+ 7.67	13.08
2	142.3	124	+ 7.99	195	+ 6.37	+ 7.18	15.33
3	148.6	144	+ 9.46	162	+ 4.54	+ 7.00	11.99
4	152.4	122	+ 7.84	153	+ 3.95	+ 5.89	13.35
5	156.1	182	+11.81	245	+ 8.61	+10.21	13.74
6	160.3	114	+ 7.16	215	+ 7.33	+ 7.24	12.04
7	166.2	135	+ 8.82	172	+ 5.13	+ 6.97	13.33
8	172.2	139	+ 9.10	187	+ 5.95	+ 7.52	14.11
9	176.5	127	+ 8.22	167	+ 4.83	+ 6.52	9.97
10	182.1	154	+10.14	273	+ 9.72	+ 9.93	12.89
11	194.1	112	+ 6.98	218	+ 7.47	+ 7.22	13.58
12	200.1	124	+ 7.99	182	+ 5.69	+ 6.84	13.32
13	206.1	127	+ 8.22	292	+10.40	+ 9.31	16.52
14	214.2	131	+ 8.53	202	+ 6.71	+ 7.62	14.23
15	222.2	131	+ 8.53	208	+ 7.00	+ 7.76	14.37
16	228.5	121	+ 7.76	168	+ 4.89	+ 6.32	14.48
17	240.3	193	+12.39	233	+ 8.12	+10.25	19.40
18	367.4	83	+ 3.88	104	+ 0.10	+ 1.99	9.12
19	373.1	128	+ 8.30	199	+ 6.57	+ 7.43	13.43
20	377.1, 2	{91, 95} {96, 97}	+ 5.26	129, 139	+ 2.62	+ 3.94	12.76
21	381.3, 5	173, 119	+ 9.45	204, 113	+ 5.99	+ 7.72	14.20
22	385.5	275	+15.91	mass	+ 4.93	+10.42	17.38
23							
24	393.2	205	+12.97	192	+ 6.21	+ 9.59	17.93
25	399.1	204	+12.93	264	+ 9.39	+11.16	20.08
26	409.1	194	+12.44	226	+ 7.82	+10.13	15.53
27	415.1	174, 178	+11.48	247	+ 8.71	+10.09	15.84
28	419.1	192	+12.33	222	+ 7.64	+ 9.98	16.09
29	423.3	315	+17.26	237	+ 8.30	+12.78	21.12
30	427.1	247	+14.83	258	+ 9.15	+11.99	19.87
31	431.2	223	+13.81	216	+ 7.37	+10.59	18.18
32	435.4	195	+12.49	191	+ 6.16	+ 9.32	15.29
33	441.2	{142, 148} {154, 204}	+10.66	157	+ 4.21	+ 7.43	14.66
34	445.4	178	+11.60	285, 297	+10.36	+10.98	18.40
35	449.5	152, 153	+10.03	200	+ 6.62	+ 8.32	15.87
36	453.2	167	+10.95	256	+ 9.07	+10.01	17.47
37	457.3	162	+10.66	212	+ 7.19	+ 8.92	15.84
38	461.1	155	+10.20	236	+ 8.25	+ 9.22	16.56
39	465.1	204	+12.93	230	+ 7.99	+10.46	17.97
40	469.2	167	+10.95	214	+ 7.28	+ 9.11	18.60
41	473.1	158	+10.40	200	+ 6.62	+ 8.51	14.74
42	477x.1	162	+10.66	208	+ 7.00	+ 8.83	16.50
Average							15.35±0.28

column at the left gives the generations, then come the catalog numbers of the matings, the facet counts of the parents and their equivalents on the factorial scale, and finally in the last column the averages of the factorial values of the two parents. It will be noted that the average of the parents is consistently low in the low line and high in the high line. The lower values of the males as compared with the females, is not due to any difference in the degree of selection in the two sexes but to the change in sexual dimorphism during the early generations (ZELENY 1921 b). The averages of the two sexes in each line serve to correct these values and to make them comparable in the two lines. To the high-line table are added these corrected differences between the parents of the high and low lines. On the average the parents of the high line are 15.35 ± 0.28 10-percent factorial units higher than those of the low line.

Parents of all offspring

The values of the parents including all matings are given in tables 10 and 11. These give the generations and catalog numbers of the different matings in each generation, the number of daughters and of sons resulting from each mating, the totals for each mating and for all the matings of each generation. Then come the facet values of female and male parents and their equivalents on the factorial scale, followed by the averages of the parents of individual matings, and finally by the weighted averages of the parents of all the matings in each generation on the basis of numbers of offspring. As in the direct line, due allowance should be made for the change in sexual dimorphism, but as in that case the averages of the two sexes serve to adjust the values. To the high-line table are added the corrected differences between the two lines. The high-line average is 14.66 ± 0.24 ten-percent factorial units above that of the low line.

According to the experimental procedure, it was to be expected that the divergence between the high-selected parents and the low-selected parents in any generation should be greater in the direct line than in the sib-matings. The vicissitudes of the experiment, as previously mentioned, frequently interfered with the attempt to use the highest (or lowest) pair as the direct line. However, the wider divergence comes there in 27 cases as opposed to only 14 cases for "all matings."

Offspring of direct-line matings

Tables 12 to 15 give for the offspring of the direct lines the numbers of offspring, the ranges in facet numbers and their equivalents on the fac-

TABLE 10

Values of selected pairs for all matings in each generation. Low line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING				FACETS		FACTORIAL UNITS			
		♀	♂	Total	Grand total	♀	♂	♀	♂	Average	Weighted average of generation
1	138.3	12	22	34		35	67	− 4.60	− 4.47	− 4.47	
	138.5	99	102	201	235	30	54	− 6.26	− 6.47	− 6.36	− 6.09
	144.4	73	63	136		34	33	− 4.93	−11.38	− 8.16	
2	144.1	6	7	13		38	34	− 3.80	−11.05	− 7.42	
	144.2	82	67	149		34	58	− 4.93	− 5.80	− 5.36	
	144.3	17	21	38	336	36	57	− 4.30	− 5.97	− 5.14	− 6.55
	146.2	5	4	9		44	48	− 2.33	− 7.65	− 4.99	
3	146.4	59	41	100		46	41	− 1.93	− 9.17	− 5.55	
	146.5	36	36	72	181	44	48	− 2.33	− 7.65	− 4.99	− 5.30
4	150.3	30	41	71	71	33	39	− 5.26	− 9.67	− 7.46	− 7.46
5	154.m	13	15	28	28	mass	mass	− 1.03	− 6.03	− 3.53	− 3.53
	162.3	20	22	42		43	51	− 2.55	− 7.05	− 4.80	
6	162.1	6	6	12		37	37	− 4.05	−10.17	− 7.11	
	162.2	21	11	32	86	41	43	− 3.05	− 8.67	− 5.86	− 5.52
7	168.1	47	32	79	79	37	43	− 4.05	− 8.67	− 6.36	− 6.36
	174.2	73	54	127		31, 39	44	− 4.74	− 8.45	− 6.60	
8	174.1	24	34	58	185	42	58	− 2.80	− 5.80	− 4.30	− 5.88
9	180.3	32	27	59		57	51	+ 0.15	− 7.05	− 3.45	
	180.1	11	4	15		45	47	− 2.13	− 7.85	− 4.99	

9	180.2	15	14	29		54	51	− 0.35	− 7.05	− 3.70	
	180.4	31	32	63		50	54	− 1.13	− 6.47	− 3.80	
	180.5	31	39	70	236	48	54	− 1.53	− 6.47	− 4.00	− 3.84
10	192.4	72	66	138		50	64	− 1.13	− 4.80	− 2.96	
	192.1	16	19	35		57	51	+ 0.15	− 7.05	− 3.45	
	192.2	21	17	38		45, 46	47	− 2.03	− 7.85	− 4.94	
	192.3	13	9	22	233	58	56	+ 0.32	− 6.13	− 2.90	− 3.35
11	198.1	48	46	94		39	41	− 3.55	− 9.17	− 6.36	
	198.2	24	14	38	132	43	44	− 2.55	− 8.45	− 5.50	− 6.11
12	204.1	89	100	189		37	42	− 4.05	− 8.92	− 6.48	
	204.2	10	9	19	208	44	47	− 2.33	− 7.85	− 5.09	− 6.35
13	212.1	5	7	12		33	41	− 5.26	− 9.17	− 7.22	
	212.2	5	8	13		41	43	− 3.05	− 8.67	− 5.86	
	212.3	99	101	200	225	35	42	− 4.60	− 8.92	− 6.76	− 6.73
14	218.2	2	3	5		37	41	− 4.05	− 9.17	− 6.61	
	218.1	6	3	9		37	53	− 4.05	− 6.65	− 5.35	
	218.3	4	1	5		39	47	− 3.55	− 7.85	− 5.70	
	218.4	34	27	61		38	40	− 3.80	− 9.42	− 6.61	
	218.5	50	71	121	201	34	39	− 4.93	− 9.67	− 7.30	− 6.95
15	224.1	43	62	105		38	40	− 3.80	− 9.42	− 6.61	
	224.2	49	61	110		36	42	− 4.30	− 8.92	− 6.61	
	224.3	13	16	29	244	38	38	− 3.80	− 9.92	− 6.86	− 6.64
16	230.2	47	61	108		32	35	− 5.60	−10.72	− 8.16	
	230.1	24	41	65	173	35	35	− 4.60	−10.72	− 7.66	− 7.97
17	236.1	8	8	16		30	31	− 6.26	−12.05	− 9.16	
	236.2	36	44	80		34	34	− 4.93	−11.05	− 7.99	
	236.3	56	52	108	204	34, 34	37	− 4.93	−10.17	− 7.55	− 7.85

TABLE 10 (continued)

Values of selected pairs for all matings in each generation. Low line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING ♀	NUMBER OF OFFSPRING ♂	NUMBER OF OFFSPRING Total	NUMBER OF OFFSPRING Grand total	FACETS ♀	FACETS ♂	FACTORIAL UNITS ♀	FACTORIAL UNITS ♂	FACTORIAL UNITS Average	FACTORIAL UNITS Weighted average of generation
18	365.3	33	41	74		35	39	− 4.60	− 9.67	− 7.14	
	365.1	5	9	14		32	34	− 5.60	−11.05	− 8.32	
	365.2	4	2	6		35	37	− 4.60	−10.17	− 7.38	
	365.4	24	20	44		37	41	− 4.05	− 9.17	− 6.61	
	365.5	9	10	19		38	41	− 3.80	− 9.17	− 6.48	
	365.6	6	5	11	168	39, 39	41	− 3.55	− 9.17	− 6.36	− 6.98
19	369.1	22	52	74		39	44	− 3.55	− 8.45	− 6.00	
	369.2	53	45	98		38	40	− 3.80	− 9.42	− 6.61	
	369.3	13	15	28		42	{42, 44 / 45}	− 2.80	− 8.45	− 5.62	
	369.4	34	25	59	259	46	46	− 1.93	− 8.05	− 4.99	− 5.96
20	375.1	9	18	27		30	33	− 6.26	−11.38	− 8.82	
	375.2	4	5	9		32	37	− 5.60	−10.17	− 7.88	
	375.3	19	14	33		37	38	− 4.05	− 9.92	− 6.98	
	375.4	28	32	60	129	39	41	− 3.55	− 9.17	− 6.36	− 7.14
21	379.2	29	51	80		40	39	− 3.30	− 9.67	− 6.48	
	379.1	38	61	99		37	37	− 4.05	−10.17	− 7.11	
	379.3	7	14	21		33	37	− 5.26	−10.17	− 7.72	
	379.4	4	10	14	214	35	36, 36	− 4.60	−10.42	− 7.51	− 6.96
22	383.2	14	21	35		33	43	− 5.26	− 8.67	− 6.96	
	383.1	4	10	14		33	37	− 5.26	−10.17	− 7.72	
	383.3	5	4	9		38	33	− 3.80	−11.38	− 7.59	
	383.4	8	14	22	80	38	38	− 3.80	− 9.92	− 6.86	− 7.14

23	387.1	50	58	108		40	41	− 3.30	− 9.17	− 6.24	
	387.2	21	21	42		43	48	− 2.55	− 7.65	− 5.10	
	387.3	2	10	12		37	44	− 4.05	− 8.45	− 6.25	
	387.4	9	11	20	182	43, 52	46, 55	− 1.83	− 7.15	− 4.49	− 5.79
24	391.2	71	62	133		30	36	− 6.26	−10.42	− 8.34	
	391.1	37	37	74		29	34	− 6.60	−11.05	− 8.82	
	391.3	10	8	18		30	36	− 6.26	−10.42	− 8.34	
	391.4	7	15	22		31	39	− 5.93	− 9.67	− 7.80	
	391.5	4	2	6	253	34	40	− 4.93	− 9.42	− 7.18	− 8.41
25	395.5b	5	12	17		23	41	− 8.68	− 9.17	− 8.92	
	395.1	10	25	35		22	29	− 9.18	−12.72	−10.95	
	395.2	40	50	90		33	38	− 5.26	− 9.92	− 7.59	
	395.3	11	8	19		33	36	− 5.26	−10.42	− 7.84	
	395.3b	13	16	29		23	42	− 8.68	− 8.92	− 8.80	
	395.4	3	3	6		29	37	− 6.60	−10.17	− 8.38	
	395.5	10	8	18		32	36	− 5.60	−10.42	− 8.01	
	395.6	3	4	7	221	21, 25	30	− 8.68	−12.38	−10.53	− 8.55
26	411.5	23	25	48		43	45	− 2.55	− 8.25	− 5.40	
	411.1	10	5	15		43	50	− 2.55	− 7.25	− 4.90	
	411.2	20	19	39		37	41	− 4.05	− 9.17	− 6.61	
	411.4	5	7	12	114	41	44	− 3.05	− 8.45	− 5.75	− 5.78
27	417.4	31	24	55		41	44	− 3.05	− 8.45	− 5.75	
	417.1	22	12	34		37	38	− 4.05	− 9.92	− 6.98	
	417.2	7	6	13		35	42	− 4.60	− 8.92	− 6.76	
	417.3	9	14	23		39	43	− 3.55	− 8.67	− 6.11	
	417.5	23	24	47	172	38	40	− 3.80	− 9.42	− 6.61	− 6.35

TABLE 10 (continued)

Values of selected pairs for all matings in each generation. Low line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING				FACETS		FACTORIAL UNITS			
		♀	♂	Total	Grand total	♀	♂	♀	♂	Average	Weighted average of generation
	421.1	47	39	86		39	43	− 3.55	− 8.67	− 6.11	
28	421.2	7	5	12	98	30	35	− 6.26	−10.72	− 8.49	− 6.40
	425.5	25	23	48		30, 38	36	− 6.26	−10.42	− 8.34	
	425.1	15	15	30		32	39	− 5.60	− 9.67	− 7.64	
29	425.2	2	2	4		35	36	− 4.60	−10.42	− 7.51	
	425.3	5	9	14		37	37	− 4.05	−10.17	− 7.11	
	425.4	4	8	12	108	33 (41)	35 (41)	− 5.26	−10.72	− 7.99	− 7.92
	429.1	21	29	50		32	37	− 5.60	−10.17	− 7.88	
30	429.2	7	8	15		38	36	− 3.80	−10.42	− 7.11	
	429.3	5	5	10	75	38	38	− 3.80	− 9.92	− 6.86	− 7.59
	433.3	42	28	70		33	38	− 5.26	− 9.92	− 7.59	
	433.1	14	15	29		37, 37	39	− 4.05	− 9.67	− 6.86	
31	433.2	28	32	60		35	37	− 4.60	−10.17	− 7.38	
	433.4	2	5	7		35	39	− 4.60	− 9.67	− 7.14	
	433.5	2	3	5	171	35	41	− 4.60	− 9.17	− 6.88	− 7.35
	437.1	49	44	93		36, 36	48	− 4.30	− 7.65	− 5.98	
	437.2	3	10	13		31	32	− 5.93	−11.72	− 8.82	
	437.3	15	21	36		32	51	− 5.60	− 7.05	− 6.32	
32	437.4	11	18	29		{52, 49} {51, 47}	49, 47	− 1.13	− 7.65	− 4.39	
	437.5	22	18	40		34	49	− 4.05	− 7.45	− 5.75	
	437.6	6	6	12		37	47	− 4.93	− 7.85	− 6.39	
	437.7	3	0	3	226	34	48	− 4.93	− 7.65	− 6.29	− 5.98

33	443.1	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]				
	443.2	13	12	25	105	35	39	− 4.60	− 9.67	− 7.14	− 7.29
34	447.2	24	21	45		34	38	− 4.93	− 9.92	− 7.42	
	447.1	9	13	22	67	33	38	− 5.26	− 9.92	− 7.59	− 7.48
35	451.4	26	19	45		34	37	− 4.93	−10.17	− 7.55	
	451.1	14	22	36		38	40	− 3.80	− 9.42	− 6.61	
	451.2	18	25	43		38	40	− 3.80	− 9.42	− 6.61	
	451.3	4	6	10	134	41	39	− 3.05	− 9.67	− 6.36	− 6.91
36	455.2	47	48	95		{32, 33} {33}	39	− 5.26	− 9.67	− 7.46	
	455.1	10	11	21		38	39, 39	− 3.80	− 9.67	− 6.74	
	455.4	34	33	67	183	31	36	− 5.93	−10.42	− 8.18	− 7.64
37	459.3	32	38	70		34, 34	42	− 4.93	− 8.92	− 6.92	
	459.1	5	1	6		33	31	− 5.26	−12.05	− 8.66	
	459.11	17	16	33		35	35	− 4.60	−10.72	− 7.66	
	459.2	4	17	21		34	39	− 4.93	− 9.67	− 7.30	
	459.4	5	5	10	140	33	41	− 5.26	− 9.17	− 7.22	− 7.25
38	463.1	34	30	64	64	33	40	− 5.26	− 9.42	− 7.34	− 7.34
39	467.1	49	49	98		35	36	− 4.60	−10.42	− 7.51	
	467.2	21	28	49	147	38	43, 43	− 3.80	− 8.67	− 6.24	− 7.09
40	471.4	7	6	13		25	34	− 7.93	−11.05	− 9.49	
	471.1	26	36	62		39	39	− 3.55	− 9.67	− 6.61	
	471.2	26	16	42		38	41	− 3.80	− 9.17	− 6.48	
	471.3	18	11	29		39	39	− 3.55	− 9.67	− 6.61	
	471.5	8	8	16	162	35	36	− 4.60	−10.42	− 7.51	− 6.90
41	475.2	19	31	50		39	42	− 3.55	− 8.92	− 6.24	
	475.1	12	19	31	81	37	38	− 4.05	− 9.92	− 6.98	− 6.52
42	479 x	32	24	56	56	34	36	− 4.93	−10.42	− 7.68	− 7.68

TABLE 11

Values of selected pairs for all matings in each generation. High line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING ♀	NUMBER OF OFFSPRING ♂	NUMBER OF OFFSPRING Total	NUMBER OF OFFSPRING Grand total	FACETS ♀	FACETS ♂	FACTORIAL UNITS ♀	FACTORIAL UNITS ♂	FACTORIAL UNITS Average	FACTORIAL UNITS Weighted average of generation	FACTORIAL UNITS Difference between high and low lines
	141.2	96	92	188		110	243	+ 6.80	+ 8.55	+ 7.68		
1	141.3	18	11	29		110	234	+ 6.80	+ 8.17	+ 7.48		
	141.5	93	106	199	416	109	213	+ 6.71	+ 7.24	+ 6.98	+ 7.33	13.42
	142.3	43	39	82		124	195	+ 7.99	+ 6.37	+ 7.18		
2	142.1	21	22	43		104	204	+ 6.22	+ 6.81	+ 6.52		
	142.2	89	62	151		81	105	+ 3.63	+ 0.20	+ 1.92		
	142.5	11	4	15	291	134	201	+ 8.75	+ 6.66	+ 7.70	+ 4.38	10.93
	148.6	51	50	101		144	162	+ 9.46	+ 4.54	+ 7.00		
	148.2	22	29	51		139	197	+ 9.10	+ 6.47	+ 7.78		
3	148.3	13	10	23		126	176	+ 8.15	+ 5.36	+ 6.76		
	148.4	3	3	6		143	205	+ 9.39	+ 6.85	+ 8.12		
	148.5	29	34	63	244	127	157	+ 8.22	+ 4.21	+ 6.22	+ 6.97	12.27
	152.4	40	45	85		122	153	+ 7.84	+ 3.95	+ 5.90		
	152.1	1	1	2		144	181	+ 9.46	+ 5.63	+ 7.54		
4	152.2	21	29	50		132	163	+ 8.61	+ 4.60	+ 6.60		
	152.3	29	30	59		129	161	+ 8.38	+ 4.48	+ 6.43		
	152.5	32	29	61		126	147	+ 8.15	+ 3.55	+ 5.85		
	152.7	25	13	38	295	102	147	+ 6.02	+ 3.55	+ 4.78	+ 5.98	13.44
	156.1	89	78	167		182	245	+11.81	+ 8.63	+10.22		
	156.2	19	20	39		155	179	+10.20	+ 5.53	+ 7.86		
5	156.3	28	33	61		140	177	+ 9.18	+ 5.42	+ 7.30		
	156.4	1	5	6		146	178	+ 9.60	+ 5.48	+ 7.54		
	156.5	22	33	55	328	139	167	+ 9.10	+ 4.83	+ 6.96	+ 8.80	12.33

6	160.3	27	18	45		114	215	+ 7.16	+ 7.33	+ 7.24		
	160.1	8	21	29		163	234	+10.72	+ 8.17	+ 9.44		
	160.2	35	43	78		111	206	+ 6.89	+ 6.90	+ 6.90		
	160.4	6	7	13		112	175	+ 6.98	+ 5.30	+ 6.14		
	160.5	7	4	11	176	98	472	+ 5.62	+15.18	+10.40	+ 7.57	13.09
7	166.2	22	21	43		135	172	+ 8.82	+ 5.13	+ 6.98		
	166.1	21	44	65		133	180	+ 8.68	+ 5.58	+ 7.13		
	166.3	19	10	29		154	162	+10.14	+ 4.54	+ 7.34		
	166.4	26	17	43		127	163	+ 8.22	+ 4.60	+ 6.41		
	166.6	3	4	7	187	127	163	+ 8.22	+ 4.60	+ 6.41	+ 6.94	13.30
8	172.2	48	43	91		139	187	+ 9.10	+ 5.95	+ 7.52		
	172.1	8	6	14	105	144	183	+ 9.46	+ 5.74	+ 7.60	+ 7.53	13.41
9	176.5	57	51	108		127	167	+ 8.22	+ 4.83	+ 6.52		
	176.1	15	16	31		103, 103	123	+ 6.12	+ 1.80	+ 3.96		
	176.2	21	28	49		105	163	+ 6.32	+ 4.60	+ 5.46		
	176.3	19	20	39		94, 95	114	+ 5.23	+ 1.04	+ 3.14		
	176.3x	4	3	7		95	184	+ 5.29	+ 5.79	+ 5.54		
	176.4	11	8	19		137	156	+ 8.96	+ 4.15	+ 6.56		
	176.6	6	2	8	261	123	239	+ 7.92	+ 8.38	+ 8.15	+ 5.54	9.38
10	182.1	66	69	135		154	273	+10.14	+ 9.72	+ 9.93		
	182.2	9	11	20		143	174	+ 9.39	+ 5.24	+ 7.32		
	182.3	13	21	34	189	172	252, 257	+11.25	+ 9.01	+10.13	+ 9.69	13.04
11	194.1	19	22	41		112	218	+ 6.98	+ 7.47	+ 7.22		
	194.2	14	17	31		125	175	+ 8.07	+ 5.30	+ 6.68		
	194.3	13	13	26		132	232	+ 8.61	+ 8.08	+ 8.34		
	194.4	24	19	43		124	223	+ 7.99	+ 7.69	+ 7.84		
	194.5	34	47	81		121	207	+ 7.76	+ 6.95	+ 7.36		
	194.6	31	36	67	289	118	307	+ 7.52	+10.89	+ 9.20	+ 7.85	13.96

TABLE 11 (continued)

Values of selected pairs for all matings in each generation. High line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING ♀	NUMBER OF OFFSPRING ♂	NUMBER OF OFFSPRING Total	NUMBER OF OFFSPRING Grand total	FACETS ♀	FACETS ♂	FACTORIAL UNITS ♀	FACTORIAL UNITS ♂	FACTORIAL UNITS Average	FACTORIAL UNITS Weighted average of generation	FACTORIAL UNITS Difference between high and low lines
12	200.1	44	40	84		124	182	+ 7.99	+ 5.69	+ 6.84		
	200.2	8	9	17	101	105	156	+ 6.32	+ 4.15	+ 5.24	+ 6.57	12.92
13	206.1	85	87	172	172	127	292	+ 8.22	+10.40	+ 9.31	+ 9.31	16.04
14	214.2	27	19	46		143	202	+ 9.39	+ 6.71	+ 8.05		
	214.1	44	46	90	136	131	202	+ 8.53	+ 6.71	+ 7.62	+ 7.77	14.72
15	222.2	57	61	118		131	208	+ 8.53	+ 7.00	+ 7.76		
	222.1	3	2	5	123	144	233	+ 9.46	+ 8.12	+ 8.79	+ 7.80	14.44
	228.5	48	68	116		121	168	+ 7.76	+ 4.89	+ 6.32		
	228.1	22	15	37		107	118	+ 6.52	+ 1.40	+ 3.96		
16	228.2	28	37	65		128	169	+ 8.30	+ 4.95	+ 6.62		
	228.3	15	9	24		124	146	+ 7.99	+ 3.48	+ 5.74		
	228.4	32	29	71	303	126	168	+ 8.15	+ 4.89	+ 6.52	+ 6.31	14.28
	240.3	31	34	65		193	233	+12.39	+ 8.12	+10.26		
	234.1	11	9	20		115, 118	158	+ 7.38	+ 4.28	+ 5.83		
17	234.2	9	15	24		124	167	+ 7.99	+ 4.83	+ 6.41		
	240.1	4	2	6		229	278	+14.07	+ 9.90	+11.98		
	240.2	5	4	9	124	146	212	+ 9.60	+ 7.19	+ 8.40	+ 8.75	16.60
18	367.4	22	21	43	43	83	104	+ 3.88	+ 0.10	+ 1.99	+ 1.99	8.97
19	373.1	12	18	30	30	128	199	+ 8.30	+ 6.57	+ 7.44	+ 7.44	13.40
	{377.1	56	51	107		91, 95	129	+ 5.07	+ 2.26	+ 3.66		
20	{377.2	57	38	95		96, 97	139	+ 5.45	+ 2.98	+ 4.22		
	377.3	31	24	55		108	131	+ 6.62	+ 2.41	+ 4.52		
	377.4	3	5	8	265	109	149	+ 6.71	+ 3.68	+ 5.20	+ 4.09	11.23

21	381.3	49	26	75		173	204	+11.30	+ 6.81	+ 9.06		
	381.5	24	14	38		119	173	+ 7.61	+ 5.18	+ 6.40		
	381.1	19	28	47		142	160	+ 9.32	+ 4.42	+ 6.87		
	381.2	12	3	15		158	184	+10.40	+ 5.79	+ 8.10		
	381.4	11	8	19	194	131	179	+ 8.53	+ 5.53	+ 7.03	+ 7.74	14.70
22	385.5	7	4	11		275	mass	+15.91	+ 4.93	+10.42		
	385.1	1	0	1		194	346	+12.44	+12.08	+12.26		
	385.2	35	28	63		142	232	+ 9.32	+ 8.08	+ 8.70		
	385.3	17	11	28		137	228	+ 8.96	+ 7.91	+ 8.44		
	385.4	26	22	48	151	107	189	+ 6.52	+ 6.05	+ 6.28	+ 8.03	15.17
23	389.6	43	65	108		138,143, 156	211	+ 9.58	+ 7.14	+ 8.36		
	389.1	11	17	28		113	154	+ 7.07	+ 4.02	+ 5.54		
	389.2	3	2	5		131	186	+ 8.53	+ 5.90	+ 7.22		
	389.3	11	10	21		125	158	+ 8.07	+ 4.28	+ 6.18		
	389.4	7	13	20		141	219	+ 9.25	+ 7.51	+ 8.38		
	389.5	4	2	6	188	145	197	+ 9.53	+ 6.47	+ 8.00	+ 7.66	13.45
24	393.2	29	15	44		205	192	+12.97	+ 6.21	+ 9.59		
	393.1	26	21	47		119	146	+ 7.61	+ 3.48	+ 5.54		
	393.11	13	18	31		122, 115	144	+ 7.56	+ 3.34	+ 5.45		
	393.3	23	21	44		121	194	+ 7.76	+ 6.32	+ 7.04		
	393.4	6	8	14		124	195	+ 7.99	+ 6.37	+ 7.18		
	393.5	5	4	9		131	198	+ 8.53	+ 6.52	+ 7.52		
	393.6	1	3	4	193	116	201	+ 7.34	+ 6.66	+ 7.00	+ 7.03	15.44
25	399.1	56	38	94		204	264	+12.93	+ 9.39	+11.16		
	399.2	13	8	21		162	254	+10.66	+ 8.99	+ 9.82		
	399.3	13	19	32		149	202	+ 9.80	+ 6.71	+ 8.26		
	399.4	13	12	25		144	238	+ 9.46	+ 8.34	+ 8.90		
	399.5	8	7	15		130	204	+ 8.45	+ 6.81	+ 7.63		
	399.6	11	9	20	207	121	178	+ 7.76	+ 5.48	+ 6.62	+ 9.61	18.16

TABLE 11 (continued)

Values of selected pairs for all matings in each generation. High line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING				FACETS		FACTORIAL UNITS				
		♀	♂	Total	Grand total	♀	♂	♀	♂	Average	Weighted average of generation	Difference between high and low lines
26	409.1	12	2	14		194	226	+12.44	+ 7.82	+10.13		
	409.2	24	24	48		212	208	+13.31	+ 7.00	+10.16		
	409.3	19	8	27		178	194	+11.60	+ 6.32	+ 8.96		
	409.4	6	8	14		197	235	+12.59	+ 8.21	+10.40		
	409.5	13	5	18	121	167	197	+10.95	+ 6.47	+ 8.71	+ 9.70	15.48
27	415.1	21	7	28		174, 178	247	+11.48	+ 8.71	+10.10		
	415.2	9	5	14		{194, 212} {208}	223	+12.96	+ 7.69	+10.32		
	415.3	0	6	6		196	197	+12.54	+ 6.47	+ 9.50		
	415.4	0	2	2	50	m	m	+10.99	+ 5.44	+ 8.22	+10.01	16.36
28	419.1	48	17	65		192	222	+12.33	+ 7.64	+ 9.98		
	419.2	5	0	5		221	219	+13.72	+ 7.51	+10.62		
	419.3	3	0	3		242	219	+14.63	+ 7.51	+11.07		
	419.4	1	2	3	76	207	209	+13.07	+ 7.04	+10.06	+10.07	16.47
29	423.3	20	17	37		315	237	+17.26	+ 8.30	+12.78		
	423.1	19	11	30		163	188	+10.72	+ 6.00	+ 8.36		
	423.2	9	6	15	82	152	178	+10.00	+ 5.48	+ 7.74	+10.24	18.16
30	427.1	13	9	22		247	258	+14.83	+ 9.15	+11.99		
	427.2	12	8	20		171	200	+11.19	+ 6.62	+ 8.90		
	427.3	20	14	34		216	329	+13.49	+11.58	+12.54		
	427.4	4	1	5	81	267	276	+15.62	+ 9.82	+12.72	+11.50	19.09

31	431.2	25	17	42		223	216	+13.81	+ 7.37	+10.59		
	431.1	36	24	60		212, 221	234	+13.51	+ 8.17	+10.84		
	431.3	19	13	32	134	216	203	+13.49	+ 6.76	+10.12	+10.59	17.94
32	435.4	31	7	38		195	191	+12.49	+ 6.16	+ 9.32		
	435.2	5	2	7		171	203	+11.19	+ 6.76	+ 8.98		
	435.3	10	2	12		178	156	+11.60	+ 4.15	+ 7.88		
	435.5	19	10	29		178	198	+11.60	+ 6.52	+ 9.06		
	435.6	6	5	11	97	102	164	+ 6.02	+ 4.66	+ 5.34	+ 8.59	14.57
33	441.2	26	27	53		{142, 148 / 154, 204}	157	+10.66	+ 4.21	+ 7.44		
	441.1	67	29	96	149	195	236	+12.49	+ 8.25	+10.37	+ 9.33	16.62
34	445.4	12	12	24		178	285, 297	+11.60	+10.36	+10.98		
	445.1	34	27	61		{162, 154 / 168, 178}	163	+10.86	+ 4.60	+ 7.73		
	445.2	10	6	16		149	158	+ 9.80	+ 4.28	+ 7.04		
	445.3	14	17	31		157, 161	197, 199	+10.47	+ 6.52	+ 8.50		
	455.5	4	5	9		159	{190, 220 / 239}	+10.47	+ 7.39	+ 8.93		
	445.6	0	3	3		184	197	+11.91	+ 6.47	+ 9.19		
	445.7	25	16	41	185	194	196	+12.44	+ 6.42	+ 9.43	+ 8.68	16.16
35	449.5	14	8	22		152, 153	200	+10.03	+ 6.62	+ 8.32		
	449.1	15	6	21		{143, 145 / 142}	189, 198	+ 9.42	+ 6.29	+ 7.86		
	449.2	9	16	25		85	119	+ 4.13	+ 1.49	+ 2.81		
	449.4	18	20	38		174	167	+11.36	+ 4.83	+ 8.10		
	449.6	9	8	17	123	{185, 188 / 199}	202, 202	+12.26	+ 6.71	+ 9.48	+ 7.21	14.12

TABLE 11 (continued)

Values of selected pairs for all matings in each generation. High line.

GENERATION	CATALOG NUMBER	NUMBER OF OFFSPRING ♀	♂	Total	Grand total	FACETS ♀	♂	FACTORIAL UNITS ♀	♂	Average	Weighted average of generation	Difference between high and low lines
36	453.2	30	31	61		167	256	+10.95	+ 9.07	+10.01		
	453.1	2	2	4		164	197	+10.78	+ 6.47	+ 8.62		
	453.3	7	8	15		158	198	+10.40	+ 6.52	+ 8.46		
	453.4	6	7	13		202	298	+12.83	+10.60	+11.72		
	453.5	25	26	51		167	177	+10.95	+ 5.42	+ 8.18		
	453.6	3	7	10	154	163	174, 178	+10.72	+11.48	+11.10	+ 9.43	17.07
37	457.3	9	5	14		162	212	+10.66	+ 7.19	+ 8.92		
	457.2	7	2	9		167	240	+10.95	+ 8.43	+ 9.69		
	457.4	16	26	42		138, 142	198, 208	+ 9.18	+ 6.76	+ 7.97		
	457.6	9	6	15	80	148	208, 211	+ 9.74	+ 7.06	+ 8.40	+ 8.41	15.66
38	461.1	17	11	28		155	236	+10.20	+ 8.25	+ 9.22		
	461.2	10	10	20		147	191, 234	+ 9.67	+ 7.21	+ 8.44		
	461.3	3	9	12	60	157, 179	{203, 220} {237}	+11.01	+ 7.56	+ 9.28	+ 8.97	16.31
39	465.1	10	23	33		204	230	+12.93	+ 7.99	+10.46		
	465.2	28	32	60	93	150	194	+ 9.87	+ 6.32	+ 8.10	+ 8.94	16.03
40	469.2	21	35	56		167	214	+10.95	+ 7.28	+ 9.12		
	469.1	7	11	18		140, 167	163, 167	+10.07	+ 4.71	+ 7.39		
	469.3	41	58	99	173	162, 167	245	+10.80	+ 8.63	+ 9.72	+ 9.28	16.18
41	473.1	14	28	42		158	200	+10.40	+ 6.62	+ 8.51		
	473.2	4	4	8	50	170	204	+11.13	+ 6.81	+ 8.92	+ 8.58	15.10
42	477.x	6	12	18	18	162	208	+10.66	+ 7.00	+ 8.83	+ 8.83	16.51
											Average	14.66±0.24

TABLE 12

White bar selection. Low line. Direct. Offspring. Females.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS		FACTORIAL UNITS			
			Range		Range		Mean	Standard deviation
			Low	High	Low	High		
P	133–7	488	21	134	−9.68	+8.75	0.00±0.10	3.12±0.07
1	138.3, 5	111	32	71	−5.60	+2.36	−2.07±0.12	1.94±0.08
2	144.4	73	32	119	−5.60	+7.61	+1.29±0.20	2.57±0.14
3	146.2	5	33	45	−5.26	−2.13	−3.13±0.35	1.17±0.25
4	150.3	30	31	85	−5.93	+4.13	−1.03±0.32	2.62±0.23
5	154.m	13	37	66	−4.05	+1.64	−1.93±0.28	1.52±0.20
6	162.3	20	35	67	−4.60	+1.78	−1.63±0.27	1.82±0.19
7	168.1	47	31	58	−5.93	+0.32	−2.38±0.17	1.79±0.12
8	174.2	73	25	84	−7.93	+4.01	+0.08±0.16	1.96±0.11
9	180.3	32	40	63	−3.30	+1.15	−0.77±0.13	1.06±0.09
10	192.4	72	39	78	−3.55	+3.26	−0.83±0.14	1.71±0.10
11	198.1	48	33	73	−5.26	+2.63	−1.08±0.18	1.85±0.13
12	204.1	88	24	84	−8.26	+4.01	−1.98±0.12	1.71±0.19
13	212.1	5	37	44	−4.05	−2.33	−3.13±0.23	0.75±0.16
14	218.2	2	38	38	−3.80	−3.80	−3.80	
15	224.1	43	31	58	−5.93	+0.32	−3.09±0.13	1.29±0.09
16	230.2	47	30	59	−6.26	+0.49	−2.76±0.17	1.69±0.12
17	236.1	8	32	41	−5.60	−3.05	−4.31±0.21	0.86±0.15
18	365.3	33	26	64	−7.60	+1.32	−3.20±0.22	1.85±0.15
19	369.1	22	30	45	−6.26	−2.13	−4.11±0.17	1.15±0.12
20	375.1	9	33	41	−5.26	−3.05	−4.04±0.17	0.74±0.12
21	379.2	29	30	49	−6.26	−1.33	−3.62±0.14	1.11±0.10
22	383.2	14	37	49	−4.05	−1.33	−2.72±0.16	0.87±0.11
23	387.1	50	29	52	−6.60	−0.73	−3.55±0.14	1.46±0.10
24	391.2	71	20	55	−10.18	−0.18	−4.87±0.18	2.26±0.13
25	395.5b	5	37	48	−4.05	−1.53	−2.73±0.23	0.75±0.16
26	411.5	23	34	47	−4.93	−1.73	−3.06±0.11	0.79±0.08
27	417.4	31	29	47	−6.60	−1.73	−3.70±0.17	1.41±0.12
28	421.1	47	30	53	−6.26	−0.53	−3.59±0.12	1.24±0.09
29	425.5	25	32	47	−5.60	−1.73	−3.81±0.16	1.18±0.11
30	429.1	21	33	48	−5.26	−1.53	−3.69±0.13	0.87±0.09
31	433.3	42	30	57	−6.26	+0.15	−2.36±0.12	1.20±0.09
32	437.1	48	35	75	−4.60	+2.88	−1.89±0.15	1.57±0.11
33	443.3	35	25	46	−7.93	−1.93	−4.56±0.14	1.26±0.10
34	447.2	24	30	43	−6.26	−2.55	−4.01±0.15	1.08±0.10
35	451.4	26	29	42	−6.60	−2.80	−4.31±0.15	1.14±0.11
36	455.2	47	19	54	−10.68	−0.35	−3.57±0.16	1.63±0.11
37	459.3	32	30	56	−6.26	−0.01	−2.71±0.18	1.56±0.13
38	463.1	34	32	60	−5.60	+0.65	−2.64±0.14	1.25±0.10
39	467.1	49	25	47	−7.93	−1.73	−4.40±0.14	1.39±0.10
40	471.4	7	36	44	−4.30	−2.33	−3.36±0.19	0.73±0.13
41	475.2	19	28	42	−6.93	−2.80	−4.14±0.17	1.10±0.12
42	479.x	32	35	51	−4.60	−0.93	−2.84±0.12	1.01±0.08

TABLE 13

White bar selection. Low line. Direct. Offspring. Males.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS Range Low	FACETS Range High	FACTORIAL UNITS Range Low	FACTORIAL UNITS Range High	FACTORIAL UNITS Mean	FACTORIAL UNITS Standard deviation
P	133-7	441	35	314	−10.72	+11.11	0.00±0.13	3.91±0.09
1	138.3,5	124	33	124	−11.38	+ 1.87	−4.85±0.16	2.66±0.11
2	144.4	62	47	134	− 7.85	+ 2.63	−2.58±0.23	2.69±0.16
3	146.2	4	35	59	−10.72	− 5.63	−8.30±0.77	2.28±0.54
4	150.3	41	41	78	− 9.17	− 2.86	−6.03±0.18	1.70±0.13
5	154.m	15	37	82	−10.17	− 2.36	−5.85±0.42	2.40±0.29
6	162.3	22	43	83	− 8.67	− 2.24	−5.14±0.29	2.02±0.20
7	168.1	32	44	97	− 8.45	− 0.61	−5.24±0.22	1.82±0.15
8	174.2	54	46	86	− 8.05	− 1.86	−5.12±0.14	1.50±0.10
9	180.3	27	43	68	− 8.67	− 4.19	−6.20±0.16	1.21±0.11
10	192.4	66	37	97	−10.17	− 0.61	−6.47±0.16	1.88±0.11
11	198.1	46	41	97	− 9.17	− 0.61	−5.03±0.24	2.44±0.17
12	204.1	100	29	86	−12.72	− 1.86	−6.61±0.12	1.78±0.09
13	212.1	7	41	53	− 9.17	− 6.65	−8.05±0.19	0.75±0.13
14	218.2	3	40	51	− 9.42	− 7.05	−8.38±0.37	0.94±0.26
15	224.1	62	34	78	−11.05	− 2.86	−7.95±0.15	1.79±0.11
16	230.2	61	31	66	−12.05	− 4.48	−8.67±0.18	2.05±0.13
17	236.1	8	34	44	−11.05	− 8.45	−9.30±0.23	0.97±0.16
18	365.3	41	32	90	−11.72	− 1.38	−7.81±0.23	2.14±0.16
19	369.1	52	33	63	−11.38	− 4.97	−9.45±0.10	1.10±0.07
20	375.1	18	34	47	−11.05	− 7.85	−9.61±0.11	0.69±0.08
21	379.2	51	29	63	−12.72	− 4.97	−9.15±0.15	1.54±0.10
22	383.2	21	41	61	− 9.17	− 5.30	−7.76±0.17	1.16±0.12
23	387.1	58	30	67	−12.38	− 4.34	−8.29±0.13	1.47±0.09
24	391.2	62	29	78	−12.72	− 2.86	−7.82±0.19	2.27±0.14
25	395.5b	12	41	58	− 9.17	− 5.80	−7.80±0.18	0.93±0.13
26	411.5	25	35	54	−10.72	− 6.47	−8.57±0.17	1.27±0.12
27	417.4	24	35	57	−10.72	− 5.97	−8.68±0.20	1.47±0.14
28	421.1	39	35	74	−10.72	− 3.36	−8.36±0.19	1.73±0.13
29	425.5	23	33	58	−11.05	− 5.80	−9.18±0.19	1.36±0.13
30	429.1	29	35	55	−10.72	− 6.30	−8.77±0.15	1.17±0.10
31	433.3	28	39	62	− 9.67	− 5.13	−7.41±0.14	1.08±0.10
32	437.1	44	37	98	−10.17	− 0.50	−7.00±0.22	2.12±0.15
33	443.3	35	29	64	−12.72	− 4.80	−8.71±0.17	1.49±0.12
34	447.2	21	34	52	−11.05	− 6.85	−9.10±0.16	1.09±0.11
35	451.4	19	36	64	−10.42	− 4.80	−7.68±0.24	1.53±0.17
36	455.2	48	37	58	−11.05	− 5.80	−8.76±0.11	1.16±0.08
37	459.3	38	37	64	− 9.42	− 4.80	−6.73±0.14	1.32±0.10
38	463.1	30	36	64	−10.42	− 4.80	−8.05±0.18	1.46±0.13
39	467.1	49	37	67	−10.17	− 4.34	−7.99±0.15	1.56±0.11
40	471.4	6	37	48	−10.17	− 7.65	−9.22±0.19	0.69±0.13
41	475.2	31	32	51	−11.72	− 7.05	−9.31±0.15	1.22±0.10
42	479.x	24	41	58	− 9.17	− 5.80	−7.59±0.15	1.08±0.10

TABLE 14

White bar selection. High line. Direct. Offspring. Females.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS Range Low	FACETS Range High	FACTORIAL UNITS Range Low	FACTORIAL UNITS Range High	FACTORIAL UNITS Mean	FACTORIAL UNITS Standard deviation
P	137.2	488	21	134	− 9.68	+ 8.75	0.00±0.10	3.12±0.07
1	141.2	96	38	144	− 3.80	+ 9.46	+ 3.03±0.22	3.26±0.16
2	142.3	43	76	166	+ 3.01	+10.89	+ 7.09±0.15	1.46±0.11
3	148.6	51	84	146	+ 4.01	+ 9.60	+ 6.87±0.12	1.24±0.08
4	152.4	40	84	182	+ 4.01	+11.81	+ 8.22±0.18	1.70±0.13
5	156.1	88	63	242	+ 1.15	+14.63	+ 8.22±0.19	2.59±0.13
6	160.3	27	91	155	+ 4.85	+10.20	+ 7.22±0.19	1.43±0.13
7	166.2	22	72	144	+ 2.50	+ 9.46	+ 6.30±0.32	2.21±0.22
8	172.2	48	70	137	+ 2.21	+ 8.96	+ 4.99±0.17	1.76±0.12
9	176.5	57	64	181	+ 1.32	+11.75	+ 7.84±0.23	2.52±0.16
10	182.1	60	88	167	+ 4.51	+10.95	+ 7.39±0.13	1.47±0.09
11	194.1	19	101	134	+ 5.92	+ 8.75	+ 7.28±0.16	1.06±0.11
12	200.1	44	90	154	+ 4.74	+10.14	+ 7.27±0.14	1.37±0.10
13	206.1	85	79	143	+ 3.38	+ 9.39	+ 6.81±0.09	1.22±0.06
14	214.2	27	93	144	+ 5.07	+ 9.46	+ 7.26±0.15	1.12±0.10
15	222.2	57	93	156	+ 5.07	+10.27	+ 6.86±0.11	1.18±0.07
16	228.5	48	82	248	+ 3.76	+14.87	+ 8.17±0.31	3.22±0.22
17	240.3	31	83	139	+ 3.88	+ 9.10	+ 6.65±0.18	1.47±0.13
18	367.4	22	68	141	+ 1.93	+ 9.25	+ 6.07±0.28	1.93±0.20
19	373.1	12	91	132	+ 4.85	+ 8.61	+ 6.32±0.23	1.17±0.16
20	377.1,2	113	72	179	+ 2.50	+11.65	+ 6.72±0.11	1.80±0.08
21	381.3,5	73	86	275	+ 4.26	+15.91	+ 7.47±0.16	2.01±0.11
22	385.5	7	94	205	+ 5.18	+12.97	+ 8.78±0.62	2.45±0.44
23								
24	393.2	29	66	206	+ 1.64	+13.02	+ 8.07±0.36	2.91±0.25
25	399.1	56	57	247	+ 0.15	+14.83	+ 8.89±0.25	2.77±0.18
26	409.1	12	108	217	+ 6.62	+13.54	+10.99±0.44	2.25±0.31
27	415.1	21	117	242	+ 7.43	+14.63	+11.02±0.32	2.19±0.23
28	419.1	48	83	315	+ 3.88	+17.26	+11.65±0.27	2.75±0.19
29	423.3	20	141	262	+ 9.25	+15.43	+12.37±0.28	1.87±0.20
30	427.1	13	116	249	+ 7.34	+14.91	+11.45±0.39	2.10±0.28
31	431.2	25	78	202	+ 3.26	+12.83	+ 9.43±0.32	2.35±0.22
32	435.4	31	65	204	+ 1.49	+12.93	+ 9.04±0.30	2.48±0.21
33	441.2	26	105	207	+ 6.32	+13.07	+ 9.72±0.22	1.66±0.16
34	445.4	12	116	170	+ 7.34	+11.13	+ 9.15±0.22	1.11±0.15
35	449.5	14	96	167	+ 5.40	+10.95	+ 9.21±0.31	1.73±0.22
36	453.2	29	94	248	+ 5.18	+14.87	+ 9.17±0.27	2.14±0.19
37	457.3	9	115	188	+ 7.25	+12.12	+10.74±0.32	1.41±0.22
38	461.1	17	102	204	+ 6.02	+12.93	+ 9.48±0.29	1.75±0.20
39	465.1	10	103	167	+ 6.12	+10.95	+ 8.77±0.36	1.68±0.25
40	469.2	21	101	184	+ 5.92	+11.91	+ 9.36±0.23	1.55±0.16
41	473.1	14	137	173	+ 8.96	+11.30	+10.28±0.14	0.77±0.10
42	477x.1	9	101	142	+ 5.92	+ 9.32	+ 8.07±0.24	1.05±0.17

TABLE 15

White bar selection. High line. Direct. Offspring. Males.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS		FACTORIAL UNITS			
			Range		Range		Mean	Standard deviation
			Low	High	Low	High		
P	137.2	441	35	314	−10.72	+11.11	0.00±0.13	3.91±0.09
1	141.2	92	44	237	− 8.45	+ 8.30	−0.35±0.24	3.45±0.17
2	142.3	39	111	197	+ 0.77	+ 6.47	+3.33±0.16	1.45±0.11
3	148.6	50	92	184	− 1.16	+ 5.79	+2.29±0.15	1.53±0.10
4	152.4	45	76	245	− 3.11	+ 8.63	+3.71±0.21	2.06±0.15
5	156.1	78	118	472	+ 1.40	+15.18	+6.99±0.23	3.01±0.16
6	160.3	18	104	229	+ 0.10	+ 7.95	+3.23±0.28	1.79±0.20
7	166.2	21	97	187	− 0.61	+ 5.95	+4.00±0.24	1.59±0.17
8	172.2	43	85	239	− 1.99	+ 8.38	+3.04±0.22	2.14±0.16
9	176.5	51	128	348	+ 2.18	+12.14	+6.46±0.22	2.32+0.15
10	182.1	69	107	316	+ 0.40	+11.05	+5.44±0.19	2.40±0.14
11	194.1	22	122	212	+ 1.72	+ 7.19	+4.54±0.19	1.37±0.13
12	200.1	40	129	384	+ 2.26	+13.12	+6.43±0.24	2.22±0.17
13	206.1	87	99	220	− 0.40	+ 7.56	+3.89±0.13	1.73±0.09
14	214.2	19	117	208	+ 1.31	+ 7.00	+4.16±0.23	1.51±0.16
15	222.2	61	101	206	− 0.20	+ 6.90	+3.15±0.14	1.63±0.10
16	228.5	68	95	278	− 0.83	+ 9.90	+4.21±0.22	2.63±0.15
17	240.3	34	104	238	+ 0.10	+ 8.34	+3.86±0.25	2.17±0.18
18	367.4	21	87	323	− 1.74	+11.40	+4.24±0.46	3.17±0.33
19	373.1	18	97	199	− 0.61	+ 6.57	+2.51±0.29	1.80±0.20
20	377.1,2	90	94	215	− 0.94	+ 7.33	+3.05±0.14	2.05±0.10
21	381.3,5	40	112	238	+ 0.86	+ 8.34	+4.93±0.19	1.75±0.13
22	385.5	4	129	192	+ 2.26	+ 6.21	+3.45±0.51	1.50±0.36
23								
24	393.2	15	97	264	− 0.61	+ 9.39	+3.82±0.52	2.96±0.36
25	399.1	38	108	244	+ 0.50	+ 8.59	+4.95±0.22	2.04±0.16
26	409.1	2	128	247	+ 2.18	+ 8.71	+5.44	
27	415.1	7	146	251	+ 3.48	+ 8.87	+7.09±0.44	1.73±0.31
28	419.1	17	152	287	+ 3.88	+10.22	+6.77±0.30	1.82±0.21
29	423.3	17	137	329	+ 2.84	+11.58	+7.71±0.35	2.13±0.25
30	427.1	9	163	284	+ 4.60	+10.11	+6.73±0.35	1.55±0.25
31	431.2	17	122	248	+ 1.72	+ 8.75	+5.60±0.32	1.97±0.23
32	435.4	7	133	182	+ 2.56	+ 5.69	+4.38±0.27	1.05±0.19
33	441.2	27	130	297	+ 2.33	+10.56	+5.69±0.29	2.23±0.20
34	445.4	12	109	320	+ 0.59	+11.31	+5.70±0.61	3.11±0.43
35	449.5	8	155	298	+ 4.08	+10.60	+7.20±0.52	2.17±0.37
36	453.2	31	138	265	+ 2.91	+ 9.43	+6.27±0.21	1.73±0.15
37	457.3	5	178	256	+ 5.48	+ 9.07	+6.75±0.35	1.17±0.25
38	461.1	10	115	230	+ 1.13	+ 7.99	+5.15±0.48	2.23±0.34
39	465.1	23	124	246	+ 1.87	+ 8.67	+4.73±0.25	1.79±0.18
40	469.2	35	134	221	+ 2.63	+ 7.60	+5.44±0.17	1.46±0.12
41	473.1	28	150	241	+ 3.75	+ 8.47	+6.09±0.19	1.46±0.13
42	477x.1	17	119	380	+ 1.49	+13.07	+5.19±0.41	2.53±0.29

torial scale and the means and standard deviations and their probable errors also in terms of the factorial scale. Table 12 includes the females and table 13 the males of the low line, and table 14 the females and table 15 the males of the high line. Mutants to full eye and to ultra-bar are omitted in these and following tables unless specifically mentioned.

It will be noted that the number of individuals is often too small for a satisfactory determination of the standard deviation. In such cases the values are usually lower than in the generations with larger numbers of individuals, probably because they usually represent the hatch of a single day and therefore have a greater environmental uniformity than those representing the hatch of several days, frequently with transfer of the parents to additional bottles. In the determination of the standard deviation values also the number of classes was often less than ten and the accuracy is somewhat lowered by that fact. It is believed, however, that no significant error is thereby introduced as far as the purposes of the present discussion are concerned.

Offspring of all matings

Tables 16 to 19 give the values for the offspring of all matings. Each table includes the generation number, catalog number, number of offspring, range in facets and in their equivalents on the factorial scale and the means and standard deviations and their probable errors also in terms of the factorial scale. Table 16 includes the females and table 17 the males of the low line, and table 18 the females and table 19 the males of the high line. The data have the advantage over those of the direct line in possessing in most generations a sufficient number of individuals for determination of the standard deviation. One would expect them, however, to contain a greater diversity in both germinal and environmental factors. A comparison of the average standard deviations, however, shows only a slight difference in this respect in favor of "all matings." Among low-line females the direct line has the greater standard deviation in 14 generations, "all matings" in 18, and 9 are even. Among low-line males the corresponding figures are 13, 23 and 6, among high-line females 17, 20 and 4, and among high males 16, 20 and 4.

Distribution of frequencies in the direct lines

The values are given in table 20 for females and table 21 for males. Each table includes at the left the class values in factorial units and their ranges in facet numbers. Then follow for each selection generation

TABLE 16

White bar selection. Low line. All matings. Offspring. Females.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS Range Low	FACETS Range High	FACTORIAL UNITS Range Low	FACTORIAL UNITS Range High	FACTORIAL UNITS Mean	FACTORIAL UNITS Standard deviation
P	133–7	488	21	134	− 9.68	+ 8.75	0.00±0.10	3.12±0.07
1	138	111	32	71	− 5.60	+ 2.36	−2.07±0.12	1.94±0.08
2	144	178	32	119	− 5.60	+ 7.61	+0.73±0.11	2.25±0.08
3	146	100	33	65	− 5.26	+ 1.49	−1.86±0.10	1.53±0.07
4	150	30	31	85	− 5.93	+ 4.13	−1.03±0.32	2.62±0.23
5	154	13	37	66	− 4.05	+ 1.64	−1.93±0.28	1.52±0.20
6	162	47	35	67	− 4.60	+ 1.78	−1.61±0.18	1.82±0.13
7	168	47	31	58	− 5.93	+ 0.32	−2.38±0.17	1.79±0.12
8	174	97	25	84	− 7.93	+ 4.01	−0.19±0.13	1.83±0.09
9	180	119	39	83	− 3.55	+ 3.88	−0.64±0.09	1.45±0.06
10	192	122	39	84	− 3.55	+ 4.01	−0.30±0.10	1.70±0.07
11	198	72	33	76	− 5.26	+ 3.01	−0.72±0.14	1.82±0.10
12	204	98	24	84	− 8.26	+ 4.01	−1.82±0.12	1.71±0.09
13	212	109	32	68	− 5.60	+ 1.93	−2.38±0.10	1.57±0.07
14	218	96	33	58	− 5.26	+ 0.32	−2.86±0.08	1.22±0.06
15	224	105	29	58	− 6.60	+ 0.32	−3.26±0.08	1.16±0.05
16	230	71	30	59	− 6.26	+ 0.49	−2.86±0.12	1.55±0.09
17	236	100	32	66	− 5.60	+ 1.64	−1.66±0.11	1.60±0.08
18	365	81	26	64	− 7.60	+ 1.32	−2.87±0.12	1.55±0.08
19	369	122	30	58	− 6.26	+ 0.32	−2.67±0.08	1.28±0.06
20	375	60	32	54	− 5.60	− 0.35	−2.81±0.12	1.37±0.08
21	379	78	30	62	− 6.26	+ 0.99	−3.34±0.10	1.27±0.07
22	383	31	37	52	− 4.05	− 0.73	−2.54±0.11	0.91±0.08
23	387	82	29	52	− 6.60	− 0.73	−3.39±0.10	1.31±0.07
24	391	129	20	62	−10.18	+ 0.99	−4.45±0.13	2.22±0.09
25	395	95	31	62	− 5.93	+ 0.99	−2.47±0.10	1.39±0.07
26	411	58	34	67	− 4.93	+ 1.78	−2.55±0.10	1.16±0.07
27	417	92	29	62	− 6.60	+ 0.99	−3.23±0.09	1.34±0.07
28	421	54	30	53	− 6.26	− 0.53	−3.41±0.12	1.28±0.08
29	425	51	32	50	− 5.60	− 1.13	−3.24±0.11	1.14±0.08
30	429	33	33	48	− 5.26	− 1.53	−3.51±0.10	0.89±0.07
31	433	88	30	57	− 6.26	+ 0.15	−2.79±0.10	1.39±0.07
32	437	108	33	75	− 5.26	+ 2.88	−2.62±0.09	1.45±0.06
33	443	52	25	46	− 7.93	− 1.93	−4.33±0.12	1.26±0.08
34	447	33	30	44	− 6.26	− 2.33	−3.93±0.13	1.10±0.09
35	451	62	29	55	− 6.60	− 0.18	−3.62±0.13	1.47±0.09
36	455	91	19	54	−10.68	− 0.35	−3.80±0.10	1.44±0.07
37	459	63	30	56	− 6.26	− 0.01	−2.85±0.11	1.32±0.08
38	463	34	32	60	− 5.60	+ 0.65	−2.64±0.14	1.25±0.10
39	467	70	25	53	− 7.93	− 0.53	−3.86±0.13	1.56±0.09
40	471	85	30	56	− 6.26	− 0.01	−2.81±0.08	1.07±0.06
41	475	31	23	54	− 8.68	− 0.35	−3.80±0.19	1.58±0.13
42	479.x	32	35	51	− 4.60	− 0.93	−2.84±0.12	1.01±0.08

TABLE 17

White bar selection. Low line. All matings. Offspring. Males.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS		FACTORIAL UNITS			
			Range		Range		Mean	Standard deviation
			Low	High	Low	High		
P	133-7	441	35	314	−10.72	+11.11	0.00±0.13	3.91±0.09
1	138	124	33	124	−11.38	+ 1.87	−4.85±0.16	2.66±0.11
2	144	157	41	134	− 9.17	+ 2.63	−3.44±0.14	2.54±0.09
3	146	81	35	91	−10.72	− 1.27	−6.35±0.14	1.91±0.10
4	150	41	41	78	− 9.17	− 2.86	−6.03±0.18	1.70±0.13
5	154	15	37	82	−10.17	− 2.36	−5.85±0.42	2.40±0.29
6	162	39	36	83	−10.42	− 2.24	−5.67±0.23	2.17±0.17
7	168	32	44	97	− 8.45	− 0.61	−5.24±0.22	1.82±0.15
8	174	88	39	86	− 9.67	− 1.86	−5.47±0.12	1.68±0.09
9	180	116	23	99	−14.80	− 0.40	−6.08±0.11	1.76±0.08
10	192	111	37	101	−10.17	− 0.20	−5.44±0.14	2.22±0.10
11	198	60	41	99	− 9.17	− 0.40	−4.85±0.22	2.50±0.15
12	204	109	29	86	−12.72	− 1.86	−6.56±0.11	1.74±0.08
13	212	116	38	87	− 9.92	− 1.74	−6.62±0.12	1.89±0.08
14	218	105	32	63	−11.72	− 4.97	−8.55±0.09	1.37±0.06
15	224	139	34	111	−11.05	+ 0.77	−7.96±0.11	1.86±0.07
16	230	102	31	66	−12.05	− 4.48	−8.67±0.12	1.81±0.09
17	236	104	34	99	−11.05	− 0.40	−7.12±0.14	2.14±0.10
18	365	87	32	90	−11.72	− 1.38	−7.92±0.12	1.67±0.08
19	369	137	33	86	−11.38	− 1.86	−7.98±0.11	1.91±0.08
20	375	69	34	66	−11.05	− 4.48	−8.60±0.11	1.40±0.08
21	379	136	29	67	−12.72	− 4.34	−9.13±0.09	1.52±0.06
22	383	49	38	69	− 9.92	− 4.05	−7.74±0.12	1.21±0.08
23	387	100	30	67	−12.38	− 4.34	−8.09±0.10	1.52±0.07
24	391	124	13	78	−20.22	− 2.86	−8.34±0.14	2.23±0.10
25	395	126	35	91	−10.72	− 1.27	−7.76±0.11	1.77±0.08
26	411	56	35	83	−10.72	− 2.24	−7.41±0.16	1.75±0.11
27	417	80	32	73	−11.72	− 3.49	−8.60±0.13	1.67±0.09
28	421	44	35	74	−10.72	− 3.36	−8.23±0.17	1.68±0.12
29	425	57	33	67	−11.38	− 4.34	−8.42±0.15	1.63±0.10
30	429	42	35	55	−10.72	− 6.30	−8.74±0.11	1.08±0.08
31	433	83	32	71	−11.72	− 3.76	−7.68±0.10	1.39±0.07
32	437	117	32	98	−11.72	− 0.50	−8.05±0.11	1.79±0.08
33	443	53	29	64	−12.72	− 4.80	−8.90±0.13	1.39±0.09
34	447	34	34	52	−11.05	− 6.85	−9.05±0.12	1.00±0.08
35	451	72	32	73	−11.72	− 3.49	−7.90±0.13	1.69±0.09
36	455	92	33	58	−11.38	− 5.80	−9.06±0.08	1.17±0.06
37	459	77	37	64	−10.17	− 4.80	−7.36±0.12	1.52±0.08
38	463	30	36	64	−10.42	− 4.80	−8.05±0.18	1.46±0.13
39	467	77	35	67	−10.72	− 4.34	−8.23±0.11	1.41±0.08
40	471	77	37	56	−10.17	− 6.13	−8.37±0.08	1.03±0.06
41	475	50	32	55	−11.72	− 6.30	−9.15±0.13	1.32±0.09
42	479x	24	41	58	− 9.17	− 5.80	−7.59±0.15	1.08±0.10

TABLE 18

White bar selection. High line. All matings. Offspring. Females.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS		FACTORIAL UNITS			
			Range		Range		Mean	Standard deviation
			Low	High	Low	High		
P	133-7	488	21	134	− 9.68	+ 8.75	0.00±0.10	3.12±0.07
1	141	207	35	203	− 4.60	+12.88	+ 2.04±0.15	3.23±0.11
2	142	164	37	166	− 4.05	+10.89	+ 5.53±0.13	2.41±0.09
3	148	118	51	146	− 0.93	+ 9.60	+ 5.76±0.12	1.95±0.08
4	152	148	67	182	+ 1.78	+11.81	+ 7.19±0.10	1.75±0.07
5	156	158	63	242	+ 1.15	+14.63	+ 8.13±0.12	2.25±0.08
6	160	82	84	182	+ 4.01	+11.81	+ 6.92±0.12	1.62±0.08
7	166	91	44	144	− 2.33	+ 9.46	+ 5.34±0.18	2.59±0.13
8	172	56	70	137	+ 2.21	+ 8.96	+ 4.91±0.15	1.69±0.11
9	176	133	63	181	+ 1.15	+11.75	+ 6.79±0.14	2.37±0.10
10	182	82	88	167	+ 4.51	+10.95	+ 7.29±0.10	1.41±0.07
11	194	135	74	164	+ 2.76	+10.78	+ 6.63±0.09	1.53±0.06
12	200	52	88	154	+ 4.51	+10.14	+ 7.15±0.13	1.38±0.09
13	206	85	79	143	+ 3.38	+ 9.39	+ 6.81±0.09	1.22±0.06
14	214	71	93	150	+ 5.07	+ 9.87	+ 7.76±0.10	1.23±0.07
15	222	60	68	156	+ 1.93	+10.27	+ 6.69±0.12	1.41±0.09
16	228	145	72	248	+ 2.50	+14.87	+ 6.97±0.14	2.54±0.10
17	240	60	55	186	− 0.18	+12.02	+ 6.65±0.18	2.07±0.13
18	367	22	68	141	+ 1.93	+ 9.25	+ 6.07±0.28	1.93±0.20
19	373	12	91	132	+ 4.85	+ 8.61	+ 6.32±0.23	1.17±0.16
20	377	147	58	179	+ 0.32	+11.65	+ 6.62±0.10	1.83±0.07
21	381	115	86	275	+ 4.26	+15.91	+ 7.60±0.12	1.97±0.09
22	385	86	39	227	− 3.55	+13.98	+ 7.00±0.21	2.89±0.15
23	389	79	36	172	− 4.30	+11.25	+ 6.91±0.17	2.21±0.12
24	393	103	66	206	+ 1.64	+13.02	+ 7.80±0.14	2.16±0.10
25	399	114	57	247	+ 0.15	+14.83	+ 8.01±0.15	2.40±0.11
26	409	73	83	220	+ 3.88	+13.68	+ 9.81±0.17	2.20±0.12
27	415	30	87	242	+ 4.38	+14.63	+ 9.47±0.38	3.12±0.27
28	419	57	83	315	+ 3.88	+17.26	+11.53±0.24	2.70±0.17
29	423	48	102	268	+ 6.02	+15.66	+11.76±0.20	2.05±0.14
30	427	49	109	249	+ 6.71	+14.91	+10.91±0.19	1.99±0.14
31	431	80	72	397	+ 2.50	+19.56	+ 9.82±0.21	2.79±0.15
32	435	71	65	228	+ 1.49	+14.03	+ 9.62±0.20	2.41±0.14
33	441	93	82	248	+ 3.76	+14.87	+ 9.24±0.16	2.25±0.11
34	445	99	72	230	+ 2.50	+14.11	+ 8.33±0.15	2.17±0.10
35	449	66	71	202	+ 2.36	+12.83	+ 8.27±0.21	2.50±0.15
36	453	72	68	248	+ 1.93	+14.87	+ 8.35±0.18	2.29±0.13
37	457	42	108	188	+ 6.62	+12.12	+10.09±0.13	1.22±0.09
38	461	30	102	204	+ 6.02	+12.93	+ 9.47±0.19	1.56±0.14
39	465	38	103	180	+ 6.12	+11.70	+ 9.31±0.17	1.60±0.12
40	469	69	100	184	+ 5.82	+11.91	+ 8.91±0.11	1.40±0.08
41	473	18	137	180	+ 8.96	+11.70	+10.40±0.13	0.82±0.09
42	477x	9	101	142	+ 5.92	+ 9.32	+ 8.07±0.24	1.05±0.17

TABLE 19

White bar selection. High line. All matings. Offspring. Males.

GENERATION	CATALOG NUMBER	NUMBER OF INDIVIDUALS	FACETS Range Low	FACETS Range High	FACTORIAL UNITS Range Low	FACTORIAL UNITS Range High	FACTORIAL UNITS Mean	FACTORIAL UNITS Standard deviation
P	133–7	441	35	314	−10.72	+11.11	0.00±0.13	3.91±0.09
1	141	209	44	237	− 8.45	+ 8.30	−1.32±0.17	3.62±0.12
2	142	127	52	227	− 6.85	+ 7.86	+1.19±0.19	3.16±0.13
3	148	126	42	212	− 8.92	+ 7.19	+1.09±0.15	2.49±0.11
4	152	147	76	245	− 3.11	+ 8.63	+2.79±0.11	2.00±0.08
5	156	169	91	472	− 1.27	+15.18	+5.48±0.15	2.80±0.10
6	160	93	103	242	0.00	+ 8.51	+3.24±0.12	1.67±0.08
7	166	96	77	238	− 2.99	+ 8.34	+2.92±0.16	2.28±0.11
8	172	49	85	239	− 1.99	+ 8.38	+2.66±0.22	2.28±0.15
9	176	128	87	348	− 1.74	+12.14	+4.02±0.17	2.91±0.12
10	182	101	102	316	− 0.10	+11.05	+4.81±0.16	2.38±0.11
11	194	154	86	238	− 1.86	+ 8.34	+3.80±0.12	2.18±0.08
12	200	49	112	384	+ 0.86	+13.12	+5.77±0.24	2.50±0.17
13	206	87	99	220	− 0.40	+ 7.56	+3.89±0.13	1.73±0.09
14	214	65	117	289	+ 1.31	+10.29	+5.06±0.13	1.54±0.09
15	222	63	93	206	− 1.05	+ 6.90	+3.01±0.15	1.76±0.11
16	228	158	91	287	− 1.27	+10.22	+3.65±0.13	2.35±0.09
17	240	64	104	238	+ 0.10	+ 8.34	+3.72±0.16	1.85±0.11
18	367	21	87	323	− 1.74	+11.40	+4.24±0.46	3.17±0.33
19	373	18	97	199	− 0.61	+ 6.57	+2.51±0.29	1.80±0.20
20	377	118	94	215	− 0.94	+ 7.33	+3.16±0.12	1.91±0.08
21	381	79	104	346	+ 0.10	+12.08	+5.18±0.16	2.12±0.11
22	385	65	99	258	− 0.40	+ 9.15	+4.60±0.16	1.95±0.11
23	389	109	87	294	− 1.74	+10.47	+4.12±0.14	2.23±0.10
24	393	90	97	288	− 0.61	+10.25	+4.65±0.15	2.11±0.11
25	399	93	106	244	+ 0.30	+ 8.59	+4.60±0.13	1.81±0.09
26	409	47	108	278	+ 0.50	+ 9.90	+5.50±0.23	2.29±0.16
27	415	20	112	251	+ 0.86	+ 8.87	+5.50±0.36	2.42±0.26
28	419	19	134	287	+ 2.63	+10.22	+6.48±0.30	1.95±0.21
29	423	34	137	329	+ 2.84	+11.58	+6.86±0.24	2.05±0.17
30	427	32	142	285	+ 3.20	+10.15	+6.11±0.20	1.72±0.14
31	431	54	119	408	+ 1.49	+13.72	+5.49±0.20	2.23±0.15
32	435	26	133	263	+ 2.56	+ 9.35	+5.10±0.23	1.77±0.16
33	441	56	103	297	0.00	+10.56	+4.90±0.19	2.17±0.14
34	445	86	104	365	+ 0.10	+12.62	+4.72±0.18	2.49±0.13
35	449	56	94	298	− 0.94	+10.60	+4.83±0.18	2.01±0.13
36	453	81	88	265	− 1.61	+ 9.43	+4.81±0.17	2.29±0.12
37	457	39	142	256	+ 3.20	+ 9.07	+6.41±0.17	1.57±0.12
38	461	29	115	230	+ 1.13	+ 7.99	+5.36±0.23	1.87±0.16
39	465	55	124	246	+ 1.87	+ 8.67	+5.22±0.16	1.73±0.11
40	469	104	114	378	+ 1.04	+12.96	+5.11±0.12	1.89±0.09
41	473	32	150	241	+ 3.75	+ 8.47	+6.14±0.16	1.38±0.12
42	477x	17	119	380	+ 1.49	+13.02	+5.19±0.41	2.53±0.29

TABLE 20

Distribution of frequencies of factorial values. Low and high selection. Females. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	P	1 L	1 H	2 L	2 H	3 L	3 H	4 L	4 H	5 L	5 H	6 L	6 H	7 L	7 H	8 L	8 H	9 L	9 H	10 L	10 H	11 L	11 H
Heterozygotes		1										1												
+20.07	397–438																							
+19.07	359–396																							
+18.07	325–358																							
+17.07	294–324																							
+16.07	266–293	1																						
+15.07	241–265											1												
+14.07	218–240																							
+13.07	197–217											1												
+12.07	178–196									1		9								1				
+11.07	161–177					1				1		7								5		1		
+10.07	146–160					2		1		7		10		3						10		4		
+ 9.07	132–145	1		4		3		2		9		12		2		5		2		11		5		3
+ 8.07	119–131			5	1	7		13		9		7		4		3		2		9		19		4
+ 7.07	108–118	7		4		13		14		5		15		7		2		4		4		13		6
+ 6.07	98–107	11		11		14		13		6		15		9		4		10		9		11		6
+ 5.07	89– 97	27		10	5	2		7		1		6		2		3		10		1		6		
+ 4.07	81– 88	25		11	12			1	1	1		2				1	1	7		3		1		
+ 3.07	73– 80	29		7	4	1			2			2				3	5	10			5		1	
+ 2.07	66– 72	51	3	11	12				3		1		1			1	11	3		3	3		3	
+ 1.07	60– 65	55	7	8	10				3			1	2				8		2	1	6		4	
+ 0.07	54– 59	54	14	11	13				4		1		3		8		25		11		10		11	
– 0.93	49– 53	58	21	3	4				3		1		1		10		12		13		15		7	
– 1.93	44– 48	54	12	7	7		2		3		4		6		6		6		2		24		13	
– 2.93	40– 43	47	9	2	2		1		5		5		4		8		2		4		7		4	
– 3.93	36– 39	40	26	2	2		1		3		1		2		8						2		2	
– 4.93	33– 35	15	4				1		2				1		5		2						3	
– 5.93	30– 32	9	3		1				1						2									
– 6.93	27– 29	3																						
– 7.93	24– 26	1															1							
– 8.93	22– 23																							
– 9.93	20– 21	1																						
–10.93	18– 19																							
Totals		490	99	96	73	43	5	51	30	40	13	89	20	27	47	22	73	48	32	57	72	60	48	19

TABLE 20 (continued)

Distribution of frequencies of factorial values. Low and high selection. Females. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES P	12 L	12 H	13 L	13 H	14 L	14 H	15 L	15 H	16 L	16 H	17 L	17 H	18 L	18 H	19 L	19 H	20 L	20 H	21 L	21 H	22 L	22 H
Heterozygotes		1	1																					
+20.07	397–438																							
+19.07	359–396																							
+18.07	325–358																							
+17.07	294–324																							
+16.07	266–293	1																				1		
+15.07	241–265											1												
+14.07	218–240											2												
+13.07	197–217											2												1
+12.07	178–196											6												
+11.07	161–177											3										2		
+10.07	146–160			3						1		1										3		2
+ 9.07	132–145	1		4		5		2		2		4		3		2		1		2		13		**1**
+ 8.07	119–131			12		20		11		16		**6**		7		4				5		20		
+ 7.07	108–118	7		**10**		**22**		**7**		**10**		4		**6**		3		4		10		**11**		2
+ 6.07	98–107	11		10		29		4		21		4		7		**5**		**3**		**19**		10		
+ 5.07	89– 97	27		5		5		3		7		9		5		3		4		11		7		1
+ 4.07	81– 88	25	1			3						6		3		2				8		6		
+ 3.07	73– 80	29				1										2								
+ 2.07	66– 72	51														1				1				
+ 1.07	60– 65	55	2												1									
+ 0.07	54– 59	**54**	12						1		5				2									
− 0.93	49– 53	58	17						4		6				1						1		1	
− 1.93	44– 48	54	**23**		1				8		10				6		2				3		4	
− 2.93	40– 43	47	19		**2**				**10**		**7**		1		**7**		3		2		7		**6**	
− 3.93	36– 39	40	8		2		**2**		15		13		4		12		**10**		**4**		**13**		3	
− 4.93	33– 35	15	4						4		2		2				3		3		3			
− 5.93	30– 32	9	1						1		4		1		2		4				2			
− 6.93	27– 29	3													1									
− 7.93	24– 26	1	1												1									
− 8.93	22– 23																							
− 9.93	20– 21	1																						
−10.93	18– 19																							
Totals		490	89	44	5	85	2	27	43	57	47	48	8	31	33	22	22	12	9	56	29	73	14	7

TABLE 20 (continued)

Distribution of frequencies of factorial values. Low and high selection. Females. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																				
		P	23		24		25		26		27		28		29		30		31		32	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Heterozygotes		1																			1	
+20.07	397–438																					
+19.07	359–396																					
+18.07	325–358																					
+17.07	294–324													1								
+16.07	266–293	1												3								
+15.07	241–265							1				1		4		3		1				
+14.07	218–240											3		2		4		2				
+13.07	197–217					3		3		4		1		8		3		1		2		1
+12.07	178–196					1		7		3		4		6		1		1		3		4
+11.07	161–177					2		5		1		3		11		5		3		5		4
+10.07	146–160					5		7		1		1		3		3		4		2		4
+ 9.07	132–145	1				1		8				6		5		1				2		7
+ 8.07	119–131					3		9		1		1		1						7		4
+ 7.07	108–118	7				2		5		2		1		2				1		2		2
+ 6.07	98–107	11				7		3												1		3
+ 5.07	89– 97	27				2		6						1								1
+ 4.07	81– 88	25				2		1						1								
+ 3.07	73– 80	29																		1	1	
+ 2.07	66– 72	51				1																
+ 1.07	60– 65	55																			2	1
+ 0.07	54– 59	54			2			1											2		4	
– 0.93	49– 53	58	2		2								4						6		9	
– 1.93	44– 48	54	10		6		2		5		7		2		4		2		16		17	
– 2.93	40– 43	47	16		8		2		11		7		13		4		5		10		5	
– 3.93	36– 39	40	6		14		1		6		8		19		11		10		7		9	
– 4.93	33– 35	15	10		13				1		6		5		3		4				1	
– 5.93	30– 32	9	5		6						1		4		3				1			
– 6.93	27– 29	3	1		10						2											
– 7.93	24– 26	1			5																	
– 8.93	22– 23				4																	
– 9.93	20– 21	1			1																	
–10.93	18– 19																					
Totals		490	50	0	71	27	5	56	23	12	31	21	47	48	25	20	21	13	42	25	49	31

TABLE 20 (continued)

Distribuiion of frequencies of factorial values. Low and high selection. Females. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	P	FREQUENCIES 33 L	33 H	34 L	34 H	35 L	35 H	36 L	36 H	37 L	37 H	38 L	38 H	39 L	39 H	40 L	40 H	41 L	41 H	42 L	42 H
Heterozygotes		1								1												
+20.07	397—438																					
+19.07	359—396																					
+18.07	325—358																					
+17.07	294—324																					
+16.07	266—293	1																				
+15.07	241—265									1												
+14.07	218—240																					
+13.07	197—217			1										1								
+12.07	178—196			3						1		2		1				1				
+11.07	161—177			3		1		4		6		5		2		2		4		6		
+10.07	146—160			8		4		3		5		1		4		1		5		5		
+ 9.07	132—145	1		5		3		2		4				5		3		6		3		4
+ 8.07	119—131			3		3		3		6				1		2		1				2
+ 7.07	108—118	7		2		1		1		3		1		2				3				2
+ 6.07	98—107	11		1						1				1		2		1				1
+ 5.07	89— 97	27						1		2												
+ 4.07	81— 88	25																				
+ 3.07	73— 80	29																				
+ 2.07	66— 72	51																				
+ 1.07	60— 65	55											1									
+ 0.07	54— 59	54							1		2		1									
— 0.93	49— 53	58							2		5		1								2	
— 1.93	44— 48	54	1						6		8		10		4		1				11	
— 2.93	40— 43	47	4		9		7		13		6		15		5		2		6		8	
— 3.93	36— 39	40	14		8		8		13		7		4		21		4		6		10	
— 4.93	33— 35	15	8		3		6		11		2		1		8				5		1	
— 5.93	30— 32	9	5		4		4				2		1		6				1			
— 6.93	27— 29	3	2				1								4				1			
— 7.93	24— 26	1	1												1							
— 8.93	22— 23																					
— 9.93	20— 21	1																				
—10.93	18— 19								1													
Totals		490	35	26	24	12	26	14	47	30	32	9	34	17	49	10	7	21	19	14	32	9

TABLE 21

Distribution of frequencies of factorial values. Low and high selection. Males. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																						
		P	1		2		3		4		5		6		7		8		9		10		11	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye																								
+14.95	439—484											1												
+13.95	397—438											3												
+12.95	359—396											2												
+11.95	325—358											2								1				
+10.95	294—324	1																		2		3		
+ 9.95	266—293											3								2		1		
+ 8.95	241—265	3								1		10								7		2		
+ 7.95	218—240	6		1								11		1				1		5		6		
+ 6.95	197—217	15		2		1				2		**14**								**6**		9		3
+ 5.95	178—196	16		2		3		1		4		5				4		4		9		13		2
+ 4.95	161—177	26		4		4		2		11		11		4		4		9		9		**14**		**6**
+ 3.95	146—160	19		2		7		10		**8**		8		2		**7**		6		5		8		6
+ 2.95	132—145	34		7	2	**15**		9		6		4		**3**		4		4		4		6		4
+ 1.95	119—131	35		8	3	5		**13**		8		3		7		1		8		1		3		1
+ 0.95	108—118	33		10	6	4		10		4		1						7				3		
— 0.05	98—107	**50**		**15**	4			3						1				2				1		
— 1.05	89— 97	55		7	3			2							1	1		1			1		3	
— 2.05	81— 88	37		13	13						2		1		3		2	1			2		3	
— 3.05	73— 80	29		4	**8**				3	1	1		6		1		3				1		8	
— 4.05	66— 72	23	3	7	7				7		2		2		6		19		2		7		11	
— 5.05	60— 65	22	2	3	8				5		1		**5**		4		**10**		6		9		**5**	
— 6.05	54— 59	18	4	3	4		2		**11**		**3**		2		11		9		**10**		**8**		2	
— 7.05	49— 53	8	1	1	2				7		3		3		2		7		5		16		3	
— 8.05	44— 48	7	**2**	3	2		**0**		4				1		4		4		3		16		5	
— 9.05	40— 43	2	5						4		2		2						1		5		6	
—10.05	36— 39	1	3				1				1										1			
—11.05	33— 35	1	2				1																	
—12.05	30— 32																							
—13.05	27— 29																							
—14.05	24— 26																							
—15.05	22— 23																							
—16.05	20— 21																							
—17.05	18— 19				1																			
Total		441	22	92	63	39	4	50	41	45	15	78	22	18	32	21	54	43	27	51	66	69	46	22

TABLE 21 (continued)

Distribution of frequencies of factorial values. Low and high selection. Males. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	P	12		13		14		15		16		17		18		19		20		21		22	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye																								
+14.95	439–484																							
+13.95	397–438																							
+12.95	359–396			1																				
+11.95	325–358			1																				
+10.95	294–324	1														1								
+ 9.95	266–293			1								1												
+ 8.95	241–265	3		2								2				1								
+ 7.95	218–240	6		6		1						5		3		2						4		
+ 6.95	197–217	15		7		8		2		1		10		1		3		1		4		5		1
+ 5.95	178–196	16		11		7		2		5		7		5						5		5		
+ 4.95	161–177	26		3		14		2		7		5		4		1				3		9		
+ 3.95	146–160	19		5		21		8		13		7		4		2		4		8		10		
+ 2.95	132–145	34		2		19		3		13		12		9		5		5		5		5		2
+ 1.95	119–131	35		1		10		1		12		8		3		3		4		10				1
+ 0.95	108–118	33				6		1		8		6		3		1		1				2		
– 0.05	98–107	50				1				2		4		2		1		2		2				
– 1.05	89– 97	55										1			1			1		2				
– 2.05	81– 88	37	1												1	1								
– 3.05	73– 80	29	3						1						1									
– 4.05	66– 72	23	9						2		1													
– 5.05	60– 65	22	15						3		3				2		1				1		1	
– 6.05	54– 59	18	18						7		7				3						2		3	
– 7.05	49– 53	8	24		2		1		9		9				3		1				3		3	
– 8.05	44– 48	7	16		3		0		17		8		2		16		8		1		12		8	
– 9.05	40– 43	2	13		2		2		11		9		3		7		11		7		10		6	
–10.05	36– 39	1							8		12		2		6		27		9		17			
–11.05	33– 35	1							4		7		1				4		1		3			
–12.05	30– 32										5				1						2			
–13.05	27– 29		1																		1			
–14.05	24– 26																							
–15.05	22– 23																							
–16.05	20– 21																							
–17.05	18– 19																							
Total		441	100	40	7	87	3	19	62	61	61	68	8	34	41	21	52	18	18	39	51	40	21	4

TABLE 21 (continued)

Distribution of frequencies of factorial values. Low and high selection. Males. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	P	FREQUENCIES 23		24		25		26		27		28		29		30		31		32	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye																						
+14.95	439–484																					
+13.95	397–438																					
+12.95	359–396																					
+11.95	325–358															1						
+10.95	294–324	1																				
+ 9.95	266–293													1		3		1				
+ 8.95	241–265	3				1		1		1		2		3		3				1		
+ 7.95	218–240	6				1		2				2		3		2		2		2		
+ 6.95	197–217	15				1		8				0		2		2		1		4		
+ 5.95	178–196	16				2		6				2		3		5		3		3		1
+ 4.95	161–177	26				2		6		0				3				2		1		3
+ 3.95	146–160	19				1		5				1		2						3		1
+ 2.95	132–145	34				2		6								1				2		2
+ 1.95	119–131	35				1		1		1										1		
+ 0.95	108–118	33				1		3														
– 0.05	98–107	50				2															1	
– 1.05	89– 97	55				1															1	
– 2.05	81– 88	37																				
– 3.05	73– 80	29			3								1								1	
– 4.05	66– 72	23	1		2																2	
– 5.05	60– 65	22	3		7								2						1		1	
– 6.05	54– 59	18	1		7		1		1		3		3		1		2		5		9	
– 7.05	49– 53	8	9		6		4		5		2		5		1		2		9		11	
– 8.05	44– 48	7	19		12		4		6		6		6		7		6		10		7	
– 9.05	40– 43	2	15		5		3		8		5		11		3		12		2		8	
–10.05	36– 39	1	8		18				3		6		10		7		6		1		3	
–11.05	33– 35	1	1						2		2		1		4		1					
–12.05	30– 32		1		1																	
–13.05	27– 29				1																	
–14.05	24– 26																					
–15.05	22– 23																					
–16.05	20– 21																					
–17.05	18– 19																					
Total		441	58	0	62	15	12	38	25	2	24	7	39	17	23	17	29	9	28	17	44	7

TABLE 21 (continued)

Distribution of frequencies of factorial values. Low and high selection. Males. Direct lines only.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																				
		P	33		34		35		36		37		38		39		40		41		42	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye									1													
+14.95	439–484																					
+13.95	397–438																					
+12.95	359–396																					1
+11.95	325–358																					
+10.95	294–324	1		1		2		1														
+ 9.95	266–293			1																		
+ 8.95	241–265	3		1				2		3		1				1				1		
+ 7.95	218–240	6		3						6				1		2		1		5		1
+ 6.95	197–217	15		5		3		2		7		1		3		1		10		6		1
+ 5.95	178–196	16		4		2		1		5		3		2		3		8		6		5
+ 4.95	161–177	26		3		1		1		4				0		2		8		5		1
+ 3.95	146–160	19		7		1		1		4				2		9		2		5		3
+ 2.95	132–145	34		2		1				2						4		6				4
+ 1.95	119–131	35		1										1		1						1
+ 0.95	108–118	33				2								1								
− 0.05	98–107	50																				
− 1.05	89– 97	55																				
− 2.05	81– 88	37																				
− 3.05	73– 80	29																				
− 4.05	66– 72	23													1							
− 5.05	60– 65	22	1				2				9		3		2							
− 6.05	54– 59	18	1				3		2		9		3		7						6	
− 7.05	49– 53	8	4		3		4		6		10		3		9				3		4	
− 8.05	44– 48	7	11		2		3		10		5		5		9		1		5		9	
− 9.05	40– 43	2	9		8		5		17		5		14		12		3		9		5	
−10.05	36– 39	1	6		7		2		12				2		9		2		10			
−11.05	33– 35	1	2		1				1										3			
−12.05	30– 32																		1			
−13.05	27– 29		1																			
−14.05	24– 26																					
−15.05	22– 23																					
−16.05	20– 21																					
−17.05	18– 19																					
Total		441	35	28	21	12	19	8	49	31	38	5	30	10	49	23	6	35	31	28	24	17

TABLE 22

Distribution of frequencies of factorial values. Low and high selection. Females. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																				
		P	1		2		3		4		5		6		7		8		9		10	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Heterozygotes		1										1		1								
+20.07	397–438																					
+19.07	359–396																					
+18.07	325–358																					
+17.07	294–324																					
+16.07	266–293	1																				
+15.07	241–265											1										
+14.07	218–240																					
+13.07	197–217			1								1										
+12.07	178–196									1		10		1						1		
+11.07	161–177					1				2		11								6		1
+10.07	146–160					2		1		11		21		4						11		4
+ 9.07	132–145	1		4		10		3		18		22		9		12		2		17		8
+ 8.07	119–131			6	1	17		16		29		**20**		12		8		2		17		23
+ 7.07	108–118	7		7		27		23		**32**		31		**17**		10		14		**15**		**20**
+ 6.07	98–107	11		16		31		**26**		28		26		23		14		11		24		16
+ 5.07	89– 97	27		16	7	**33**		22		19		9		12		**17**		**13**		16		9
+ 4.07	81– 88	25		20	16	14		14	1	6		3		4		8	1	9	1	17	1	1
+ 3.07	73– 80	29		15	11	10		4	2	1		2				10	5	12	2	4	7	
+ 2.07	66– 72	51	3	**17**	25	4		5	3	1	1		2			3	11	3	7	3	10	
+ 1.07	60– 65	55	7	20	**30**	11	6	2	3			1	5			4	10		10	2	19	
+ 0.07	54– 59	**54**	15	36	34	1	10	1	4		1		8		8	3	**28**		29		**24**	
– 0.93	49– 53	58	21	18	23	1	28	1	**3**		1		4		10	1	24		**33**		24	
– 1.93	44– 48	54	**14**	22	22	1	**20**		3		4		**8**		**6**	1	11		27		28	
– 2.93	40– 43	47	13	5	4		17		5		5		14		8		4		9		7	
– 3.93	36– 39	40	30	3	3	1	15		3		1		4		8				1		2	
– 4.93	33– 35	15	5	1	1		4		2				2		5		2					
– 5.93	30– 32	9	3		1				1						2							
– 6.93	27– 29	3																				
– 7.93	24– 26	1															1					
– 8.93	22– 23																					
– 9.93	20– 21	1																				
–10.93	18– 19																					
Totals		490	111	207	178	164	100	118	30	148	13	159	47	83	47	91	97	56	119	133	122	82

TABLE 22 (continued)

Distribution of frequencies of factorial values. Low and high selection. Females. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																				
		P	11		12		13		14		15		16		17		18		19		20	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Heterozygotes		1			1																	
+20.07	397–438																					
+19.07	359–396																					
+18.07	325–358																					
+17.07	294–324																					
+16.07	266–293	1																				
+15.07	241–265													1								
+14.07	218–240													2								
+13.07	197–217													2								
+12.07	178–196													6		1						1
+11.07	161–177			3										3								2
+10.07	146–160			2		3				3		1		7		2						3
+ 9.07	132–145	1		9		4		5		17		2		13		4		2		1		14
+ 8.07	119–131			18		13		20		**21**		16		15		15		4				22
+ 7.07	108–118	7		**28**		**14**		**22**		20		**10**		**16**		**12**		3		4		**33**
+ 6.07	98–107	11		50		11		29		5		21		31		11		**5**		**3**		33
+ 5.07	89– 97	27		15		6		5		5		8		30		6		3		4		22
+ 4.07	81– 88	25		7	1	1		3						15		4		2				12
+ 3.07	73– 80	29	2	3				1				1		2		3		2				2
+ 2.07	66– 72	51	8				1					1		2	1	1		1				2
+ 1.07	60– 65	55	5		3		3								5		1					
+ 0.07	54– 59	**54**	17		16		12		3		1		5		19	1	3		3		1	1
– 0.93	49– 53	58	**13**		21		10		9		5		8		21		8		14		8	
– 1.93	44– 48	54	18		**24**		**19**		22		16		16		**23**		20		45		19	
– 2.93	40– 43	47	4		19		43		**26**		**36**		**14**		17		**21**		**22**		**11**	
– 3.93	36– 39	40	2		8		13		29		34		18		7		20		30		12	
– 4.93	33– 35	15	3		4		5		7		10		6		4		3		4		8	
– 5.93	30– 32	9			1		3				2		4		1		3		4		1	
– 6.93	27– 29	3									1						1					
– 7.93	24– 26	1			1												1					
– 8.93	22– 23																					
– 9.93	20– 21	1																				
–10.93	18– 19																					
Totals		490	72	135	99	52	109	85	96	71	105	60	71	145	98	60	81	22	122	12	60	147

TABLE 22 (continued)

Distribution of frequencies of factorial values. Low and high selection. Females. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																						
		P	21		22		23		24		25		26		27		28		29		30		31	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Heterozygotes		1												1										
+20.07	397–438																							1
+19.07	359–396																							
+18.07	325–358																							
+17.07	294–324																	1						
+16.07	266–293	1		1														3		1				
+15.07	241–265											1				1		5		4		2		
+14.07	218–240					1								1		3		2		5		4		3
+13.07	197–217			1		1				3		3		9		1		9		6		3		7
+12.07	178–196			2		1				1		7		11		4		8		8		7		9
+11.07	161–177			4		2		2		4		7		7		3		**11**		**11**		**13**		15
+10.07	146–160			3		9		2		9		8		**6**		1		5		8		9		**9**
+ 9.07	132–145	1		21		12		11		20		16		17		**7**		7		2		4		10
+ 8.07	119–131			**26**		13		21		**22**		**19**		8		1		1		2		4		12
+ 7.07	108–118	7		22		**15**		**12**		12		20		12		3		3				3		5
+ 6.07	98–107	11		19		6		11		16		17		1		1				1				4
+ 5.07	89– 97	27		10		13		13		8		12				3		1						2
+ 4.07	81– 88	25		6		5		4		6		3		1		2		1						1
+ 3.07	73– 80	29						1		1														1
+ 2.07	66– 72	51				5				1			1											1
+ 1.07	60– 65	55	1			1		1	1		3				1									
+ 0.07	54– 59	**54**	1			1			2		4	1											3	
– 0.93	49– 53	58	4		4		2		9		10		7		5		5		1				9	
– 1.93	44– 48	54	8		9		20		13		30		17		21		5		13		4		27	
– 2.93	40– 43	47	**23**		**13**		24		11		24		**20**		**22**		**16**		**15**		11		**23**	
– 3.93	36– 39	40	31		5	1	17		34		17		12		28		19		16		**13**		14	
– 4.93	33– 35	15	6				13		**21**		6		1		12		5		3		5		8	
– 5.93	30– 32	9	4				5		13		1				1		4		3				4	
– 6.93	27– 29	3					1		11						2									
– 7.93	24– 26	1							8															
– 8.93	22– 23								4															
– 9.93	20– 21	1							2															
–10.93	18– 19																							
Totals		490	78	115	31	86	82	79	129	103	95	114	58	74	92	30	54	57	51	48	33	49	88	80

TABLE 22 (continued)

Distribution of frequencies of factorial values. Low and high selection. Females. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	P	FREQUENCIES																					
			32		33		34		35		36		37		38		39		40		41		42	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Heterozygotes		1	1									1												
+20.07	397–438																							
+19.07	359–396																							
+18.07	325–358																							
+17.07	294–324																							
+16.07	266–293	1																						
+15.07	241–265					1						1												
+14.07	218–240			1		1		1																
+13.07	197–217			2		4		2		1						1								
+12.07	178–196			15		8		2		5		2		3		1		1		1		1		
+11.07	161–177			12		11		9		9		11		15		4		8		8		7		
+10.07	146–160			**7**		20		13		7		8		**10**		9		10		12		**7**		
+ 9.07	132–145	1		14		**14**		17		14		11		10		**9**		**9**		**23**		3		4
+ 8.07	119–131			7		9		**25**		**6**		**13**		2		2		4		12				**2**
+ 7.07	108–118	7		5		13		12		7		11		2		2		2		9				2
+ 6.07	98–107	11		5		7		5		8		6				2		4		4				1
+ 5.07	89– 97	27		1		4		8		3		7												
+ 4.07	81– 88	25				1		4		4														
+ 3.07	73– 80	29	1	1						1		1												
+ 2.07	66– 72	51						1		1		1												
+ 1.07	60– 65	55	2	1											1									
+ 0.07	54– 59	**54**	4						3		1		2		1				1		1			
− 0.93	49– 53	58	12								3		6		1		3		8				2	
− 1.93	44– 48	54	25		2		1		7		8		17		10		12		19		2		11	
− 2.93	40– 43	47	**31**		9		12		17		21		**17**		**15**		10		**33**		11		**8**	
− 3.93	36– 39	40	24		**21**		**11**		**20**		**31**		14		4		**24**		21		**9**		10	
− 4.93	33– 35	15	9		11		4		8		23		5		1		10		2		5		1	
− 5.93	30– 32	9			5		5		5		1		2		1		6		1		1			
− 6.93	27– 29	3			3				2		2						4				1			
− 7.93	24– 26	1			1												1							
− 8.93	22– 23																				1			
− 9.93	20– 21	1																						
−10.93	18– 19										1													
Totals		490	109	71	52	93	33	99	62	66	91	73	63	42	34	30	70	38	85	69	31	18	32	9

TABLE 23

Distribution of frequencies of factorial values. Low and high selections. Males. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																				
		P	1		2		3		4		5		6		7		8		9		10	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye																						
+14.95	439–484											1										
+13.95	397–438											3										
+12.95	359–396											2										
+11.95	325–358											2								1		
+10.95	294–324	1																		2		3
+ 9.95	266–293											3								2		1
+ 8.95	241–265	3								1		11		1						7		2
+ 7.95	218–240	6		1		2						13		2		1		1		5		6
+ 6.95	197–217	15		4		5		1		4		19								6		11
+ 5.95	178–196	16		3		4		1		7		**20**		2		11		4		13		14
+ 4.95	161–177	26		6		5		3		20		26		16		15		9		19		**20**
+ 3.95	146–160	19		6		9		15		22		28		17		18		6		**17**		18
+ 2.95	132–145	34		13	2	24		17		**25**		27		**24**		**15**		4		16		11
+ 1.95	119–131	35	1	15	3	17		21		34		7		21		10		8		15		5
+ 0.95	108–118	33	2	19	6	**19**		**25**		15		6		6		6		9		8	1	7
− 0.05	98–107	**50**	3	23	8	7		19		16				4		11		5	1	13	4	3
− 1.05	89– 97	55	10	**13**	15	3	1	10		1		1			1	7		1	1	3	7	
− 2.05	81– 88	37	6	24	26	13	1	7			2		1		3	1	2	2		1	12	
− 3.05	73– 80	29	13	14	**23**	7	4	2	3	2	1		8		1	1	5		4		19	
− 4.05	66– 72	23	25	28	18	8	7	2	7		2		4		6		26		13		12	
− 5.05	60– 65	22	**17**	15	21	3	12		5		1		8		4		**16**		20		**13**	
− 6.05	54– 59	18	17	11	19		**21**		**11**		**3**		4		11		15		**35**		21	
− 7.05	49– 53	8	8	6	7	1	14	1	7		3		6		2		11		21		16	
− 8.05	44– 48	7	10	8	7		11	1	4				2		4		11		18		5	
− 9.05	40– 43	2	7		2		6	1	4		2		3				1		2		1	
−10.05	36– 39	1	3				3				1		2				1					
−11.05	33– 35	1	2				1															
−12.05	30– 32																					
−13.05	27– 29																					
−14.05	24– 26																					
−15.05	22– 23																		1			
−16.05	20– 21																					
−17.05	18– 19				1																	
−18.05	16– 17																					
Totals		441	124	209	158	127	81	126	41	147	15	169	39	93	32	96	88	49	116	128	111	101

TABLE 23 (continued)

Distribution of frequencies of factorial values. Low and high selection. Males. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES P	11		12		13		14		15		16		17		18		19		20	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye																						
+14.95	439–484																					
+13.95	397–438																					
+12.95	359–396					1																
+11.95	325–358					1																
+10.95	294–324	1																1				
+ 9.95	266–293					1				1				2								
+ 8.95	241–265	3				2								2				1				
+ 7.95	218–240	6		8		6		1		2				6		3		2				
+ 6.95	197–217	15		10		7		8		8		1		13		2		3		1		5
+ 5.95	178–196	16		14		**11**		7		13		5		14		7						8
+ 4.95	161–177	26		28		3		14		**20**		7		16		7		1				15
+ 3.95	146–160	19		**35**		9		**21**		13		13		**25**		**13**		**2**		4		30
+ 2.95	132–145	34		21		4		19		5		**13**		24		20		5		**5**		**18**
+ 1.95	119–131	35		10		2		10		2		12		28		4		3		4		21
+ 0.95	108–118	33		15		2		6		1	1	8		18		6		1		1		9
– 0.05	98–107	**50**	1	11				1				2		8	2	2		1		2		8
– 1.05	89– 97	55	4	1								2		2	1		1			1		4
– 2.05	81– 88	37	6	1	1		1								1		1	1	2			
– 3.05	73– 80	29	9		3		7				3				4		1		2			
– 4.05	66– 72	23	13		9		8				2		1		2				2		1	
– 5.05	60– 65	22	**6**		19		21		3		7		4		4		3		9		1	
– 6.05	54– 59	18	4		21		19		5		13		10		23		5		16		3	
– 7.05	49– 53	8	4		**24**		**17**		14		19		12		**21**		15		18		10	
– 8.05	44– 48	7	6		18		22		**30**		**40**		18		20		**33**		**29**		15	
– 9.05	40– 43	2	7		13		17		25		28		**22**		16		17		25		**19**	
–10.05	36– 39	1					4		24		20		21		7		10		30		18	
–11.05	33– 35	1							3		6		9		3				4		2	
–12.05	30– 32								1				5				1					
–13.05	27– 29				1																	
–14.05	24– 26																					
–15.05	22– 23																					
–16.05	20– 21																					
–17.05	18– 19																					
–18.05	16– 17																					
Totals		441	60	154	109	49	116	87	105	65	139	63	102	158	104	64	87	21	137	18	69	118

TABLE 23 (continued)

Distribution of frequencies of factorial values. Low and high selection. Males. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																						
		P	21		22		23		24		25		26		27		28		29		30		31	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye																								
+14.95	439–484																							
+13.95	397–438																							1
+12.95	359–396																							
+11.95	325–358			1																1				
+10.95	294–324	1		1				1																
+ 9.95	266–293									1				2				1		3		2		1
+ 8.95	241–265	3				2		1		2		1		4		2		3		4				2
+ 7.95	218–240	6		7		4		2		5		2		3		3		3		4		5		5
+ 6.95	197–217	15		15		5		13		8		14		9		3		**2**		**6**		6		6
+ 5.95	178–196	16		10		8		16		16		11		**5**		4		3		9		**8**		**12**
+ 4.95	161–177	26		**16**		**14**		17		**19**		**25**		7		2		4		3		4		8
+ 3.95	146–160	19		12		15		**18**		14		15		8		1		2		2		6		9
+ 2.95	132–145	34		11		11		12		12		15		5		1		1		2		1		7
+ 1.95	119–131	35		3		2		17		7		4		2		3								3
+ 0.95	108–118	33		2		2		7		3		5		2		1								
– 0.05	98–107	**50**		1		2		4		2		1												
– 1.05	89– 97	55								1	1													
– 2.05	81– 88	37						1			1		1											
– 3.05	73– 80	29							3		1				1		1							
– 4.05	66– 72	23	1		1		2		3		3		2		1				2				2	
– 5.05	60– 65	22	3		1		5		8		5		4				2		1				2	
– 6.05	54– 59	18	5		5		7		9		17		10		10		4		4		2		11	
– 7.05	49– 53	8	5		13		18		13		24		**11**		5		7		7		3		24	
– 8.05	44– 48	7	32		**16**		**29**		**29**		**29**		14		18		**8**		**16**		11		**23**	
– 9.05	40– 43	2	**28**		11		23		22		26		9		**19**		11		11		**17**		16	
–10.05	36– 39	1	45		2		13		29		17		3		20		10		12		8		3	
–11.05	33– 35	1	12				2		3		2		2		5		1		4		1		1	
–12.05	30– 32		4				1		3						1								1	
–13.05	27– 29		1						1															
–14.05	24– 26																							
–15.05	22– 23																							
–16.05	20– 21																							
–17.05	18– 19																							
–18.05	16– 17								1															
Totals		441	136	79	49	65	100	109	124	90	126	93	56	47	80	20	44	19	57	34	42	32	83	54

TABLE 23 (continued)

Distribution of frequencies of factorial values. Low and high selection. Males. All matings.

CLASS VALUES IN FACTORIAL UNITS	CLASS RANGES IN FACET NUMBERS	FREQUENCIES																						
		P	32		33		34		35		36		37		38		39		40		41		42	
			L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Full eye											1													
+14.95	439–484																							
+13.95	397–438																							
+12.95	359–396							1																
+11.95	325–358																			1				1
+10.95	294–324	1				1		2		1														
+ 9.95	266–293					1		1																
+ 8.95	241–265	3		2		1		1		2		3		3				2		2		1		
+ 7.95	218–240	6		1		3		2				7		8		3		4		5		5		1
+ 6.95	197–217	15		3		6		11		8		13		8		8		10		17		8		1
+ 5.95	178–196	16		2		10		14		8		10		10		5		7		20		8		5
+ 4.95	161–177	26		9		8		16		14		13		7		3		10		21		5		1
+ 3.95	146–160	19		3		13		14		10		13		1		5		13		14		5		3
+ 2.95	132–145	34		6		7		8		7		9		2		3		8		20				4
+ 1.95	119–131	35				3		5		5		8				1		1		2				1
+ 0.95	108–118	33				2		9				2				1				2				
− 0.05	98–107	50	1			1		2				2												
− 1.05	89– 97	55	1							1														
− 2.05	81– 88	37										1												
− 3.05	73– 80	29	1						1															
− 4.05	66– 72	23	2						2								1							
− 5.05	60– 65	22	1		1				4				13		3		2							
− 6.05	54– 59	18	14		1				7		3		12		3		8		7		2		6	
− 7.05	49– 53	8	17		4		4		13		6		15		3		10		3		5		4	
− 8.05	44– 48	7	23		18		4		17		19		17		5		20		34		7		9	
− 9.05	40– 43	2	42		11		15		17		30		15		14		23		24		14		5	
−10.05	36– 39	1	12		13		10		10		27		5		2		12		9		17			
−11.05	33– 35	1	2		4		1				7						1				4			
−12.05	30– 32		1						1												1			
−13.05	27– 29				1																			
−14.05	24– 26																							
−15.05	22– 23																							
−16.05	20– 21															1								
−17.05	18– 19																							
−18.05	16– 17																							
Totals		441	117	26	53	56	34	86	72	56	93	81	77	39	30	30	77	55	77	104	50	32	24	17

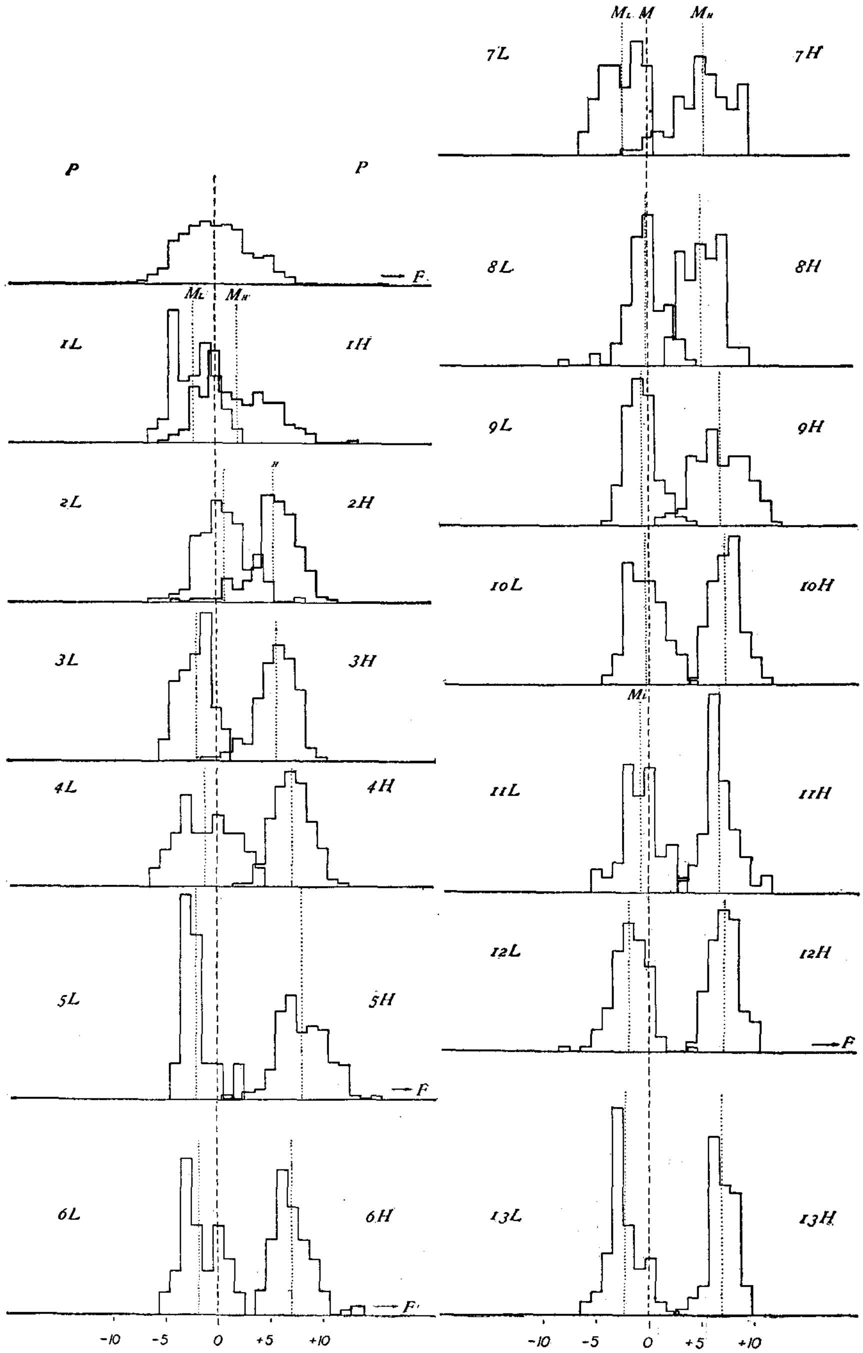
for low line (L) and high line (H) the numbers of offspring to be found within the limits of each class. The basis of reference is the mean value of the unselected population and the class corresponding to this value is inclosed in two horizontal lines. In each generation for both low and high lines the frequency of the class which includes the mean value for that generation is put in bold-faced type so that in a general way the effect of selection may be followed.

Because of the change in sexual dimorphism during the course of selection, a proper picture of the effect of selection can not be drawn from one sex alone. The high-line values of the females depart from the unselected population more widely than those of the low line, while the reverse is true of the males. Since all the offspring of each mating are included, it is possible by comparing the two tables to obtain the relative numbers of females and males. In the direct line where only a single brother or sister mating is involved, this ratio is of value in determining the presence of lethal mutant factors. A number of these are indicated by the data. Some are of the usual type with twice as many females as males. Others are of the type recently discovered by THOMPSON (1921) with twice as many males as females.

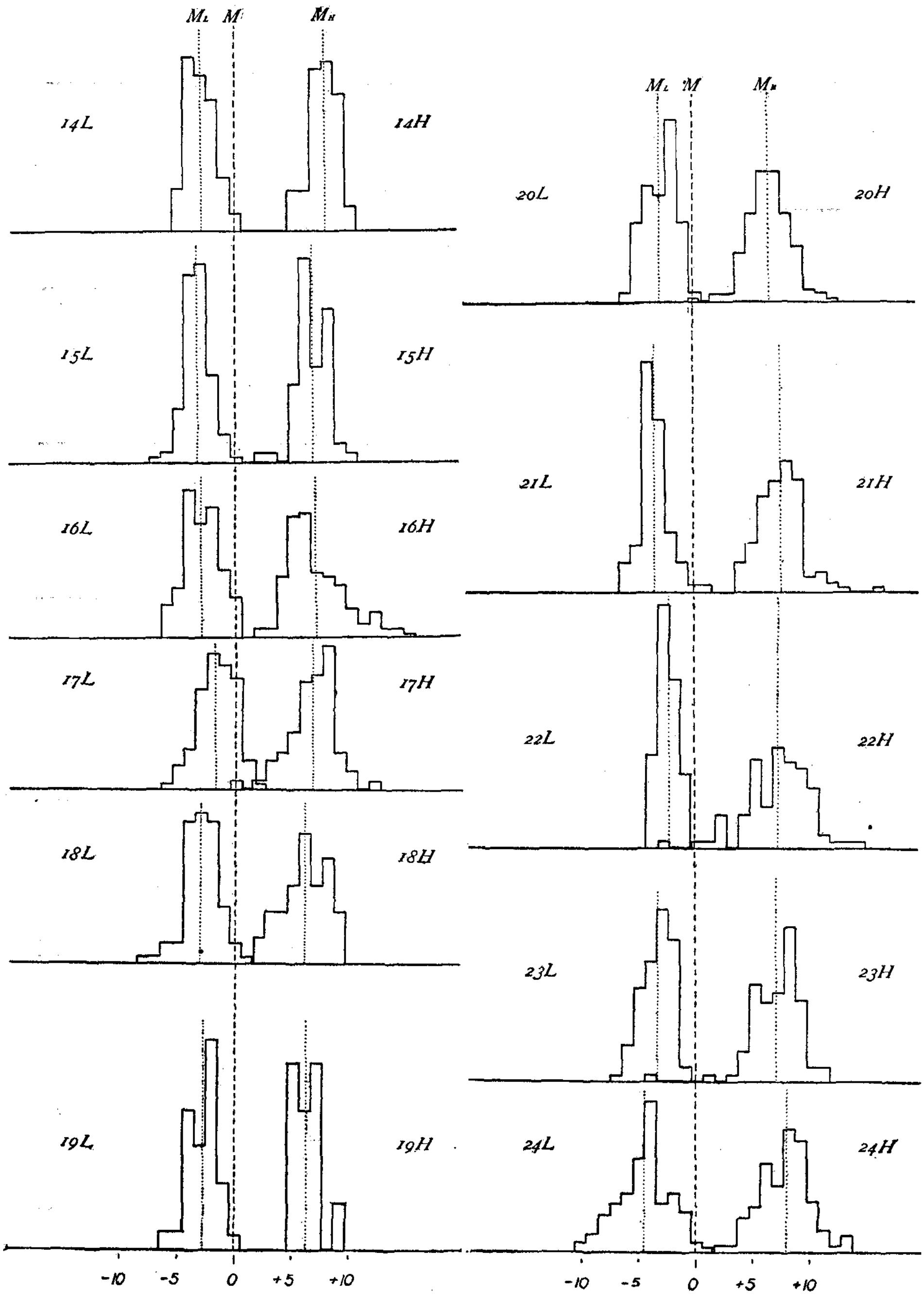
Distribution of frequencies for "all matings"

When all matings are included there is the advantage of the large numbers of individuals and the disadvantage of less uniformity. The data are given in table 22 for the females and table 23 for the males. The arrangement is the same as for the direct-line generations. The divergence of the high and low lines is clearly indicated, as is the general failure of the selection generations to extend their range beyond that of the original population.

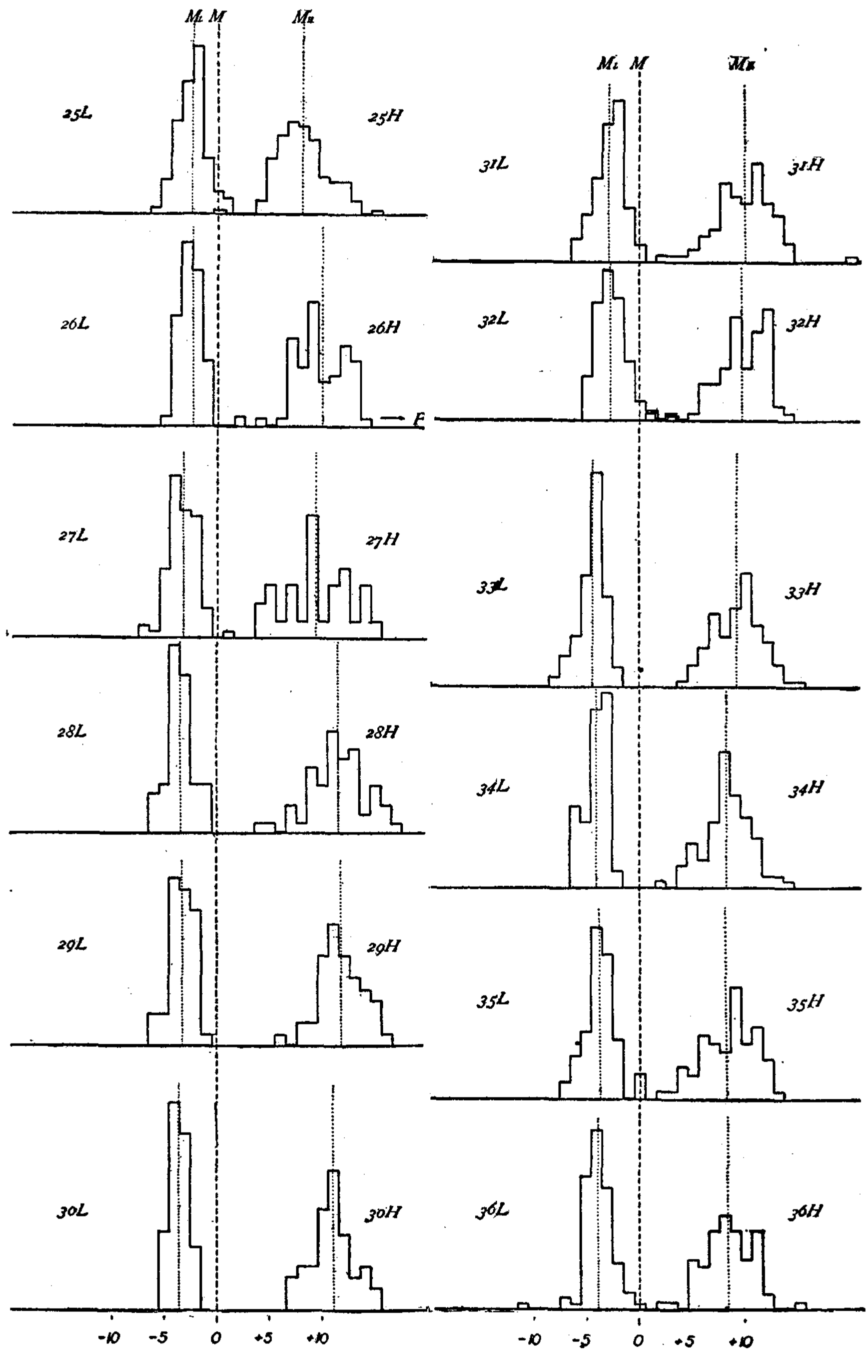
The data are given in graphic form in figures 12 to 54 for the females and figures 55 to 97 for the males. In each figure the horizontal scale represents the classes in terms of departure from the mean of the unselected population (M), the zero of the scale, which is indicated by the central dotted line. The mean of the low selection (M_L) is shown by the dotted line at the left, and the mean of the high selection (M_H) by the dotted line at the right. The distance between the two is the effectiveness of selection up to the given generation in terms of 10-percent factorial units. The vertical distances in the graphs represent the percentages of the individuals to be found in each class.



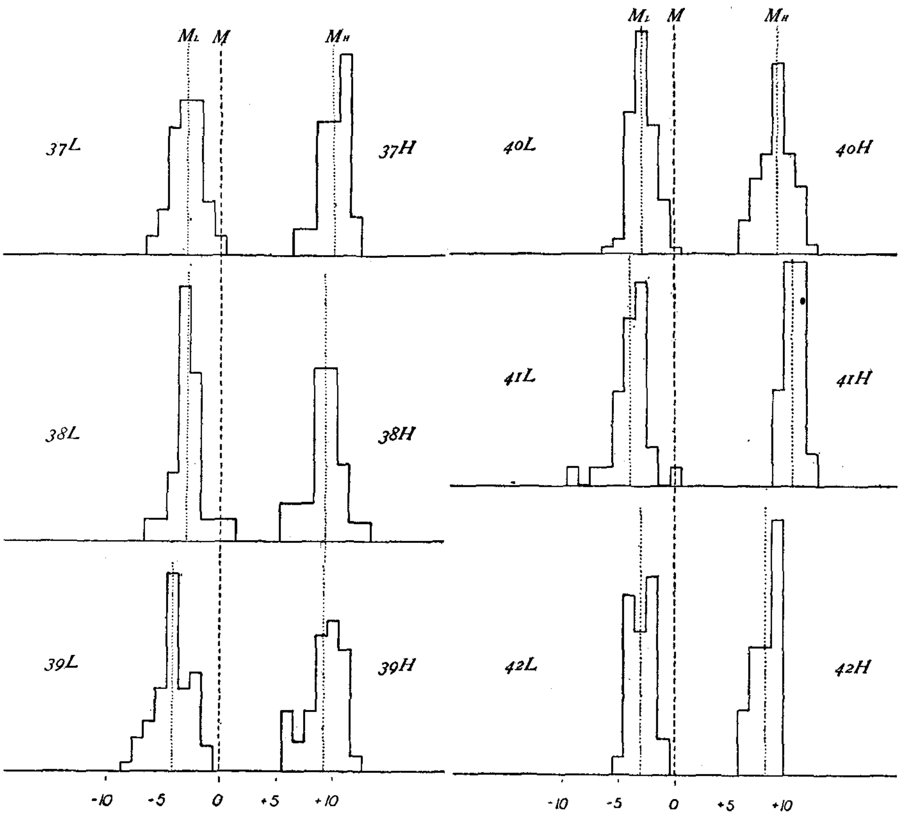
FIGURES 12–25.—Frequency distributions of factorial values in females of the parental unselected population and of selection generations 1 to 13. M, the central dotted line, is the mean of the parental unselected population. Of the other two dotted lines, the left-hand one is the mean of the low-selection line and the right-hand one the mean of the high-selection line. The scale of factorial values is given at the bottom of each row of figures and has the mean of the unselected population as its zero and departures are represented in factorial units, each unit representing a factor capable of producing a ten-percent change in facet value.



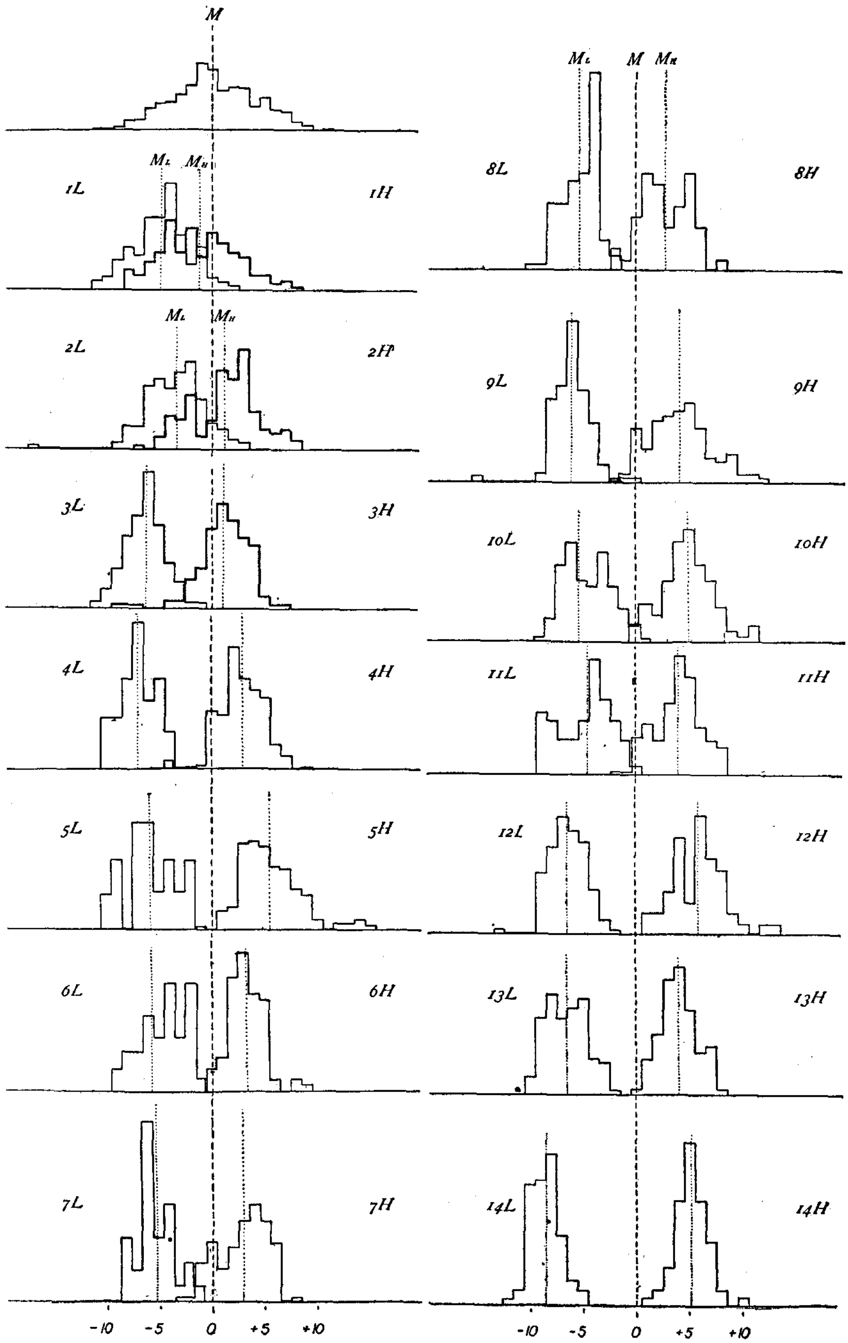
FIGURES 26–36.—Frequency distributions of factorial values in females of selection generations 14 to 24.



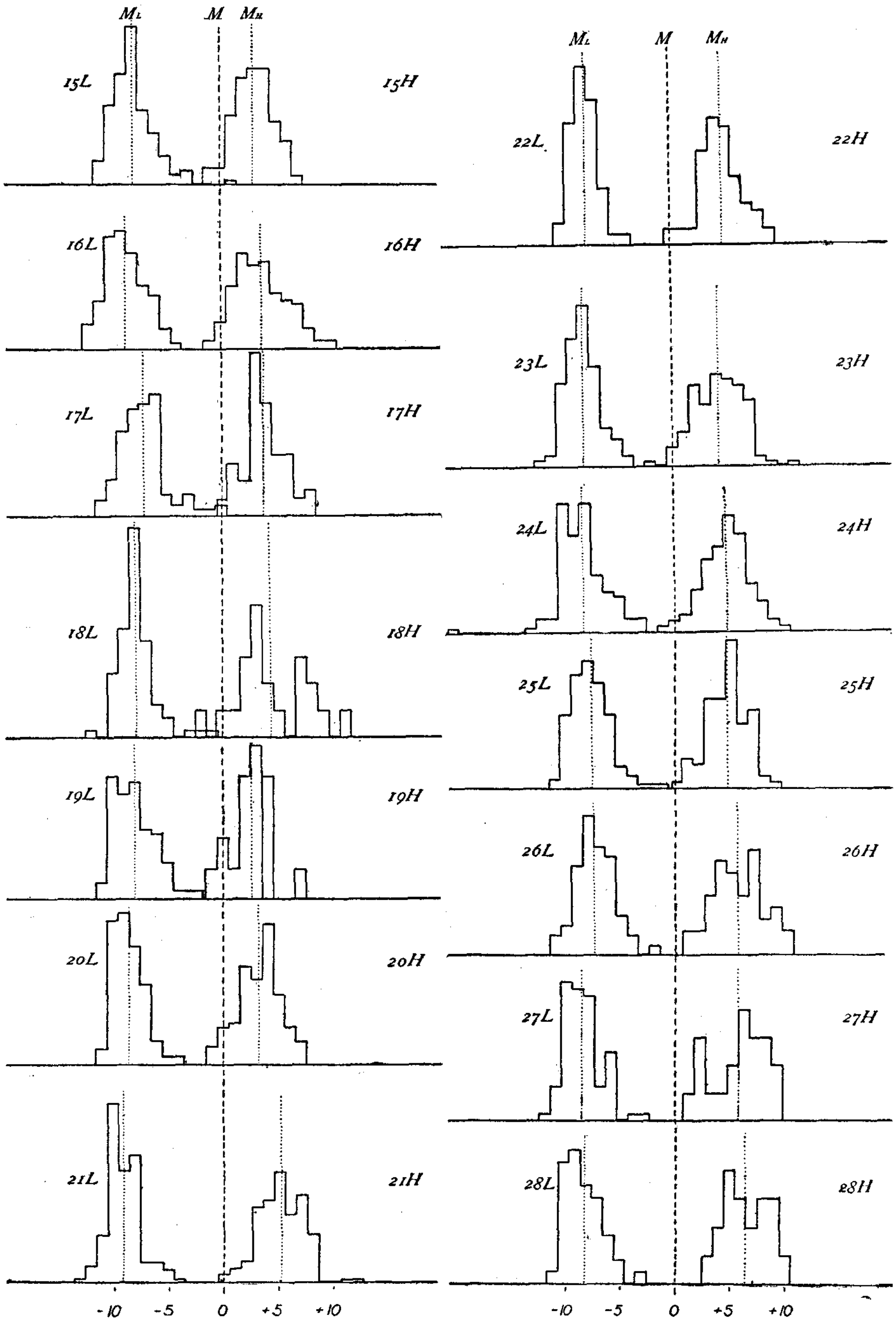
FIGURES 37–48.—Frequency distributions of factorial values in females of selection generations 25 to 36.



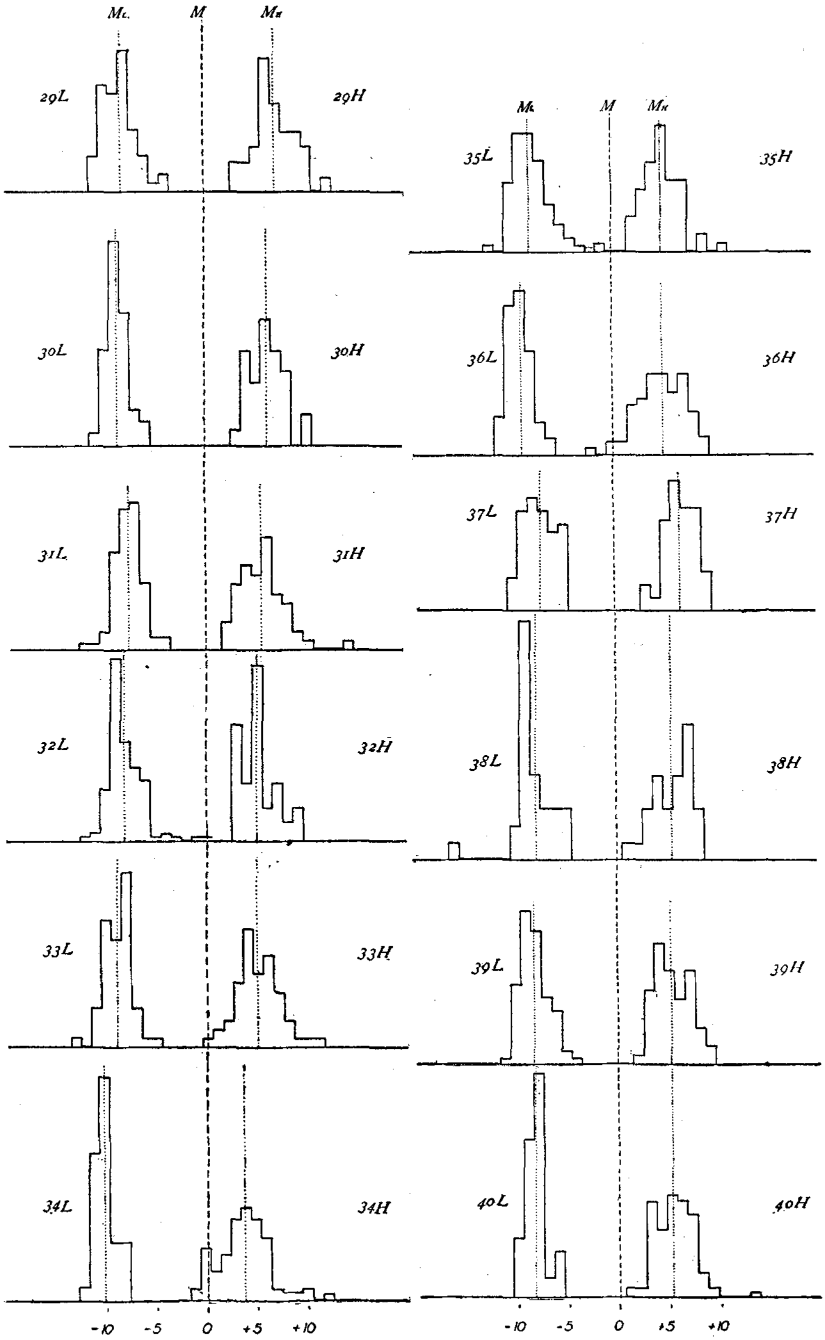
FIGURES 49–54.—Frequency distribution of factorial values in females of selection generations 37 to 42.



FIGURES 55–69.—Frequency distributions of factorial values in males of the parental unselected population and of selection generations 1 to 14.



FIGURES 70–83.—Frequency distributions of factorial values in males of selection generations 15 to 28.



FIGURES 84–95.—Frequency distributions of factorial values in males of selection generations 29 to 40.

In considering these graphs, it is again important to bear in mind the decrease in sexual dimorphism during the course of selection, which makes it appear that the high selection is more effective than the low in the females and the low more effective than the high in the males. The graphs show very clearly that there is no pronounced increase in total range as a result of selection, but that there is practically a complete separation in range of the high and low lines after the first few generations. Since they are constructed on the factorial basis, they are strictly comparable throughout. They also bring out in a striking manner the decrease in variability during the early generations of selection.

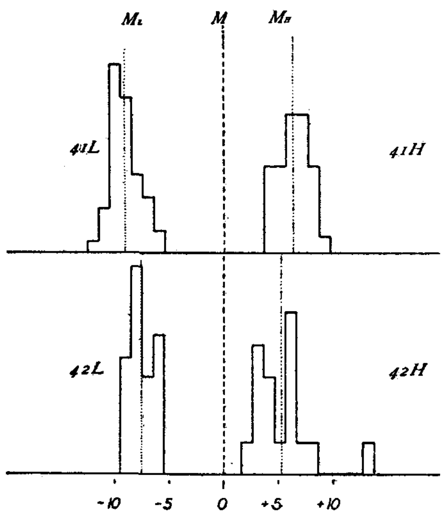


FIGURE 96–97.—Frequency distributions of factorial values in males of selection generations 41 and 42.

RESULTS

Range

That the effect of selection is due to the elimination of the high germinal groups in the low line without essential modification of the existing low groups and to the elimination of low germinal groups in the high line without essential modification of existing high groups is well illustrated by the ranges as given in tables 12 to 15 and figures 98, 100, 102 and 104 for the direct line, and tables 16 to 19 and figures 99, 101, 103 and 105 for "all matings." In the figures the vertical scale represents factorial values, the zero of the scale being the mean of the unselected population. The values of the highest and lowest individuals in the unselected population are represented on this scale under P. The continuous horizontal line (HV) extending from the upper value makes it available for reference throughout the selection generations, and one can determine directly the modification of the original upper extreme in each generation. The lower continuous horizontal line (LV) serves in the same way for the lower extreme. The upper zigzag line follows the values of the highest individual in each generation, HL in the low-selection line and HH in the high line. The lower zigzag line follows the values of the lowest individual, LL in the low-selection line and LH in the high line.

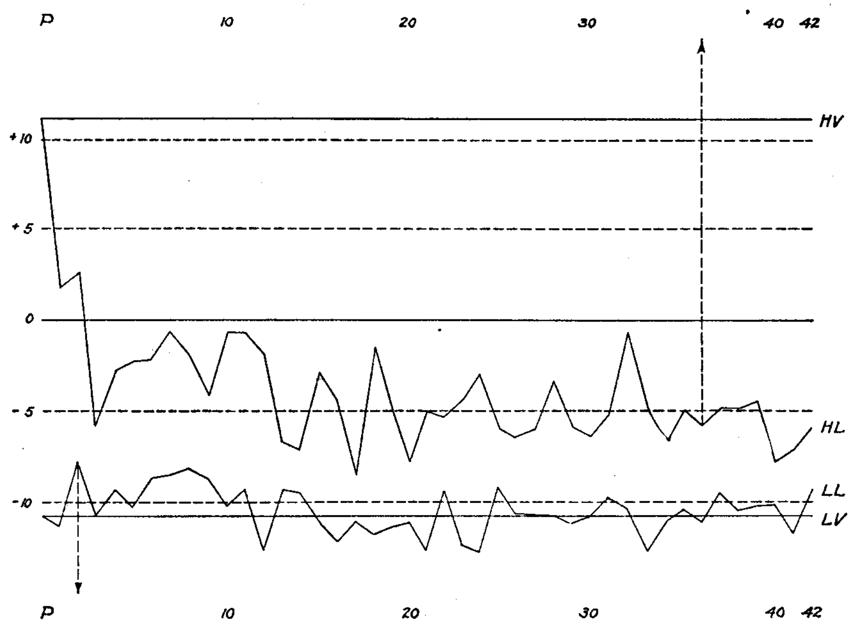


FIGURE 98.—Upper and lower limits of range in males of the direct low line. The vertical scale is in factorial units, the zero of the scale being the mean of the unselected population. The values of the highest and lowest individuals in the unselected population are represented on this scale under P. The continuous horizontal line (HV) extending from the upper value makes it available for reference throughout the selection generations, and one can determine directly the modification of the original upper extreme in each generation. The lower continuous horizontal line (LV) serves in the same way for the lower extreme. The upper zigzag line (HL) follows the values of the highest individual in each generation. The lower zigzag line (LL) follows the values of the lowest individual in the same way.

It is evident at a glance that the values of the lowest individuals of the unselected population have not been made still lower as a result of selection in the low line, nor have the values of the highest individuals with an exception to be mentioned later, been made still higher in the high line. The result of selection is accomplished by the elimination of the high individuals in the low line and of the low individuals in the high line.

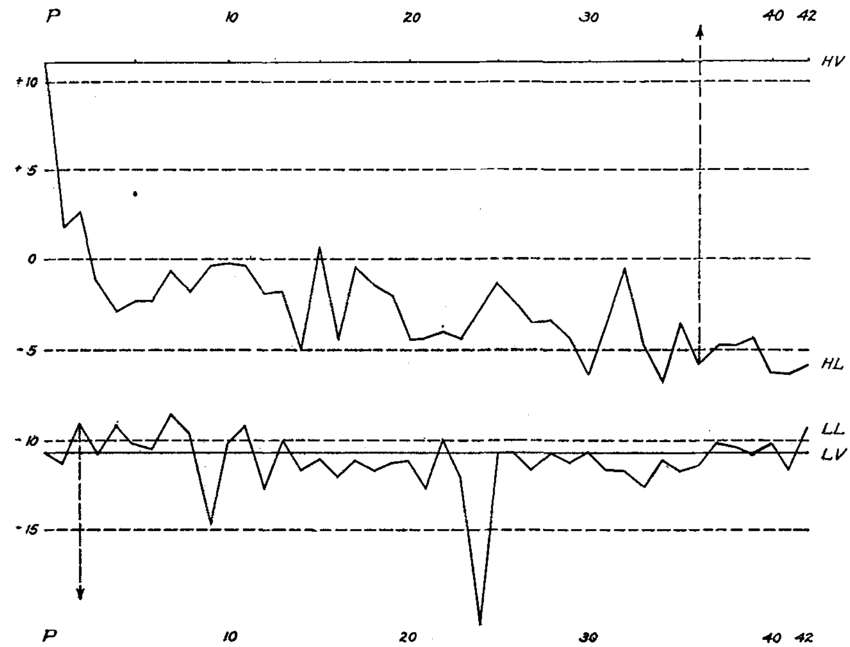


FIGURE 99.—Upper and lower limits of range in males of the low line including all matings.

In a study of the ranges it is necessary to bear in mind certain facts. First, the upward mutations to full eye and the downward ones to ultra-bar are purposely omitted in the figures except for the upwardly and downwardly directed dotted arrows which indicate their location. If they were included in the present discussion, obviously the effect of selection would be to bring bar very quickly up to full eye on the one hand and down to ultra-bar on the other. The transformation to full eye would have been accomplished in the first generation of upward selection and that to ultra-bar in the third generation of downward selection because a mutation to full appeared in the parental generation and one to ultra-bar in the second low selection. Some very low individuals which could not be tested because of early death or sterility may be

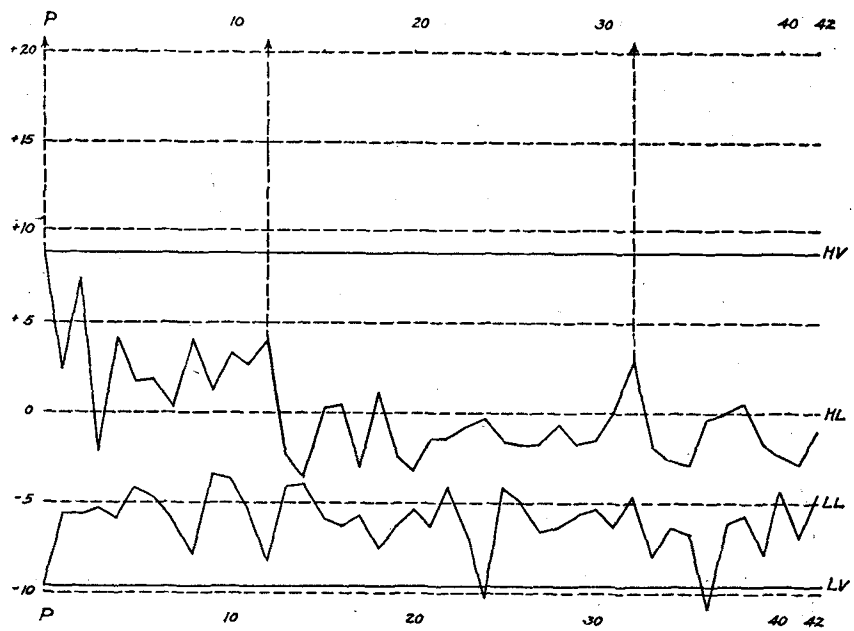


FIGURE 100.—Upper and lower limits of range in females of the direct low line.

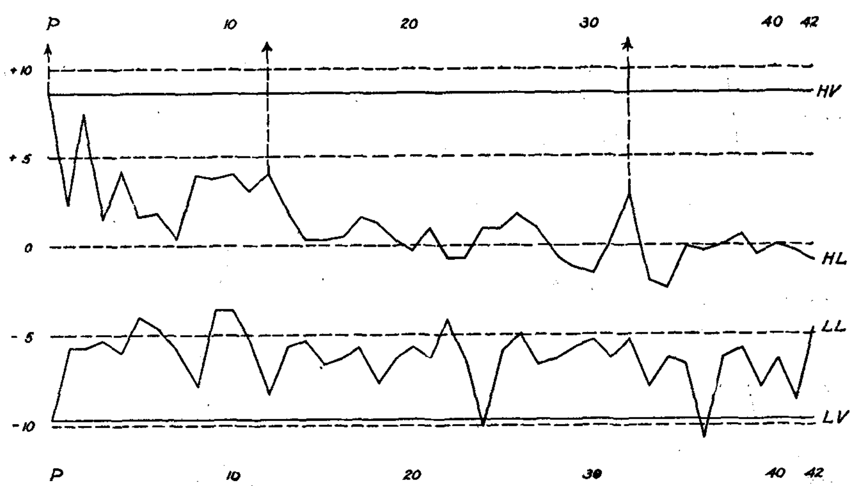


FIGURE 101.—Upper and lower limits of range in females of the low line including all matings.

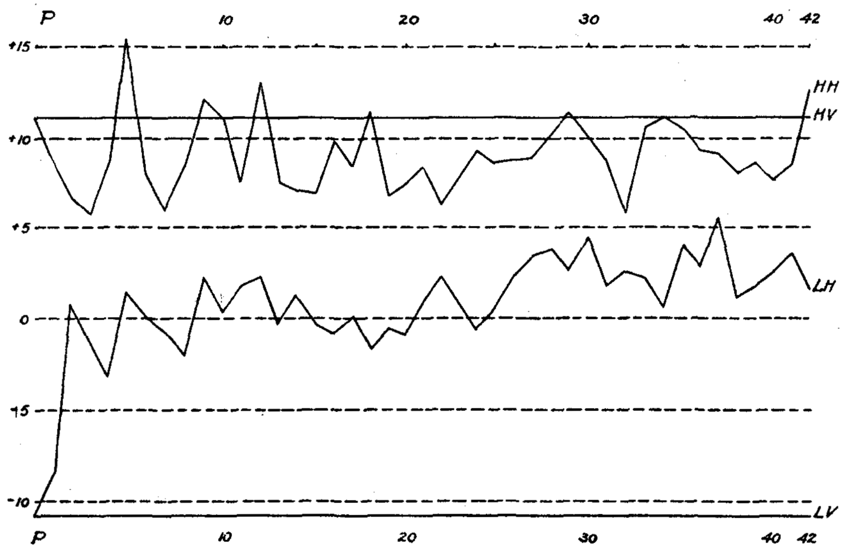


FIGURE 102.—Upper and lower limits of range in males of the direct high line. Arrangement as in figure 98 except that the values of the upper extremes are designated by HH and of the lower extremes by LH.

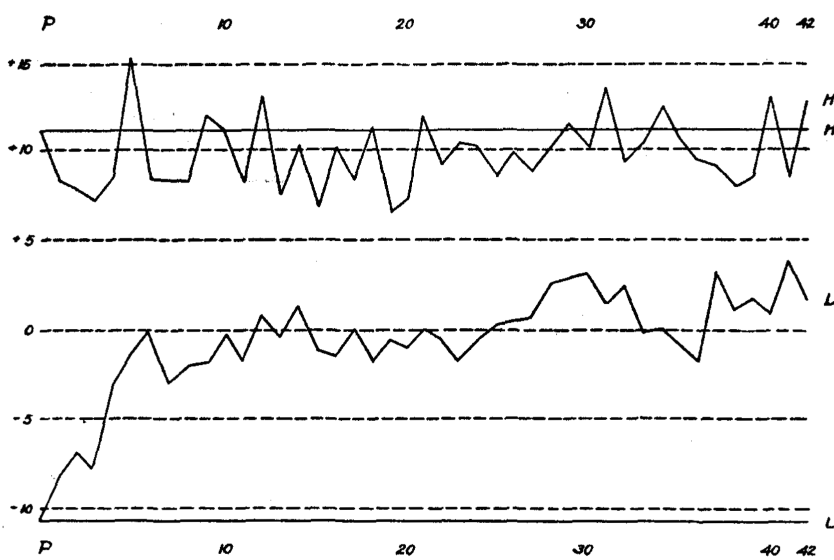


FIGURE 103.—Upper and lower limits of range in males of the high line including all matings.

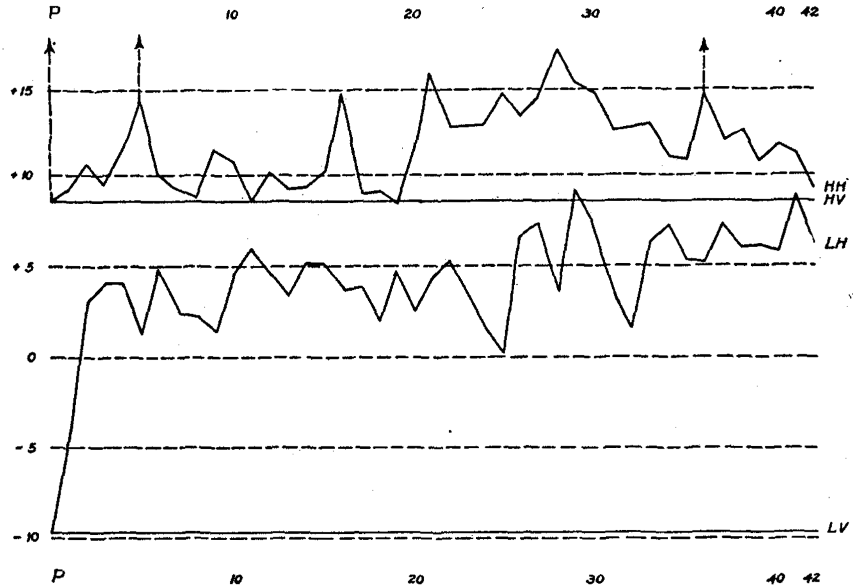


FIGURE 104.—Upper and lower limits of range in females of the direct high line.

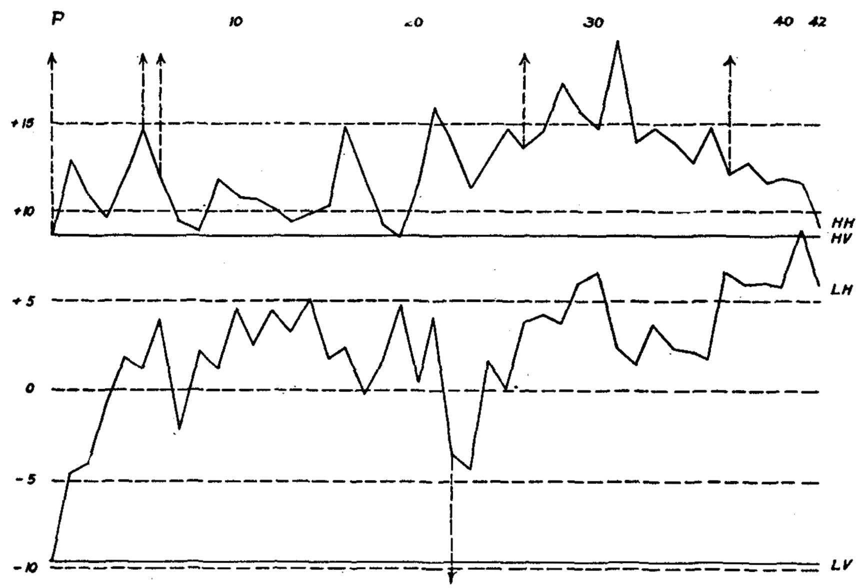


FIGURE 105.—Upper and lower limits of range in females of the high line including all matings.

ultra-bars, but in the absence of complete demonstration of their character they are included with the regular series of bars.

Second, the number of individuals in the parental generation is greater than in any one of the selection generations. Therefore the range of values should be less in individual generations of the latter than in the former. A part of the apparent restriction in range may be due to this cause. It is the probable explanation of the fact that the highest males in the high line are so frequently slightly lower than the highest male in the unselected population.

Third, as shown elsewhere (ZELENY 1921 b) the decrease in heterozygosis following selection with inbreeding increases the facet number of the females. This is not to be confused with the ordinary selection effect as the males are not involved. One of its results is to raise the level of all females and this is reflected in the figures of range by an exaggeration of the sorting effect in the females of the high line and an under-valuation of it in the low line. Likewise, it produces a false appearance of elimination of low extreme females in the low line and of extension of range upward in the high line.

Turning to a more detailed examination of the figures, it may be well to take up the males first because they do not show the change with decreased heterozygosis just described for the females. In the low direct line (figure 98) it is clear that neglecting the single mutation to ultra-bar in the second generation there has been no extension of the range downward. The lowest individuals (LL) in the selection generations follow very closely the lowest one in the unselected population which had a value of -10.72. The highest individuals (HL), however, drop very rapidly in value during the 1st and 3rd generations from $+11.11$ to -5.63, after which they fluctuate around the value of -8.00 until the 12th generation following which there is a further drop of about three units to a new level This last lowering of the high extreme is to be considered as a significant one, especially as it is reflected in a change in the mean and standard deviation. It is probable, therefore, that at this time selection has taken hold of one of the smaller germinal differences which had up to this time been masked by non-heritable fluctuations. The mutation to full eye in the 36th generation is neglected in this consideration.

If the sib-matings are included, the changes in the general features of the range are the same (figure 99). The lowest individuals again follow the general course of the lowest one of the unselected population, but there are two marked projections downward which represent two very low individuals. These are probably ultra-bar mutants like that in the 2nd generation but which died without leaving offspring and therefore can not be certainly listed as ultra-bar. At the upper limit the lowering of range between the 12th and 14th generations may again be made out but its location is not as clear here as in the direct line.

In females of the low direct line (figure 100) the lower limit of the range jumps up from -9.68 to -5.60 during the first generation and then fluctuates around the latter value. The two downward extensions, one in the 24th and one in the 36th generation, come within the range of ultra-bar heterozygotes, but are not listed as ultra-bar as they left no offspring during the test. The upward jump in the first generation is due to the decrease in heterozygosis as previously explained and does not represent a true restriction of range except for that part of it which is due to the fact that the number of individuals in the selected generations is smaller than in the unselected parental population. That the decrease in heterozygosis and the resulting increase in female facet values is the principal element in the result is indicated by the fact that at the upper limit of the range in the high-selection line there is an extension rather than a restriction. The females therefore confirm the conclusion drawn from the male data that there is no change in the lower limit of range as a result of downward selection.

The upper limit in the females of the low direct line drops during the first generation from $+8.75$ to $+2.36$ and with considerable irregularity maintains the latter level for the first twelve generations. There is then a sudden drop to a level about four units lower than this. The fluctuation is now around a value of -1.50 until the end of the selection. The drop in this case is pronounced and, as already stated, undoubtedly represents a further step in the elimination of the factors for high facet number.

The less pronounced early drop in the upper limit in the females as compared with the males, is to be explained, as previously stated, by the rise in value of the females as a result of decrease in heterozygosis and does not indicate any difference between males and females in the essential sorting mechanism of selection.

When the sib-matings are included in the tabulation (figure 101) the range is extended somewhat because of the larger number of individuals, but all the features of the curve of range as described for the direct line can be made out.

In the high line the same principles apply as in the low line, but in the reverse direction as far as selection is concerned. In the males of the high direct line (figure 102), there is no upward extension of the original limit of +11.11 but rather a slight restriction which is probably the result of the smaller numbers of individuals in the single selection generations. As is to be expected on this view, individuals in some of the generations rise above the original value. At the lower limit the situation is quite different. The value rises from −10.72 to +0.77 in two generations and then fluctuates around zero until the 24th generation, when it goes up to a new level about three units above zero. In a very striking manner it is shown that there is an early elimination of factors for low facet numbers, followed by a considerable period of no progress and then by a small upward shift of about three units after the 24th generation, when apparently the masking effect of non-heritable fluctuations upon a small germinal factor was penetrated by selection.

Including the sib-matings (figure 103) the same general features can be made out for the range as in the direct line. High selection does not extend the range upward. Its whole effect is upon the lower limit.

The females of the high direct line (figure 104) during the first twenty selection generations have an upper limit of range slightly higher than that of the parental generation because of the rise in the value of all females due to the decrease in heterozygosis. Since a similar rise occurs in the low-selection lines, it can not be attributed to the upward selection. After the 20th generation there is a further rise which may be explained as due to the appearance of a sex-linked lethal factor affecting facet number in the viable heterozygous females. Such a lethal factor kills all males possessing it and all females with a double dose. Its existence is demonstrated by the fact that in the direct-line generations consisting of brother-and-sister matings there is a ratio of approximately two females to one male in generations 21 to 28. Since approximately half of the females in each generation have the new factor, it follows that the range is extended upward in the females but not in the males. After a few generations the lethal is lost because the females necessarily remain heterozygous for it and with the considerable non-heritable fluctuations in facet number, it follows that even with high selection sooner or later a female without the new factor is chosen and the factor is lost. The range then drops back to the level it had before the 20th generation.

At the lower limit the value rises from −9.68 to +3.01 in two generations and remains at the higher level until the 26th generation, when it reaches a new level at +6.00. This second rise corresponds to that in the males and represents a further sorting effect of the selection as already mentioned.

Including the sib-matings (figure 105) the higher limit shows the same features as in the direct line except for a slight extension of the range due to the greater number of individuals. At the lower limit the rapidity of the early elimination of the low individuals is not as great as in the direct line. At the new level the fluctuations are greater and the further rise to a higher level at the 26th generation is not as clear as in the direct line.

The data on range taken as a whole demonstrate in a striking manner the fact that the early pronounced effect of selection is not due to an extension of the range but to the elimination in the low line of those germinal factors that produce high facet number and in the high line of those that produce low facet numbers. This effect is rapidly accomplished and then the ranges remain fairly uniform except for one small shift in the low line and two in the high line. In the low line there is a further restriction of the upper limit after the 12th generation which is due to the capture in the selection net of a minor germinal factor for high facet number which had up to this time escaped because of the protection of non-heritable fluctuations. In the high line the extension of the range in the females after the 20th generation is probably due to the appearance of a sex-linked lethal mutation of small degree which took place in the direction of selection and was preserved, therefore, for a few generations. In the 25th generation the restriction of the lower limit of range is due to the elimination of one of the original germinal differences which up to this time had escaped the selection net.

Mean

The values in the direct line with their probable errors are given in tables 12 to 15. All of them without the probable errors are collected in table 24 which gives as well the differences between the high and low lines for each sex and also the average differences between the two lines. It may be well to recall that the low- and high-line values as given represent directly the departures in ten-percent factorial units from the mean of the unselected population which, it will be recalled, is used as the zero point or point of reference. The table includes the mean value in each generation of the female offspring for both high and low lines and the difference between the two. Then follow the same values for the males, and finally, in the last column, the average of the two differences for each generation, or the amount of divergence of high and low lines. This last value is the best expression for the effectiveness of the past selection at any point.

The values for the means including all matings are given in tables 16 to 19. The means for all matings in each generation are collected without their probable errors in table 25. The arrangement of the data is the same as that for the direct lines.

A comparison of the direct-line values with those of all matings can be made in 40 of the generations. In 31 of these the direct line has the greater average difference between high and low, while the averages of all matings are ahead in only 9. This may signify one or both of the two probabilities (1) that there is a germinal difference between the two groups, and (2) that the introduction of the element of selection on the basis of performance as mentioned on page 8 gives a false appearance of greater effectiveness of selection in the direct line. That the second is true is evident from the fact that during the generations during which selection has no effect, the direct line has the same preponderance over "all matings" that it does during the early generations when selection is obviously effective.

In the more detailed discussion of the means, it will be convenient to consider: first, the total divergence between the high and low lines; second, the contribution of each line to the total divergence; and third, the female and male means in each line.

Total divergence

The difference between the high and low line in each generation is given in table 24 and figure 106 for direct-line matings and in table 25 and figure 107 for all matings. There is a pronounced increase in divergence during the first five generations, amounting to +11.49 in the direct line and to +10.69 if the sib-matings are included. This period is followed by one with considerable fluctuation but no essential advance to the 25th generation, when there is a value of +12.18 in the direct line and +11.42 in "all matings." From the 25th to the 29th generations there is a distinct upward trend to +16.53 in the direct line and +15.14 in "all matings." After the 29th generation there is no further advance but even a slight regression though the level remains somewhat higher than it was before the 25th generation. Evidently the sorting out of major differences was completed within the first five generations

TABLE 24

Differences between the means of the high and the low lines in each generation. Direct lines.

GENERATION	FEMALES			MALES			AVERAGE DIFFERENCE
	High	Low	Difference	High	Low	Difference	
1	+ 3.03	−2.07	+ 5.10	−0.35	−4.85	+ 4.50	+ 4.80
2	+ 7.09	+1.29	+ 5.80	+3.33	−2.58	+ 5.91	+ 5.85
3	+ 6.87	−3.13	+10.00	+2.29	−8.30	+10.59	+10.29
4	+ 8.22	−1.03	+ 9.25	+3.71	−6.03	+ 9.74	+ 9.49
5	+ 8.22	−1.93	+10.15	+6.99	−5.85	+12.84	+11.49
6	+ 7.22	−1.63	+ 8.85	+3.23	−5.14	+ 8.37	+ 8.61
7	+ 6.30	−2.38	+ 8.68	+4.00	−5.24	+ 9.24	+ 8.96
8	+ 4.99	+0.08	+ 4.91	+3.04	−5.12	+ 8.16	+ 6.53
9	+ 7.84	−0.77	+ 8.61	+6.46	−6.20	+12.66	+10.64
10	+ 7.39	−0.83	+ 8.22	+5.44	−6.47	+11.91	+10.06
11	+ 7.28	−1.08	+ 8.36	+4.54	−5.03	+ 9.57	+ 8.96
12	+ 7.27	−1.98	+ 9.25	+6.43	−6.61	+13.04	+11.14
13	+ 6.81	−3.13	+ 9.94	+3.89	−8.05	+11.94	+10.94
14	+ 7.26	−3.93	+11.19	+4.16	−8.38	+12.54	+11.86
15	+ 6.86	−3.09	+ 9.95	+3.15	−7.95	+11.10	+10.52
16	+ 8.17	−2.76	+10.93	+4.21	−8.67	+12.88	+11.90
17	+ 6.65	−4.31	+10.96	+3.86	−9.30	+13.16	+12.06
18	+ 6.07	−3.20	+ 9.27	+4.24	−7.81	+12.05	+10.66
19	+ 6.32	−4.11	+10.43	+2.51	−9.45	+11.96	+11.19
20	+ 6.72	−4.04	+10.76	+3.05	−9.61	+12.66	+11.71
21	+ 7.47	−3.62	+11.09	+4.93	−9.15	+14.08	+12.58
22	+ 8.78	−2.72	+11.50	+3.45	−7.76	+11.21	+11.35
23		−3.55			−8.29		
24	+ 8.07	−4.87	+12.94	+3.82	−7.82	+11.64	+12.29
25	+ 8.89	−2.73	+11.62	+4.95	−7.80	+12.75	+12.18
26	+10.99	−3.06	+14.05	+5.44	−8.57	+14.01	+14.03
27	+11.02	−3.70	+14.72	+7.09	−8.68	+15.77	+15.24
28	+11.65	−3.59	+15.24	+6.77	−8.36	+15.13	+15.18
29	+12.37	−3.81	+16.18	+7.71	−9.18	+16.89	+16.53
30	+11.45	−3.69	+15.14	+6.73	−8.77	+15.50	+15.32
31	+ 9.43	−2.36	+11.79	+5.60	−7.41	+13.01	+12.40
32	+ 9.04	−1.89	+10.93	+4.38	−7.00	+11.38	+11.15
33	+ 9.72	−4.56	+14.28	+5.69	−8.71	+14.40	+14.34
34	+ 9.15	−4.01	+13.16	+5.70	−9.10	+14.80	+13.98
35	+ 9.21	−4.31	+13.52	+7.20	−7.68	+14.88	+14.20
36	+ 9.17	−3.57	+12.74	+6.27	−8.76	+15.03	+13.88
37	+10.74	−2.71	+13.45	+6.75	−6.73	+13.48	+13.46
38	+ 9.48	−2.64	+12.12	+5.15	−8.05	+13.20	+12.66
39	+ 8.77	−4.40	+13.17	+4.73	−7.99	+12.72	+12.94
40	+ 9.36	−3.36	+12.72	+5.44	−9.22	+14.66	+13.69
41	+10.28	−4.14	+14.42	+6.09	−9.31	+15.40	+14.91
42	+ 8.07	−2.84	+10.91	+5.19	−7.59	+12.78	+11.84

TABLE 25

Differences between the means of the high and the low lines in each generation. All matings.

GENERATION	FEMALES			MALES			AVERAGE DIFFERENCE
	High	Low	Difference	High	Low	Difference	
1	+ 2.04	−2.07	+ 4.11	−1.32	−4.85	+ 3.53	+ 3.82
2	+ 5.53	+0.73	+ 4.80	+1.19	−3.44	+ 4.63	+ 4.71
3	+ 5.76	−1.86	+ 7.62	+1.09	−6.35	+ 7.44	+ 7.53
4	+ 7.19	−1.03	+ 8.22	+2.79	−6.03	+ 8.82	+ 8.52
5	+ 8.13	−1.93	+10.06	+5.48	−5.85	+11.33	+10.69
6	+ 6.92	−1.61	+ 8.53	+3.24	−5.67	+ 8.91	+ 8.72
7	+ 5.34	−2.38	+ 7.72	+2.92	−5.24	+ 8.16	+ 7.94
8	+ 4.91	−0.19	+ 5.10	+2.66	−5.47	+ 8.13	+ 6.61
9	+ 6.79	−0.64	+ 7.43	+4.02	−6.08	+10.10	+ 8.76
10	+ 7.29	−0.30	+ 7.59	+4.81	−5.44	+10.25	+ 8.92
11	+ 6.63	−0.72	+ 7.35	+3.80	−4.85	+ 8.65	+ 8.00
12	+ 7.15	−1.82	+ 8.97	+5.77	−6.56	+12.33	+10.65
13	+ 6.81	−2.38	+ 9.19	+3.89	−6.62	+10.51	+ 9.85
14	+ 7.76	−2.86	+10.62	+5.06	−8.55	+13.61	+12.11
15	+ 6.69	−3.26	+ 9.95	+3.01	−7.96	+10.97	+10.46
16	+ 6.97	−2.86	+ 9.83	+3.65	−8.67	+12.32	+11.07
17	+ 6.65	−1.61	+ 8.26	+3.72	−7.12	+10.84	+ 9.55
18	+ 6.07	−2.87	+ 8.94	+4.24	−7.92	+12.16	+10.55
19	+ 6.32	−2.67	+ 8.99	+2.51	−7.98	+10.49	+ 9.74
20	+ 6.62	−2.81	+ 9.43	+3.16	−8.60	+11.76	+10.59
21	+ 7.60	−3.34	+10.94	+5.18	−9.13	+14.31	+12.62
22	+ 7.00	−2.54	+ 9.54	+4.60	−7.74	+12.34	+10.94
23	+ 6.91	−3.39	+10.30	+4.12	−8.09	+12.21	+11.25
24	+ 7.80	−4.45	+12.25	+4.65	−8.34	+12.99	+12.62
25	+ 8.01	−2.47	+10.48	+4.60	−7.76	+12.36	+11.42
26	+ 9.81	−2.55	+12.36	+5.50	−7.41	+12.91	+12.63
27	+ 9.47	−3.23	+12.70	+5.50	−8.60	+14.10	+13.40
28	+11.53	−3.41	+14.94	+6.48	−8.23	+14.71	+14.82
29	+11.76	−3.24	+15.00	+6.86	−8.42	+15.28	+15.14
30	+10.91	−3.51	+14.42	+6.11	−8.74	+14.85	+14.63
31	+ 9.82	−2.79	+12.61	+5.49	−7.68	+13.17	+12.89
32	+ 9.62	−2.62	+12.24	+5.10	−8.05	+13.15	+12.69
33	+ 9.24	−4.33	+13.57	+4.90	−8.90	+13.80	+13.68
34	+ 8.33	−3.93	+12.26	+4.72	−9.05	+13.77	+13.01
35	+ 8.27	−3.62	+11.89	+4.83	−7.90	+12.73	+12.31
36	+ 8.35	−3.80	+12.15	+4.81	−9.06	+13.87	+13.01
37	+10.09	−2.85	+12.94	+6.41	−7.36	+13.77	+13.35
38	+ 9.47	−2.64	+12.11	+5.36	−8.05	+13.41	+12.76
39	+ 9.31	−3.86	+13.17	+5.22	−8.23	+13.45	+13.31
40	+ 8.91	−2.81	+11.72	+5.11	−8.37	+13.48	+12.60
41	+10.40	−3.80	+14.20	+6.14	−9.15	+15.29	+14.74
42	+ 8.07	−2.84	+10.91	+5.19	−7.59	+12.78	+11.84

or earlier. The later effect as shown elsewhere is due either to the elimination of smaller germinal differences which had previously been masked by non-heritable factors or to the appearance of new mutations of small degree.

The contributions of low and high lines to the total divergence

These are shown in figures 108 and 109 and in the fourth columns of tables 26 to 29 where the female and male means are combined. It will be noticed that in the low line the initial period of pronounced sorting

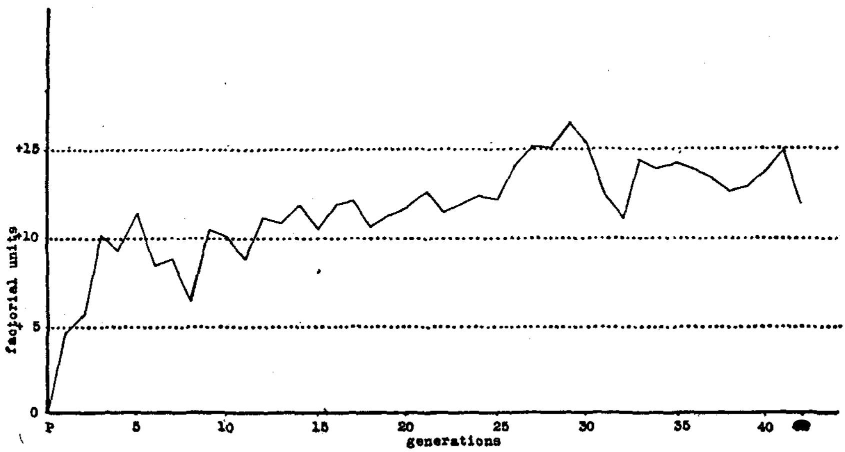


FIGURE 106.—Total divergences between the means of the high and low direct lines for each generation represented as distances above a base line. The scale at the left is in factorial units. Each unit of vertical distance represents a factorial value capable of producing a ten-percent change in facet number.

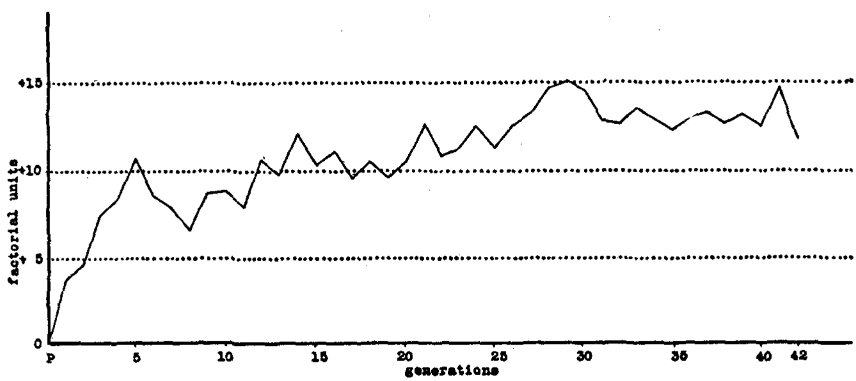


FIGURE 107.—Total divergences between the means of the high and low lines including all matings for each generation. Arrangement as in figure 106.

effect is completed by the first selection in which the value decreases to −3.46. From that time until the 11th generation, when the value is −3.05 in the direct line and −2.78 in "all matings," there is no further decrease. From the 11th to the 14th generations there is a rapid decrease to a new level, the value at the 14th generation being −6.15 in the direct line and −5.70 in "all matings." After the 14th generation there is no further effect of selection, the values fluctuating around −6.00.

In the high line the initial period of effectiveness is completed at the fifth generation when the mean has reached a value of +7.60 in the direct line and +6.80 in "all matings." From that time there is no further increase until the 20th generation has been passed, when the values increase until the 28th generation. Following the 28th there is a decline, but the level remains somewhat higher than it was before the 20th generation. The rise between the 20th and 28th generations is due to the appearance of a sex-linked lethal factor, the following drop to the elimination of the lethal and the retention of a somewhat higher level to the elimination of a germinal factor for low facet number which took place following the 25th generation.

Returning to the divergence between the two lines, it is clear that the general upward trend from the 8th to the 29th generations shown in figures 106 and 107 is due on the one hand to the elimination of a high factor in the low line between the 12th and 14th generations, and to the two processes described above as taking place in the high line between the 20th and 29th generations. In fact a close examination of the upward trend between the 8th and 29th generations shows that between the 14th generation, when the first-mentioned elimination takes place, and the 20th, when the lethal factor appears, there is actually no increase in divergence.

The female and male means

The female and male means are considered separately in figures 110 and 111 for the direct line and figures 112 and 113 for "all matings." These figures show in a very striking manner the great decrease in sexual dimorphism during the course of selection. The males show a much lower value comparatively than the females in both high and low lines. This gives the impression that selection in the high line is much more effective in its action upon the females than upon the males, and that the reverse is true for the low line where the effectiveness seems to be largely confined to the males. This appearance obviously is due to the

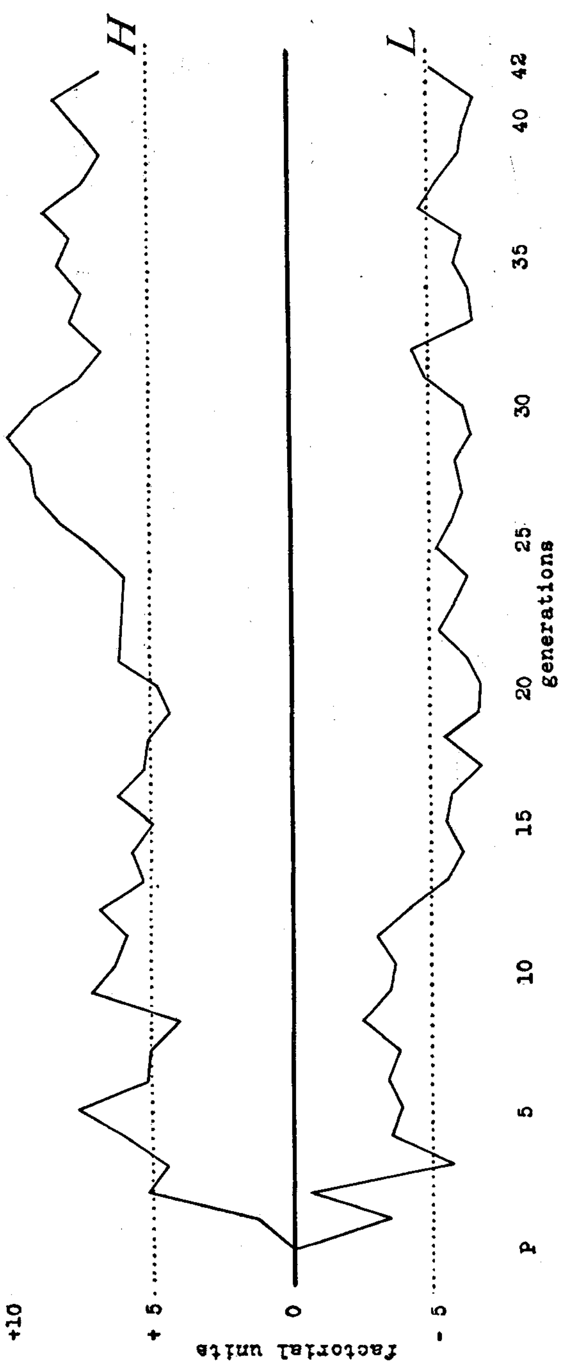


FIGURE 108.—The means of the high direct line (H) and low direct line (L) compared with the mean of the unselected population (zero) for each selection generation. The female and male values are averaged in each case. The present figure gives the contribution of each of the two lines to the total divergence. The vertical distance between the upper zigzag line and the lower zigzag line in each generation gives the corresponding total divergence of figure 106.

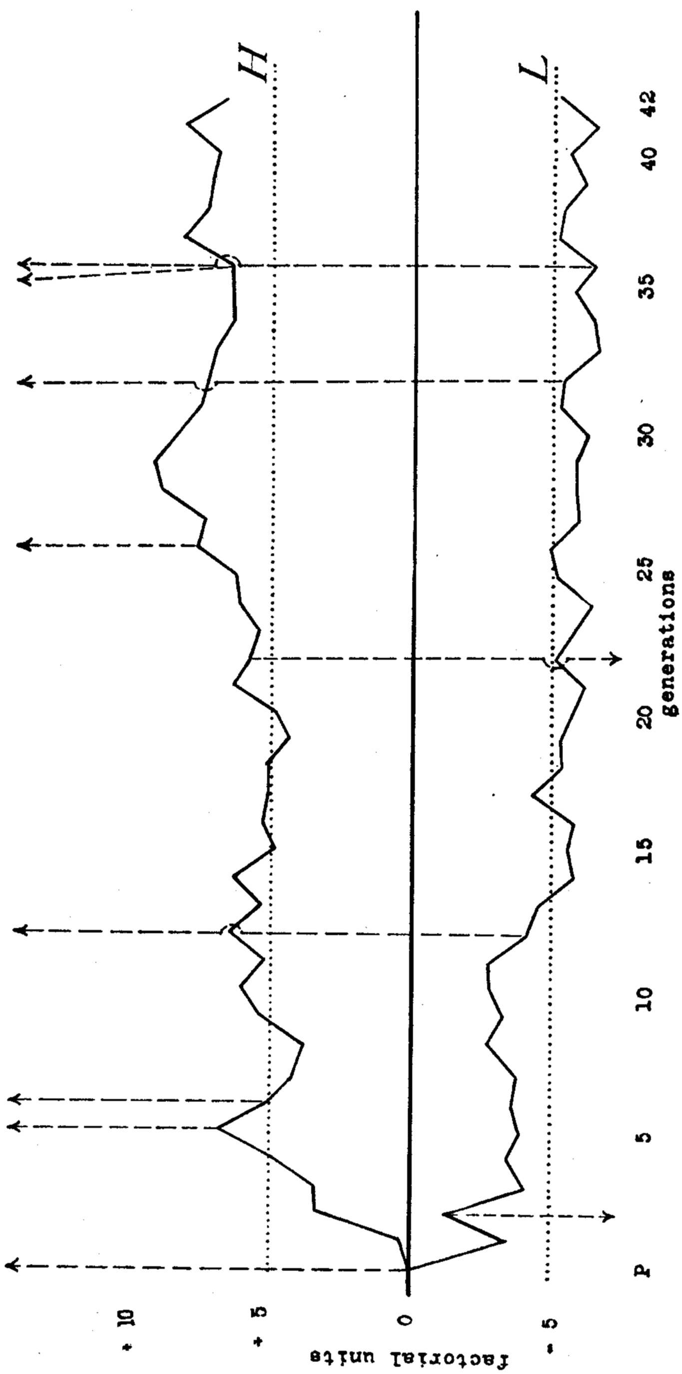


FIGURE 109.—The means of the high line including all matings (H) and low line including all matings (L) compared with the mean of the unselected population (zero) for each selection generation. Arrangement as in figure 108. The vertical distance between H and L in each generation gives the corresponding total divergence of figure 107.

TABLE 26

Degree of selection, difference between parents and offspring, and effectiveness of selection for each generation. Low line. Direct. Values in ten-percent factorial units.

GENERATION	WEIGHTED AVERAGE OF SELECTED PAIRS S	AVERAGE OF ♀ AND ♂ MEANS PARENTAL GENERATION P	AVERAGE OF ♀ AND ♂ MEANS OFFSPRING O	DEGREE OF SELECTION S−P	DIFFERENCE BETWEEN PARENTS AND OFFSPRING O−	EFFECTIVENESS OF SELECTION O−P
1	−5.41	0.00	−3.46	−5.41	+1.95	−3.46
2	−8.15	−3.46	−0.64	−4.69	+7.51	+2.82
3	−4.99	−0.64	−5.71	−4.35	−0.72	−5.07
4	−7.46	−5.71	−3.53	−1.75	+3.93	+2.18
5	−3.53	−3.53	−3.89	0.00	−0.36	−0.36
6	−4.80	−3.89	−3.38	−0.91	+1.42	+0.51
7	−6.36	−3.38	−3.81	−2.98	+3.38	−0.43
8	−6.59	−3.81	−2.52	−2.78	+4.07	+1.29
9	−3.45	−2.52	−3.48	−0.93	−0.03	−0.96
10	−2.96	−3.48	−3.65	+0.52	−0.69	−0.17
11	−6.36	−3.65	−3.05	−2.71	+3.31	+0.60
12	−6.48	−3.05	−4.29	−3.43	+2.19	−1.24
13	−7.21	−4.29	−5.59	−2.92	+1.62	−1.30
14	−6.61	−5.59	−6.15	−1.02	+0.46	−0.56
15	−6.61	−6.15	−5.52	−0.46	+1.09	+0.63
16	−8.16	−5.52	−5.71	−2.64	+2.45	−0.19
17	−9.15	−5.71	−6.80	−3.44	+2.35	−1.09
18	−7.13	−6.80	−5.50	−0.33	+1.63	+1.30
19	−6.00	−5.50	−6.78	−0.50	−0.78	−1.28
20	−8.82	−6.78	−6.82	−2.04	+2.00	−0.04
21	−6.48	−6.82	−6.38	+0.34	+0.10	+0.44
22	−6.96	−6.38	−5.24	−0.58	+1.72	+1.14
23	−6.23	−5.24	−5.92	−0.99	+0.31	−0.68
24	−8.34	−5.92	−6.34	−2.42	+2.00	−0.42
25	−8.92	−6.34	−5.26	−2.58	+3.66	+1.08
26	−5.40	−5.26	−5.81	−0.14	−0.41	−0.55
27	−5.75	−5.81	−6.19	+0.06	−0.44	−0.38
28	−6.11	−6.19	−5.97	+0.08	+0.14	+0.22
29	−8.34	−5.97	−6.49	−2.37	+1.85	−0.52
30	−7.88	−6.49	−6.23	−1.39	+1.65	+0.26
31	−7.59	−6.23	−4.88	−1.36	+2.71	+1.35
32	−5.97	−4.88	−4.44	−1.09	+1.53	+0.44
33	−7.23	−4.44	−6.63	−2.79	+0.60	−2.19
34	−7.42	−6.63	−6.55	−0.79	+0.87	+0.08
35	−7.55	−6.55	−5.99	−1.00	+1.56	+0.56
36	−7.46	−5.99	−6.16	−1.47	+1.30	−0.17
37	−6.92	−6.16	−4.72	−0.76	+2.20	+1.44
38	−7.34	−4.72	−5.34	−2.62	+2.00	−0.62
39	−7.51	−5.34	−6.19	−2.17	+1.41	−0.85
40	−9.49	−6.19	−6.29	−3.30	+3.20	−0.10
41	−6.23	−6.29	−6.72	+0.06	−0.49	−0.43
42	−7.67	−6.72	−5.21	−0.95	+2.46	+1.51
Average				−1.71		−0.12

TABLE 27

Degree of selection, difference between parents and offspring and effectiveness of selection for each generation. Low line. All matings. Values in ten-percent factorial units.

GENERATION	WEIGHTED AVERAGE OF SELECTED PAIRS S	AVERAGE OF ♀ AND ♂ MEANS PARENTAL GENERATION P	AVERAGE OF ♀ AND ♂ MEANS OFFSPRING O	DEGREE OF SELECTION S−P	DIFFERENCE BETWEEN PARENTS AND OFFSPRING O−S	EFFECTIVENESS OF SELECTION O−P
1	−6.09	0.00	−3.46	−6.09	+2.63	−3.46
2	−6.55	−3.46	−1.35	−3.09	+5.20	+2.11
3	−5.30	−1.35	−4.10	−3.95	+1.20	−2.75
4	−7.46	−4.10	−3.53	−3.36	+3.93	+0.57
5	−3.53	−3.53	−3.89	0.00	−0.36	−0.36
6	−5.52	−3.89	−3.64	−1.63	+1.88	+0.25
7	−6.36	−3.64	−3.81	−2.72	+2.55	−0.17
8	−5.88	−3.81	−2.83	−2.07	+3.05	+0.98
9	−3.84	−2.83	−3.36	−1.01	+0.48	−0.53
10	−3.35	−3.36	−2.87	+0.01	+0.48	+0.49
11	−6.11	−2.87	−2.78	−3.24	+3.33	+0.09
12	−6.35	−2.78	−4.19	−3.57	+2.16	−1.41
13	−6.73	−4.19	−4.50	−2.54	+2.23	−0.31
14	−6.95	−4.50	−5.70	−2.45	+1.25	−1.20
15	−6.64	−5.70	−5.61	−0.94	+1.03	+0.09
16	−7.97	−5.61	−5.76	−2.36	+2.21	−0.15
17	−7.85	−5.76	−4.36	−2.09	+3.49	+1.40
18	−6.98	−4.36	−5.39	−2.62	+1.59	−1.03
19	−5.96	−5.39	−5.32	−0.57	+0.64	+0.07
20	−7.14	−5.32	−5.70	−1.82	+1.44	−0.38
21	−6.96	−5.70	−6.23	−1.26	+0.73	−0.53
22	−7.14	−6.23	−5.14	−0.91	+2.00	+1.09
23	−5.79	−5.14	−5.74	−0.65	+0.05	−0.60
24	−8.41	−5.74	−6.39	−2.67	+2.02	−0.65
25	−8.55	−6.39	−5.11	−2.16	+3.44	+1.28
26	−5.78	−5.11	−4.98	−0.67	+0.80	+0.13
27	−6.35	−4.98	−5.91	−1.37	+0.44	−0.93
28	−6.40	−5.91	−5.82	−0.49	+0.58	+0.09
29	−7.92	−5.82	−5.83	−2.10	+2.09	−0.01
30	−7.59	−5.83	−6.12	−1.76	+1.47	−0.29
31	−7.35	−6.12	−5.23	−1.23	+2.12	+0.89
32	−5.98	−5.23	−5.33	−0.75	+0.65	−0.10
33	−7.29	−5.33	−6.61	−1.96	+0.68	−1.28
34	−7.48	−6.61	−6.49	−0.87	+0.99	+0.12
35	−6.91	−6.49	−5.76	−0.42	+1.15	+0.73
36	−7.64	−5.76	−6.43	−1.88	+1.21	−0.67
37	−7.25	−6.43	−5.10	−0.82	+2.15	+1.33
38	−7.34	−5.10	−5.34	−2.24	+2.00	−0.24
39	−7.09	−5.34	−6.04	−1.75	+1.05	−0.70
40	−6.90	−6.04	−5.59	−0.86	+1.31	+0.45
41	−6.52	−5.59	−6.47	−0.93	+0.05	−0.88
42	−7.68	−6.47	−5.21	−1.21	+2.47	+1.26
Average				−1.79		−0.12

TABLE 28

Degree of selection, difference between parents and offspring and effectiveness of selection for each generation. High line. Direct. Values in ten-percent factorial units.

GENERATION	WEIGHTED AVERAGE OF SELECTED PAIRS S	AVERAGE OF ♀ AND ♂ MEANS PARENTAL GENERATION P	AVERAGE OF ♀ AND ♂ MEANS OFFSPRING O	DEGREE OF SELECTION S−P	DIFFERENCE BETWEEN PARENTS AND OFFSPRING O−S	EFFECTIVENESS OF SELECTION O−P
1	+ 7.67	0.00	+ 1.34	+7.67	−6.33	+1.34
2	+ 7.18	+ 1.34	+ 5.21	+5.84	−1.97	+3.87
3	+ 7.00	+ 5.21	+ 4.58	+1.79	−2.42	−0.63
4	+ 5.89	+ 4.58	+ 5.96	+1.31	+0.07	+1.38
5	+10.21	+ 5.96	+ 7.60	+4.25	−2.61	+1.64
6	+ 7.24	+ 7.60	+ 5.22	−0.36	−2.02	−2.38
7	+ 6.97	+ 5.22	+ 5.15	+1.75	−1.82	−0.07
8	+ 7.52	+ 5.15	+ 4.01	+2.37	−3.51	−1.14
9	+ 6.52	+ 4.01	+ 7.15	+2.51	+0.63	+3.14
10	+ 9.93	+ 7.15	+ 6.41	+2.78	−3.52	−0.74
11	+ 7.22	+ 6.41	+ 5.91	+0.81	−1.31	−0.50
12	+ 6.84	+ 5.91	+ 6.85	+0.93	+0.01	+0.94
13	+ 9.31	+ 6.85	+ 5.35	+2.46	−3.96	−1.50
14	+ 7.62	+ 5.35	+ 5.71	+2.27	−1.91	+0.36
15	+ 7.76	+ 5.71	+ 5.00	+2.05	−2.76	−0.71
16	+ 6.32	+ 5.00	+ 6.19	+1.32	−0.13	+1.19
17	+10.25	+ 6.19	+ 5.25	+4.06	−5.00	−0.94
18	+ 1.99	+ 5.25	+ 5.15	−3.26	+3.16	−0.10
19	+ 7.43	+ 5.15	+ 4.41	+2.28	−3.02	−0.74
20	+ 3.94	+ 4.41	+ 4.88	−0.47	+0.94	+0.47
21	+ 7.72	+ 4.88	+ 6.20	+2.84	−1.51	+1.33
22	+10.42	+ 6.20	+ 6.12	+4.22	−4.30	−0.08
23						
24	+ 9.59	+ 6.12	+ 5.94	+3.47	−3.65	−0.18
25	+11.16	+ 5.94	+ 6.92	+5.22	−4.24	+0.98
26	+10.13	+ 6.92	+ 8.21	+3.21	−1.92	+1.29
27	+10.09	+ 8.21	+ 9.05	+1.88	−1.04	+0.84
28	+ 9.98	+ 9.05	+ 9.21	+0.93	−0.77	+0.16
29	+12.78	+ 9.21	+10.04	+3.57	−2.74	+0.83
30	+11.99	+10.04	+ 9.09	+1.95	−2.90	−0.95
31	+10.59	+ 9.09	+ 7.51	+1.50	−3.08	−1.58
32	+ 9.32	+ 7.51	+ 6.71	+1.81	−2.61	−0.80
33	+ 7.43	+ 6.71	+ 7.70	+0.72	+0.27	+0.99
34	+10.98	+ 7.70	+ 7.42	+3.28	−3.56	−0.28
35	+ 8.32	+ 7.42	+ 8.20	+0.90	−0.12	+0.78
36	+10.01	+ 8.20	+ 7.72	+1.81	−2.29	−0.48
37	+ 8.92	+ 7.72	+ 8.74	+1.20	−0.18	+1.02
38	+ 9.22	+ 8.74	+ 7.31	+0.48	−1.91	−1.43
39	+10.46	+ 7.31	+ 6.75	+3.15	−3.71	−0.56
40	+ 9.11	+ 6.75	+ 7.40	+2.36	−1.71	+0.65
41	+ 8.51	+ 7.40	+ 8.18	+1.11	−0.33	+0.78
42	+ 8.83	+ 8.18	+ 6.63	+0.65	−2.20	−1.55
Average				+2.16		+0.16

TABLE 29

Degree of selection, difference between parents and offspring and effectiveness of selection for each generation. High line. All matings. Values in ten-percent factorial units.

GENERATION	WEIGHTED AVERAGE OF SELECTED PAIRS S	AVERAGE OF ♀ AND ♂ MEANS PARENTAL GENERATION P	AVERAGE OF ♀ AND ♂ MEANS OFFSPRING O	DEGREE OF SELECTION S−P	DIFFERENCE BETWEEN PARENTS AND OFFSPRING O−S	EFFECTIVENESS OF SELECTION O−P
1	+ 7.33	0.00	+0.36	+7.33	−6.97	+0.36
2	+ 4.38	+0.36	+3.36	+4.02	−1.02	+3.00
3	+ 6.97	+3.36	+3.42	+3.61	−3.55	+0.06
4	+ 5.98	+3.42	+4.99	+2.56	−0.99	+1.57
5	+ 8.80	+4.99	+6.80	+3.81	−2.00	+1.81
6	+ 7.57	+6.80	+5.08	+0.77	−2.49	−1.72
7	+ 6.94	+5.08	+4.13	+1.86	−2.81	−0.95
8	+ 7.53	+4.13	+3.78	+3.40	−3.75	−0.35
9	+ 5.54	+3.78	+5.40	+1.76	−0.14	+1.62
10	+ 9.69	+5.40	+6.05	+4.29	−3.64	+0.65
11	+ 7.85	+6.05	+5.21	+1.80	−2.64	−0.84
12	+ 6.57	+5.21	+6.46	+1.36	−0.11	+1.25
13	+ 9.31	+6.46	+5.35	+2.85	−3.96	−1.11
14	+ 7.77	+5.35	+6.41	+2.42	−1.36	+1.06
15	+ 7.80	+6.41	+4.85	+1.39	−2.95	−1.56
16	+ 6.31	+4.85	+5.31	+1.46	−1.00	+0.46
17	+ 8.75	+5.31	+5.18	+3.44	−3.57	−0.13
18	+ 1.99	+5.18	+5.15	−3.19	+3.16	−0.03
19	+ 7.44	+5.15	+4.41	+2.29	−3.03	−0.74
20	+ 4.09	+44.1	+4.89	−0.32	+0.80	+0.48
21	+ 7.74	+4.89	+6.39	+2.85	−1.35	+1.50
22	+ 8.03	+6.39	+5.80	+1.64	−2.23	−0.59
23	+ 7.66	+5.80	+5.51	+1.86	−2.15	−0.29
24	+ 7.03	+5.51	+6.22	+1.52	−0.81	+0.71
25	+ 9.61	+6.22	+6.30	+3.39	−3.31	+0.08
26	+ 9.70	+6.30	+7.65	+3.40	−2.05	+1.35
27	+10.01	+7.65	+7.48	+2.36	−2.53	−0.17
28	+10.07	+7.48	+9.00	+2.59	−1.07	+1.52
29	+10.24	+9.00	+9.31	+1.24	−0.93	+0.31
30	+11.50	+9.31	+8.51	+2.19	−2.99	−0.80
31	+10.59	+8.51	+7.65	+2.08	−2.94	−0.86
32	+ 8.59	+7.65	+7.36	+0.94	−1.23	−0.29
33	+ 9.33	+7.36	+7.07	+1.97	−2.26	−0.29
34	+ 8.68	+7.07	+6.52	+1.61	−2.16	−0.55
35	+ 7.21	+6.52	+6.55	+0.69	−0.66	+0.03
36	+ 9.43	+6.55	+6.58	+2.88	−2.85	+0.03
37	+ 8.41	+6.58	+8.25	+1.83	−0.16	+1.67
38	+ 8.97	+8.25	+7.41	+0.72	−1.56	−0.84
39	+ 8.94	+7.41	+7.26	+1.53	−1.68	−0.15
40	+ 9.28	+7.26	+7.01	+2.02	−2.27	−0.25
41	+ 8.58	+7.01	+8.27	+1.57	−0.31	+1.26
42	+ 8.83	+8.27	+6.63	+0.56	−2.20	−1.64
Average				+2.10		+0.16

decrease in sexual dimorphism, the graphs being constructed on the basis of the departures of each sex from its mean in the unselected population.

Recognizing this peculiarity in the graphs for individual sexes, an examination shows the same effective periods as in the previous groupings of the data. In both males and females, there is the same early effective period and the further ineffectiveness except during a single limited period in the low line and during the two overlapping periods in the high line.

The fluctuations during individual generations have many interesting features, but a discussion of them is purposely omitted at present as a further investigation of the environmental factors to which they seem to be due is under way.

Standard deviation

That the selection effect is the result of a sorting of original germinal differences is further shown by the decrease in variability as indicated by the standard deviations. The data are given in the last columns of tables 12 to 15 for the direct line and tables 16 to 19 for "all matings." Figures 114 to 121 give the same data in graphic form. The small numbers of individuals in many of the direct-line generations make these determinations less reliable than those for "all matings" but they are interesting for comparison with the latter. Though the fluctuations are much greater, the general trend of the curve of variability is much the same.

Corresponding to the marked effectiveness of selection on the range and mean during the early generations, there is a marked decrease in variability. The standard deviation drops from 3.12 ten-percent factorial units in the unselected females to 1.53 for "all matings" at the 3rd generation of the low line (figures 114 and 115). Among the males there is a corresponding drop from 3.91 to 1.70 in the fourth generation (figures 116 and 117).

In the high line the females drop to 1.24 in the 3rd generation of the direct line (figure 118) and to 1.95 in the same generation of "all matings" (figure 119). In the males the corresponding values are 1.53 for the 3rd generation of the direct line (figure 120) and 2.00 for the 4th generation of "all matings" (figure 121).

The changes in the range and mean following the 11th or 12th generation in the low line are reflected in a further decline in the standard

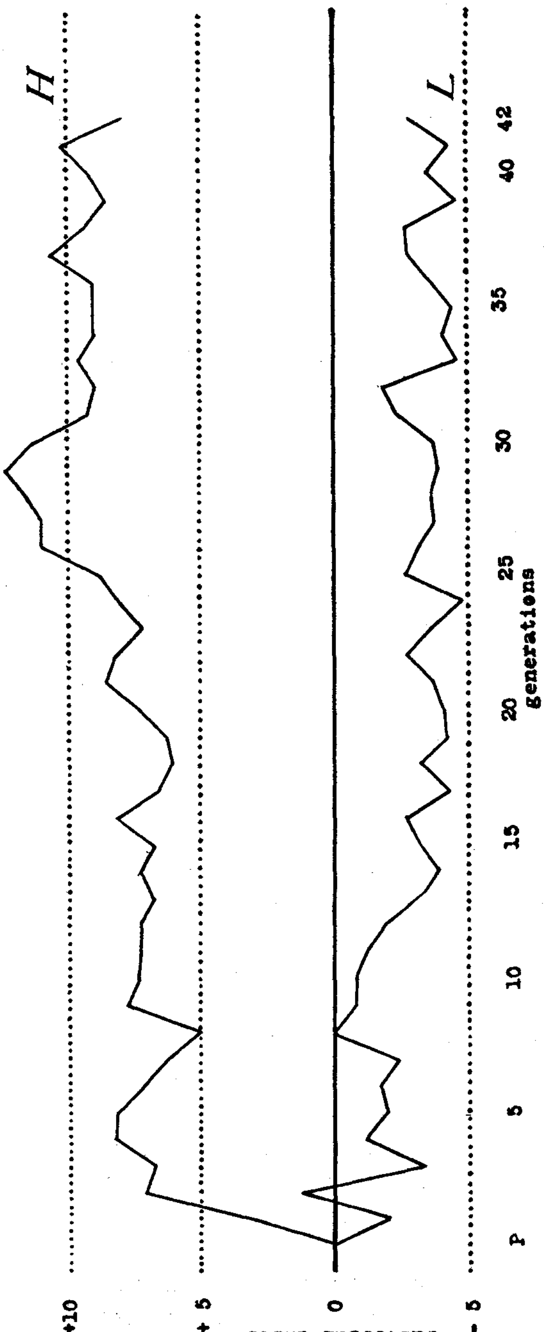


FIGURE 110.—Divergences of female means including all matings.

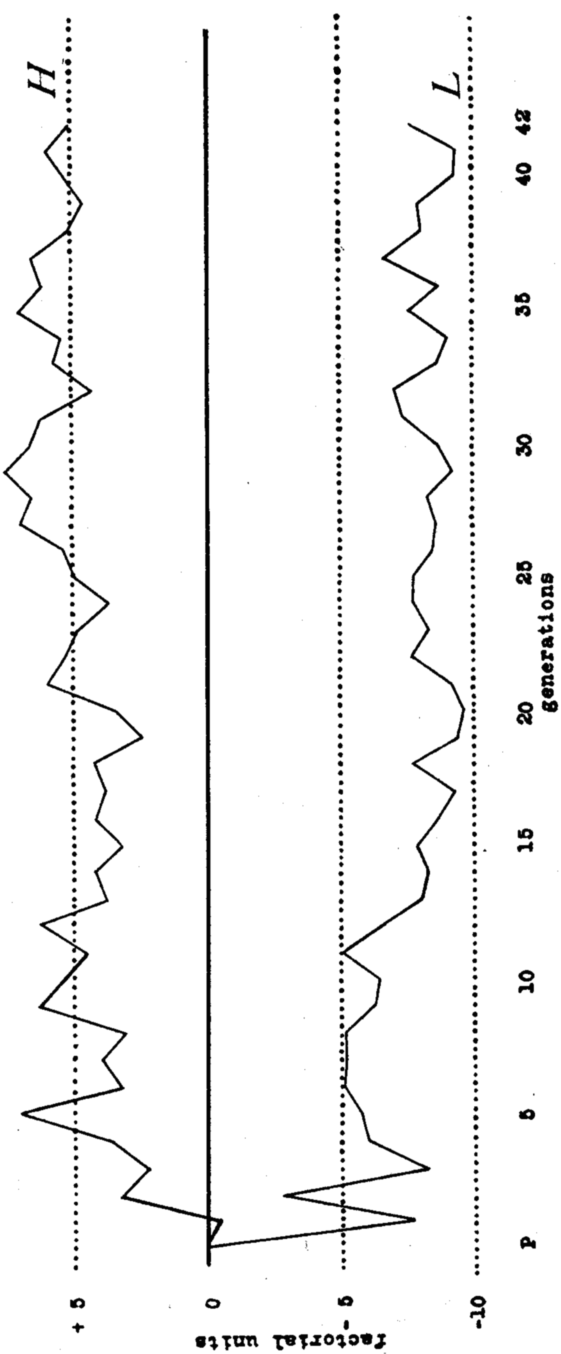


FIGURE 111.—Divergences of male means in the high direct line (H) and low direct line (L) from the mean of the unselected population (O) in each selection generation.

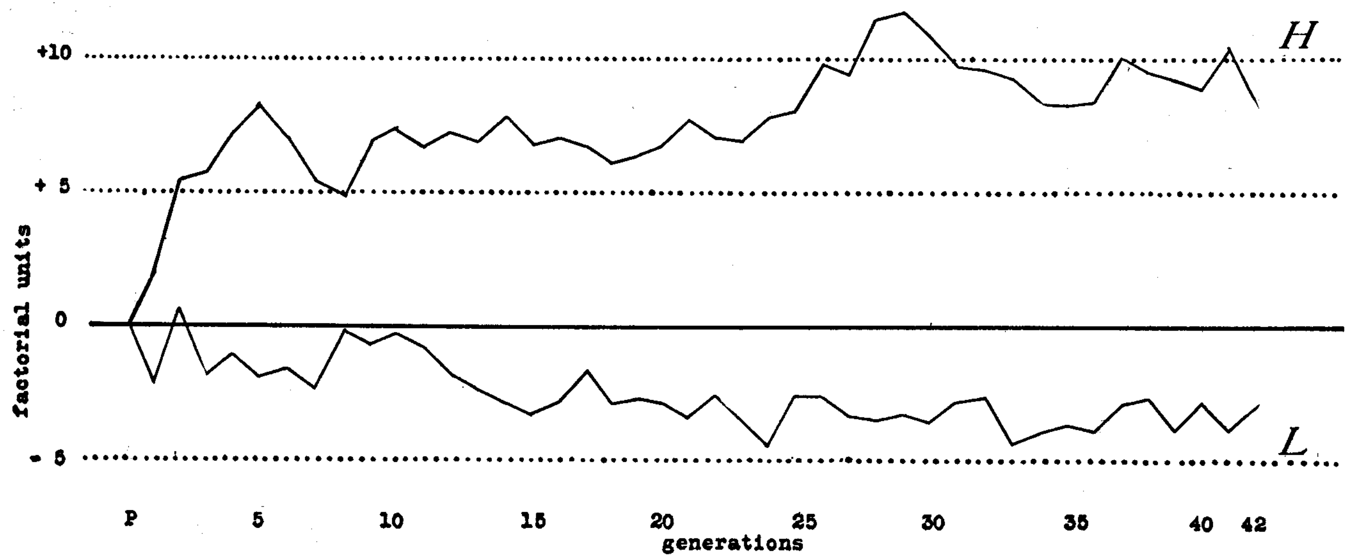


FIGURE 112.—Divergences of female means in the high direct line (H) and low direct line (L) from the mean of the unselected population (O) in each selection generation.

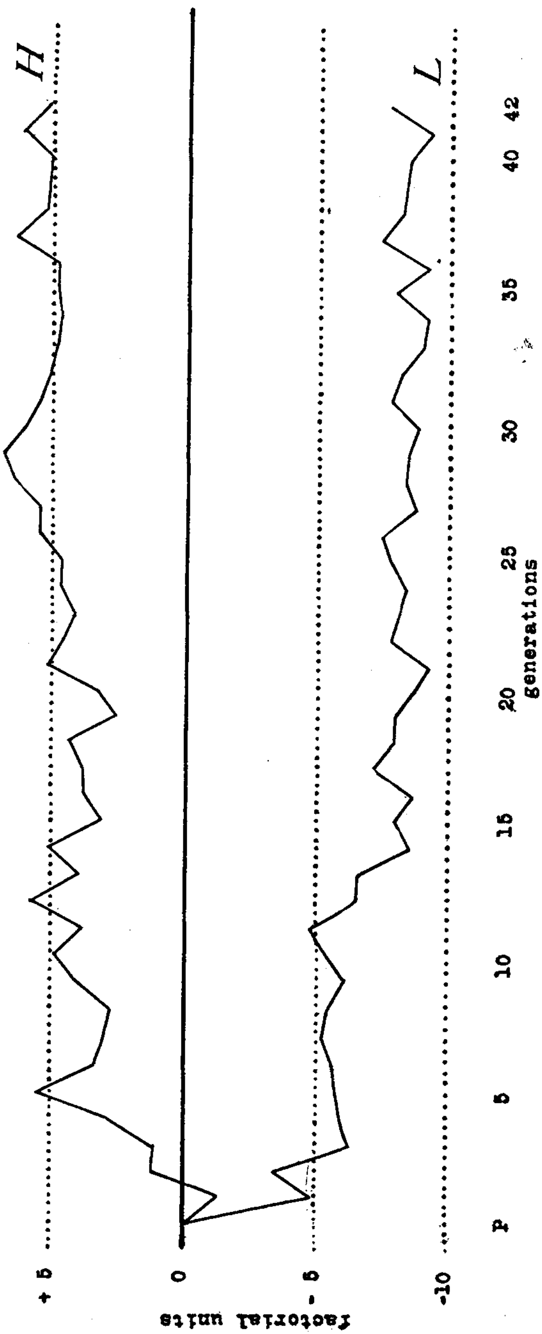


FIGURE 113.—Divergences of male means including all matings.

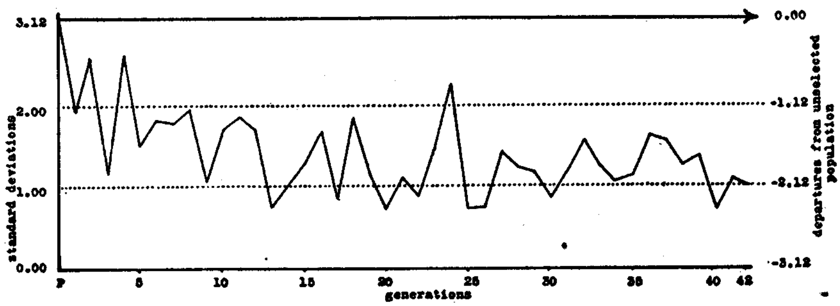


FIGURE 114.—Standard deviations of low-line direct females in factorial units which serve directly as coefficients of variation. The upper horizontal line represents the value of the standard deviation of the females in the unselected population. The bottom horizontal line represents zero standard deviation. The scale at the left gives the standard deviations and the scale at the right the decrease from the value of the unselected population.

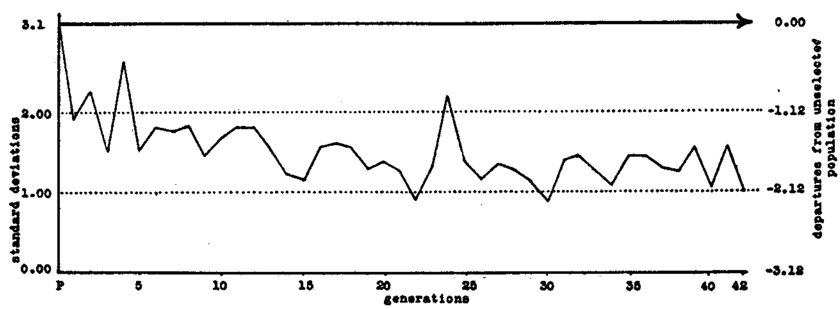


FIGURE 115.—Standard deviations of low-line females including all matings.

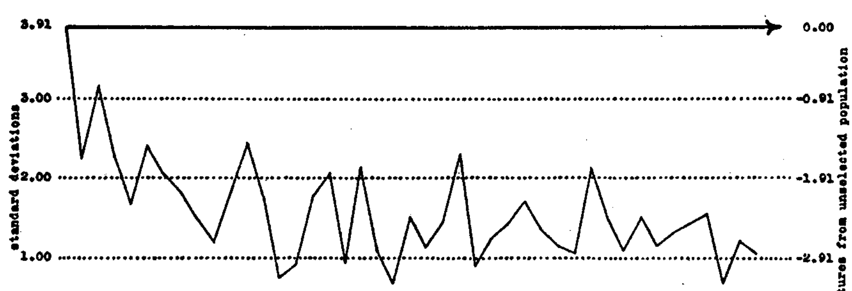


FIGURE 116.—Standard deviations of low-line direct males.

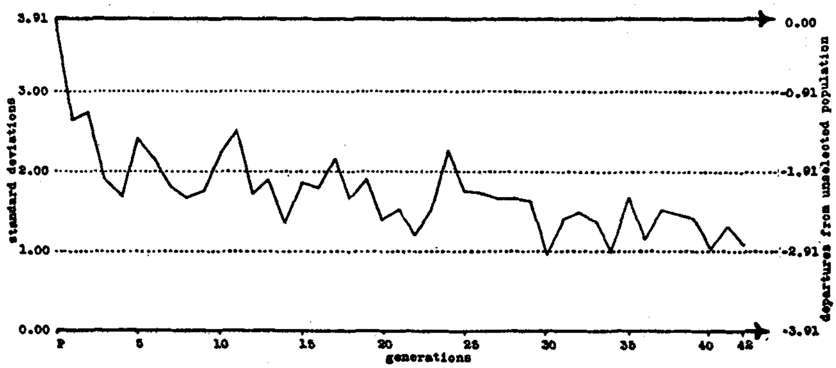


FIGURE 117.—Standard deviations of low-line males including all matings.

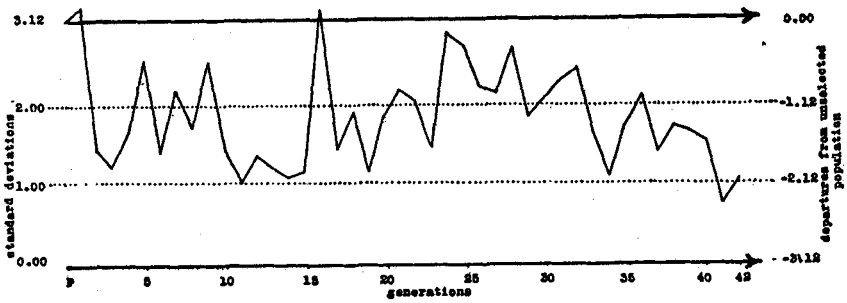


FIGURE 118.—Standard deviations of high-line direct females.

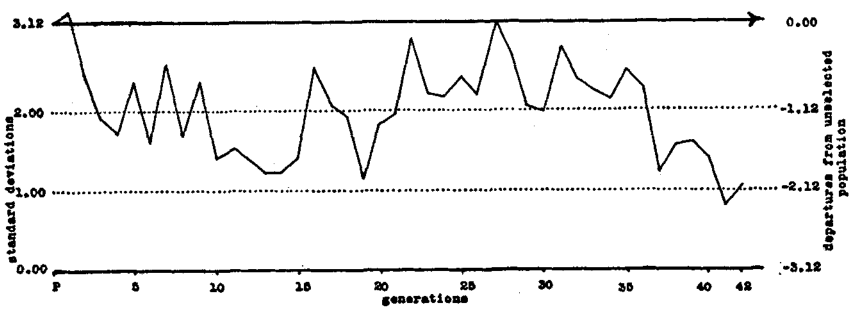


FIGURE 119.—Standard deviations of high-line females including all matings.

deviation at about this time. The decline can not be localized in a specific generation, but it is clear that in the generations following the 12th the standard deviations are at a slightly lower level than before. This

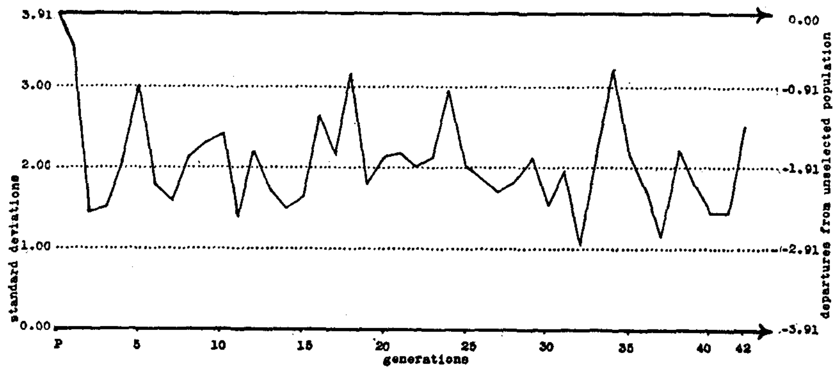


FIGURE 120.—Standard deviations of high-line direct males.

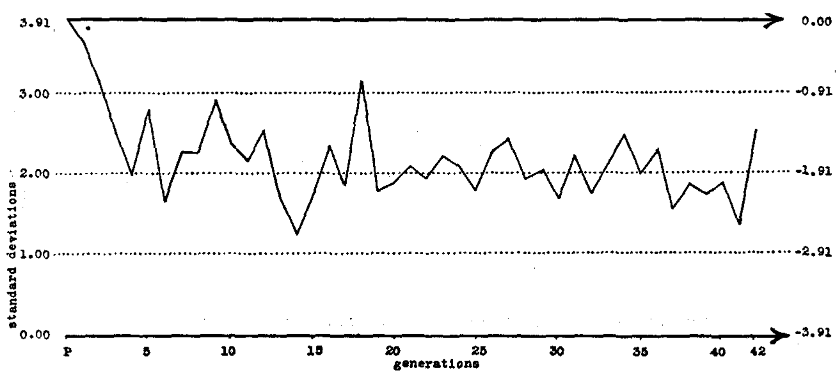


FIGURE 121.—Standard deviations of high-line males including all matings.

confirms the view that the change is due to the elimination of a high-facet group rather than the addition of a low-facet one.

In the high line, the increase in the mean following the 20th generation and the change in range at the same time are reflected in an increase in the variability of the females but there is no change in the males. Later the female variability drops back to its previous level.

On the whole, the changes in variability confirm the general conclusion reached from a study of the ranges and means. Selection acts by eliminating certain germinal groups, thereby decreasing the variability. The only demonstrated new germinal difference during the course of the selection, apart from full eye and ultra-bar eye, is that which appears following the 20th generation of the high line. It is a sex-linked lethal and therefore affects the facet numbers of the females only.

Correlation between degree of selection and effectiveness of selection

While an effort was made in each generation to select the lowest possible pairs in the high line, the attempt was not always equally successful. It is, therefore, desirable to get in each generation an expression for the degree of selection (S−P) or the departure of the mean value of the selected pair (S) from the mean value of the parental generation (P) from which it was derived. This value should be minus in the low-selection lines and plus in the high lines. There may also be obtained a value for the difference between the mean of the parents and the mean of the offspring (O−S) in which O is the mean value of the offspring. Finally, these values may be compared with the effectiveness of the selection in each generation (O−P).

Tables 26 to 29 give the value in each generation of offspring of the mean of the selected pair (S) that gave rise to that generation, the mean of the parental generation (P) and the mean of the generation of offspring (O). Then follow the comparisons including a column for the values of the degree of selection (S−P), one for the difference between parents and offspring (O−S) and finally one for the effectiveness of selection (O−P). Table 26 and figure 122 give these values for the direct matings of the low line and table 28 and figure 124 for the direct matings of the high line. Table 27 and figure 123, and table 29 and figure 125 give the corresponding values for "all matings."

In figures 122 to 125 the vertical distances represent the degrees of selection in departures from the means of the parental generations, using the scale of factorial units. It will be noted that there are a few high selections in the low line and a few low selections in the high line. The horizontal distances represent increases in facet means of the offspring, as compared with the parental generation, when to the right of the axis of reference, and decreases when to the left. The length of the double-headed arrow between the horizontal axis of reference and the horizontal dotted line represents the average degree of selection for all the generations. The short double-headed arrow between the vertical axis and the vertical dotted line shows the corresponding average effectiveness of selection.

If all variation in facet number were due to fixed hereditary factors, it would be expected that there would be a complete correspondence between degree and effectiveness of selection. It is evident that there is no striking agreement between the two. Taking the direct matings, in the low line 37 of the 42 pairs have minus values and 20 of the 37 generations of offspring are lower than the parental generation and 17 are higher. In the high line 38 of the 41 pairs have a plus value and exactly half of the generations of offspring are higher than the parental generations while the other half are lower. It is obvious that the net effectiveness of selection is due to pronounced progress in a few generations.

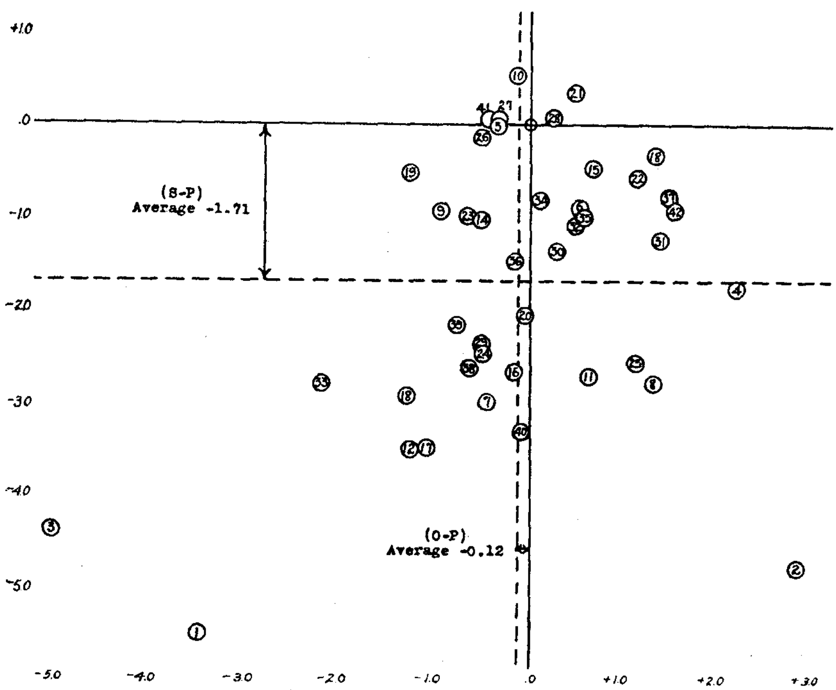


FIGURE 122.—Low direct line. Correlation between degree of selection (S−P) and departure of offspring from the mean of their parental generation (O−P). S = average of the means of the parents. P = mean of the parental generation, average of females and males. O = mean of offspring, average of females and males. Ordinates represent degree of selection. The unbroken horizontal line is the axis of reference, and the departures of parents from the means of their generations are put above or below it according as they are plus or minus. Abscissae represent effectiveness of selection, increases of mean of offspring over mean of the parental generation being to the right of the vertical unbroken line and decreases to the left. The dotted horizontal line gives the average degree of selection, i.e., the average departure of the selected pairs from the means of their generations. The vertical dotted line gives the average effectiveness of selection, i.e., the average departure of offspring from the means of their parental generations.

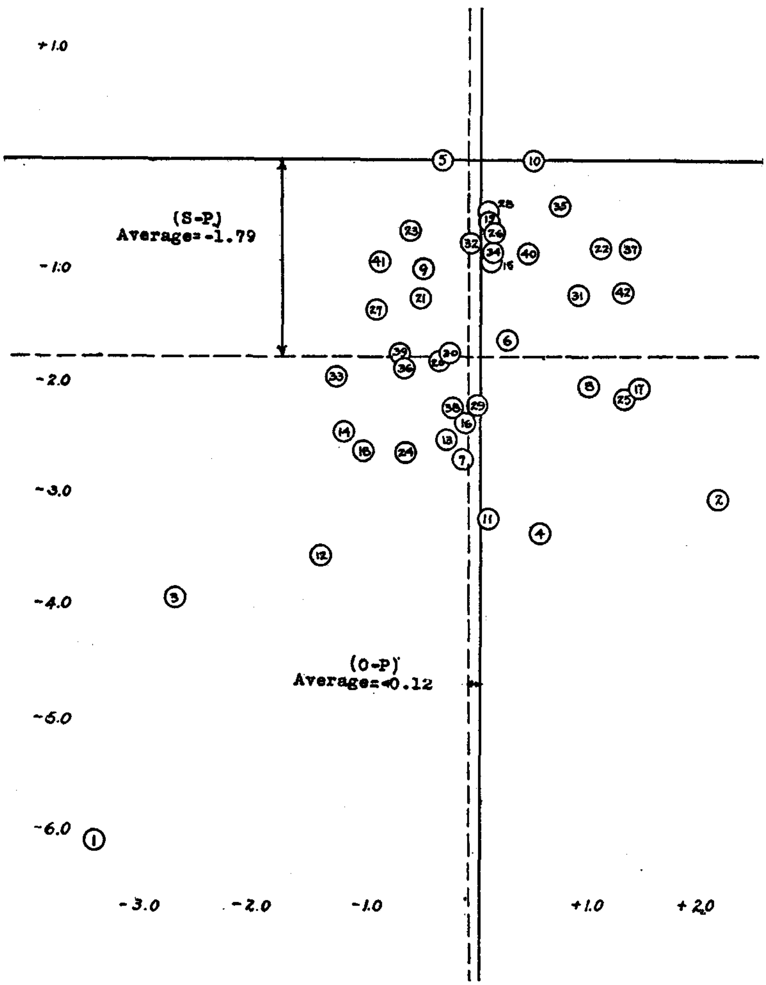


FIGURE 123.—Low line, including all matings. Correlation between degrees of selection (S—P) and departures of offspring from the means of their parental generations (O—P). For explanation see figure 122.

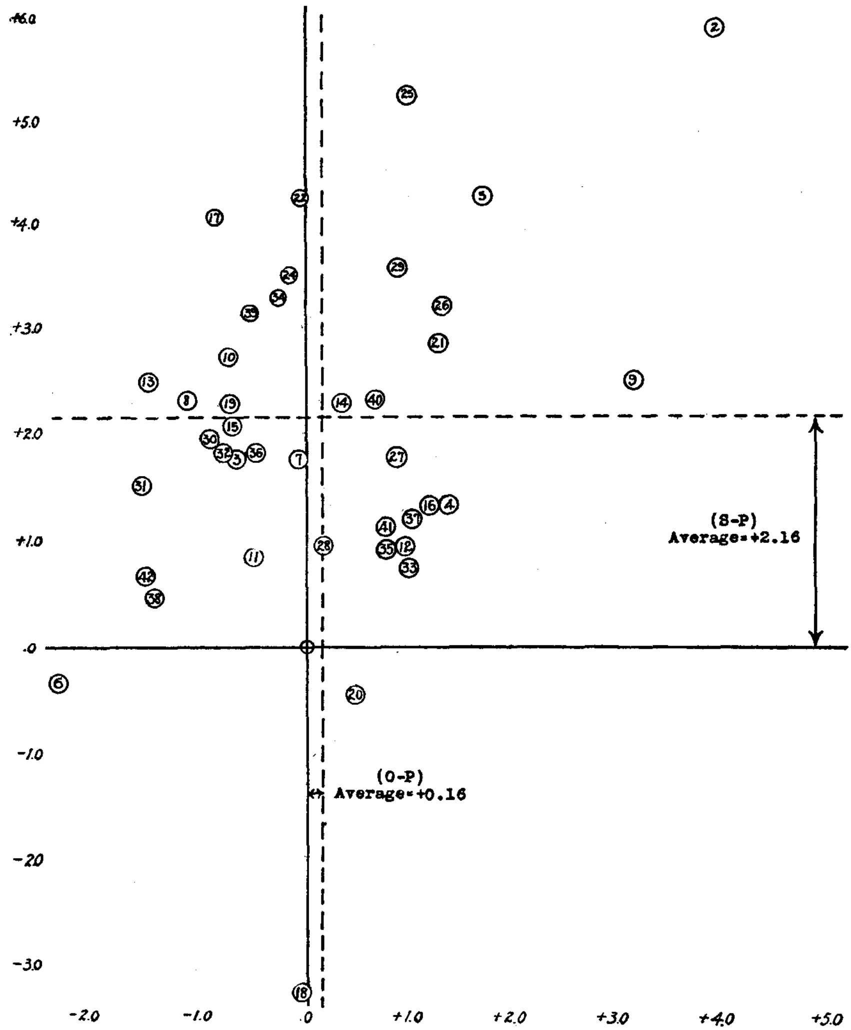


FIGURE 124.—High direct line. Correlation between degrees of selection (S—P) and departures of offspring from the means of their parental generations (O—P). For explanation see figure 122.

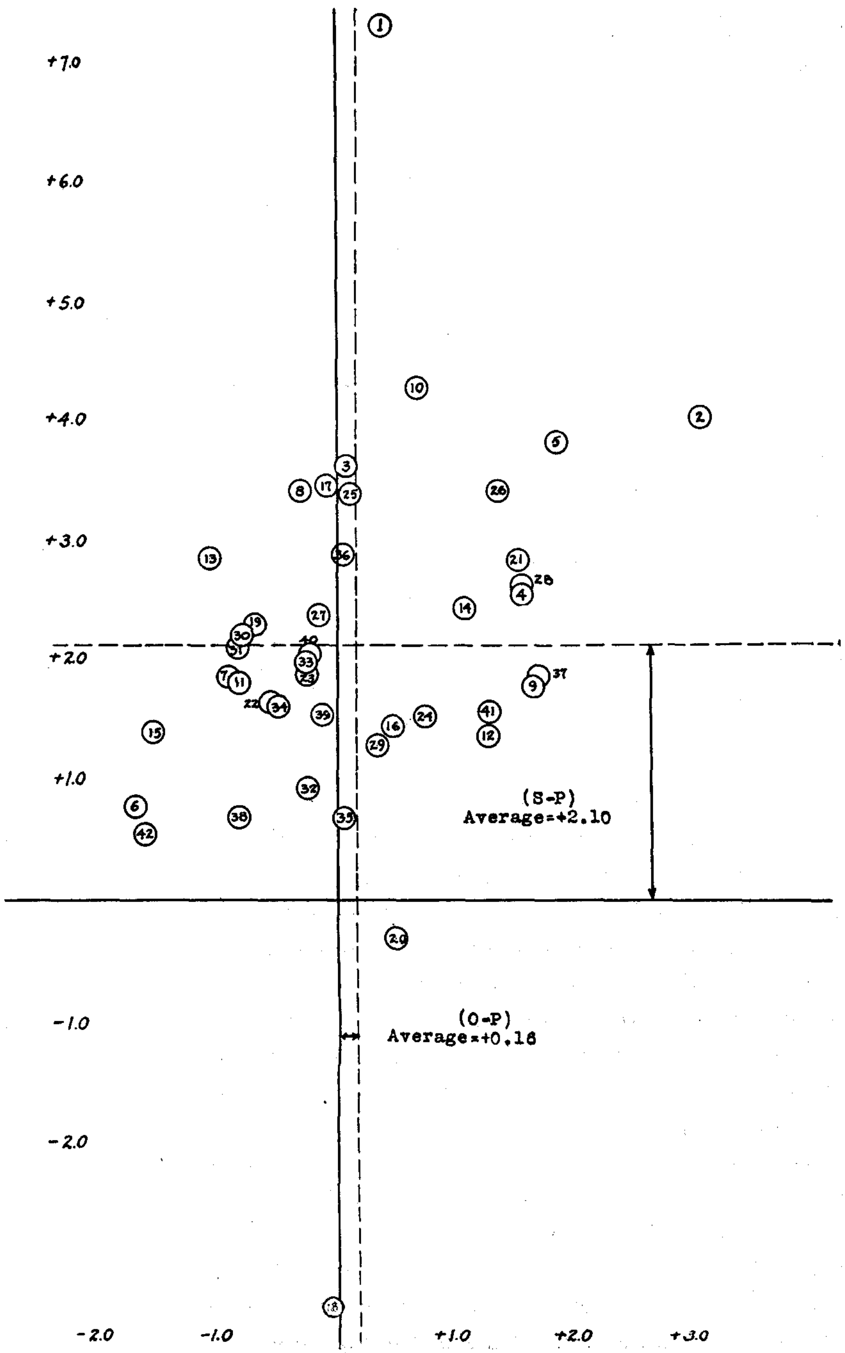


FIGURE 125.—High line, including all matings. Correlation between degrees of selection (S—P) and departures of offspring from the means of their parental generations (O—P). For explanation see figure 122.

The average degree of selection in the low line is -1.71 ten-percent factorial units, and the average effectiveness -0.12 or one-fourteenth of the degree (figure 122). Including all matings, the degree is -1.79 and the effectiveness again -0.12, one-fifteenth of the degree (figure 123). In the high direct line these values are $+2.16$ for degree and $+0.16$ or one-fourteenth of the degree for the effectiveness (figure 124). Including all matings, the values are $+2.10$ for the degree and $+0.16$ or one-thirteenth of the degree for the effectiveness (figure 125).

It is evident that the facet differences when taken throughout the experiment as a whole are largely not of hereditary value. An analysis of the effectiveness of the selection shows clearly that only a very few of the selections were markedly effective. For the great majority of the generations the low-facet parents in the low line and the high-facet parents in the high line gave indifferently lower or higher offspring than the means of the parental generations. The total effectiveness can be ascribed to a very few generations, principally 1 and 3 in the low line and 2 in the high line. This agrees with the conclusion reached previously by a study of the ranges, means and standard deviations, that only those selections which eliminated definite germinal factors were effective, and that the number of such differences is small.

CONCLUSION

In order to understand the nature of the selection effect, it is necessary first of all to consider the two most striking mutations of bar. In the upward direction there is a sudden change from bar to full eye in about one individual in 1600. In the downward direction there is a sudden change to ultra-bar with a frequency considerably less than that to full. If these mutations are considered in the experiments under discussion, upward selection effected a change to full eye in the very first generation and downward selection a change to ultra-bar in the second generation, though it took a generation or two longer to establish full and ultra-bar in homozygous condition.

If these two striking mutations are left out of the consideration, the results of the selection can be explained on the view that there is an early effective sorting of definite germinal differences which were present in the unselected population. This early sorting is completed in from one to five generations, and there is no further progress except at one point in the low line and at two points in the high line.

In the low line immediately following the 12th generation, there is a shift to a slightly lower level. This is undoubtedly a further sorting of original differences because the drop affects only the upper limit of the range, the lower limit remaining unchanged.

In the high line, the early effective period is followed by no further change until the 20th generation. After that time two independent events occur, each of which has its effects upon facet number. First, there is a marked upward shift in the females, the males remaining unaffected. This shift which persists for eight generations is explained by the appearance of a sex-linked lethal factor affecting facet number which kills all males possessing it but allows the heterozygous females to live. That a lethal factor is actually present is shown by the ratio of two females to one male in these generations. The drop after the 28th generation is to be explained by the fact that only half of the females in each generation contain the new lethal factor, and with the large fluctuation in facet number due to non-heritable factors, there is certain sooner or later to be a choice of a female with high facet number due to such non-heritable factors rather than to the heritable one. The lethal is thus immediately eliminated and the facet average of the females drops.

The second shift takes place following the 25th generation and is a sorting phenomenon similar to the one mentioned as occurring in the low line. The upper range of the males remains unchanged, but the lower range of both females and males shifts upward to a higher level as is to be expected on the hypothesis of the elimination of a germinal factor for low facet number which up to this time had been obscured by non-heritable fluctuations. The action of the upper limit of range of the females with respect to this change is obscured by the more pronounced temporary effect of the lethal factor discussed above.

These results are in agreement with the general trend of recent work on the nature of the selection effect. A critical discussion of this work is, however, reserved for another occasion. The existence of defintie hereditary factors on which selection can act by elimination of certain ones and preservation of others seems to be clearly demonstrated. New germinal differences arise by mutations whose origin, as shown elsewhere, is independent of selection. When they have arisen they are, however, subject to the further action of selection. In the present material the striking character of the mutations makes possible the early change to full eye by upward selection and to ultra-bar by downward selection.

SUMMARY

1. Selection for high and low facet number in a white bar race of Drosophila quickly gave full eye on the one hand and ultra-bar on the other, because of the appearance of definite mutations for these characters.

2. The origin of these mutations is independent of selection which has merely the function of preserving or eliminating them after they have appeared.

3. Neglecting these striking mutations, selection causes a rapid decrease in mean facet number in the low line during the first one to three generations. This decrease is accompanied by a striking decrease in variability. There is, however, no extension of the range downward, the whole change being brought about by the elimination of high-facet individuals.

4. From the fourth to the twelfth generations selection is without effect.

5. Between the 12th and 14th generations there is a further lowering of the mean with a decrease in variability. Again there is an elimination of high facet numbers but no downward extension of the range.

6. From the 14th to the 42nd generations there is no further effect of selection.

7. Neglecting the striking mutations as before, selection causes a rapid increase in mean facet number in the high line during the first five generations. This increase is accompanied by a striking decrease in variability. There is, however, no upward extension of range, the change being brought about by the elimination of individuals with low facet numbers.

8. From the 5th to the 20th generations, selection is without effect.

9. From the 21st to the 28th generations the means of the females are temporarily higher than before, but the males are unchanged. The sex ratios indicate that this increase is due to the appearance of a sex-linked lethal factor for increased facet number. At the 28th generation the lethal factor is lost and the facet number drops again.

10. At the 25th generation there is a rise in the means, apparent in the males but obscured for the moment in the females by the sex-linked lethal just mentioned. There is at the same time an elimination of individuals with low facet numbers but no upward extension of the range.

11. These facts and others discussed in the paper demonstrate the existence of definite hereditary factors for facet number which are sorted out by selection. The major ones are caught in the selection net in from one to five selection generations. Some of the minor ones are

protected by the non-heritable fluctuations until a later period when they also are separated out.

12. Apart from this sorting effect of pre-existing differences which must necessarily be completed sooner or later, the appearance of definite mutations causes new germinal differences which are acted upon by selection as they appear.

13. Of the mutations noted during the course of the selection, the striking one to full eye appeared four times in the high line and three times in the low line.

14. The mutations to ultra-bar appeared at least twice, once in the 2nd generation of the low line and once in the 22nd generation of the high line. Several other very low individuals that died without offspring were probably ultra-bar also.

15. A sex-linked lethal factor causing increase in facet number appeared in the 21st generation of the high line.

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