Radiation of *Drosophila melanogaster* with Low-Intensity Ultra-Violet Light for One Complete Generation. II. Effect on Crossing-Over in the First Chromosome

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Introduction

To date no work has been published indicating the effects of long-time ultra-violet radiation on crossing-over in the first chromosome and this work was undertaken in order to discover, if possible, these effects.

Previous Work Concerned with the Effect of Radition on Crossing-over in the First Chromosome

Mavor (1923) found a decrease in crossing-over in the White-Miniature region treated with X-rays.

Mavor (1929) treated females with X-rays in order to discover the resulting effects on non-disjunction and crossing-over. The females which were heterozygous for White-Long and Eosin-Miniature were radiated while still in the pupa stage. The anterior portion of the body of a number of females was exposed in one instance, the posterior portion of a number of others, and the entire body of others. Unradiated females were used as controls. He found that crossover values between the White and Miniature loci were significantly reduced in the offspring of the flies which were exposed entirely to the effect of X-rays and also in the flies which were treated posteriorly.

Investigators using first chromosome factors had found that the crossover values were reduced here in contrast to the increase found in the autosomes. Stern (1926) pointed out that the factors used by these workers were located at a distance from the spindle-fibre attachment and that if crossover increases were not found in the remote (from the spindle-fiber attachment) regions of the autosomes, then one should not expect increases in crossover values for the factors in the distal regions of the heterosomes. Accordingly, he exposed eggs heterozygous for Bar and Bobbed factors to high temperatures (30° C.) until the time of hatching, when they were transferred to 25° C. The offspring of the females exposed to high temperatures showed a significant increase in crossing-over (8.5 times the probable error) when compared to the controls which were kept at a constant temperature of 25° C. This increase disappeared about nine days after exposure. Stern explains the drop in crossover values by assuming that high temperature produces its effects upon crossing-over at the oögonial stage and does not effect germ cells that are in the oöcyte stage. Eggs laid seven or eight days after the removal of the females from 30° C. temperature had not yet reached the susceptible oögonial stage at the time they were subjected to the high temperatures.

Methods

The methods used were similar to those of Rifenburgh and Paradise (1938), a General Electric S2 sun lamp being used from the time of mating the P_1's until the F_1's emerged, at a distance of forty-eight inches.

The female parents were virgins from the stock of Yellow-White-Miniature Drosophila. The male parents used were of pure Bar stock. One male and one female were put into each beaker and after the flies had been given sufficient time to recover from the effects of etherization, the beakers were placed under the lamp. These parents were allowed to remain in the beakers until larvae appeared and then were removed.

The offspring were irradiated during their entire life history until the time of mating. The female offspring were heterozygous for all four pairs of factors and Bar in phenotype, but, since the factors were sex-linked, the male offspring were homozygous recessive.

The irradiated Bar females were removed at 8-hour intervals in order to assure their virginity. The males were discarded or used for back-crossing.

The females were back-crossed to Yellow-White-Miniature males which were the quadruple recessives, Bar being a dominant factor.

The parent flies were left in the original bottles for four days, then transferred to a new bottle for another four-day period, and then re-transferred to a third bottle for still another four-day period. It was expected that more offspring would be produced by one female in a series of bottles than she would produce normally if left in only one bottle for the egg-laying period.

The offspring were counted on the eleventh, fourteenth, and seventeenth days after the parents were placed in the bottles. Classification was made as to phenotype and sex.

Results

Eighty-six matings of experimentals were made. Fifty pairs were transferred at the end of four days to new bottles where each remained for another four-day period before being transferred to a third bottle.

Fifty-five control matings were made of the non-irradiated Bar females. Forty pairs were transferred to second and to third bottles.

The 176 experimental bottles produced 18,174 flies which were distributed among the phenotypes as follows:

4263	Bar	7	Yellow-Miniature
5526	Yellow-White-Miniature	292	Miniature-Bar
116	White-Miniature	2001	Yellow-White
93	Yellow-Bar	0	White-Miniature-Bar
2618	Miniature	17	Yellow
1067	Yellow-White-Bar	6	White
1368	Wild	1	Yellow-Miniature-Bar
697	Yellow-White-Miniature-Bar		
2	White-Bar	18174	

The 135 control bottles produced 2793 flies which were distributed among the phenotypes as follows:

688	Bar	3	Yellow-Miniature
825	Yellow-White-Miniature	47	Miniature-Bar
11	White-Miniature	337	Yellow-White
19	Yellow-Bar	0	White-Miniature-Bar
396	Miniature	4	Yellow
161	Yellow-White-Bar	3	White
205	Wild	0	Yellow-Miniature-Bar
94	Yellow-White-Miniature-Bar		
0	White-Bar	2793	

Crossover percentages for the three regions of the chromosome were calculated. The values are tabulated in Tables I-II-III.

TABLE I.—Crossover Percentage in the First Chromosomes of Females Between Yellow and White Loci

Experimentals			Controls			Difference	D/P.E.(diff.)
Number of Matings	Total Population	Crossover % Y to W	Number of Matings	Total Population	Crossover % Y to W		
176	18174	1.33±.0513	135	2793	1.432±.1524	Decrease .100±.163	.615

Map Distance 1.5 Morgan (1932).

TABLE II.—Crossover Percentage in the First Chromosome of Females Between White and Miniature Loci

Experimentals			Controls			Difference	D/P.E.(diff.)
Number of Matings	Total Population	Crossover % W to M	Number of Matings	Total Population	Crossover % W to M		
176	18174	32.981±.744	135	2793	33.962	Decrease .981±.910	1.08

Map Distance 34.6 (Morgan 1932).

TABLE III.—Crossover Percentage in the First Chromosomes of Females Between Miniature and Bar Loci (The Region of Spindle-fiber Attachment)

Experimentals			Controls			Difference	D/P.E. (diff.)
Number of Matings	Total Population	Crossover % M to B	Number of Matings	Total Population	Crossover % M to B		
176	18174	24.111±.068	135	2793	21.124±.402	Increase 2.981±.408	7.321

Map Distance 20.9 (Morgan 1932).

Discussion

The results of this experiment show a slight decrease in crossover percentage between the Yellow and White loci. This decrease was not significant, being less than its probable error. This Yellow-White region has a map distance of only 1.5, and, because of its extreme shortness, it must be rather resistant to changes in amount of crossing-over.

In the White-Miniature region the experimentals show a decrease in crossing-over as compared with the controls, but, again, the decrease is not significant. Rifenburgh (1935) used these same loci and found that ultra-violet light of high intensity caused an increase in crossing-over in offspring of females radiated as pupae but a decrease in offspring of females radiated as adults.

Working with X-rays, Mavor found a decreased crossover percentage for the White-Miniature region. He attributed this decrease to a crossover inhibitor developed by the X-rays or to increased double crossing-over which he could not measure since his experiment involved only two loci.

The increase in crossing-over between the Miniature and Bar loci is somewhat unexpected in the light of Mavor's and Rifenburgh's work. However, neither of these workers used a region so near the spindle-fiber attachment as this. The increase is significant, being 7.3 times the probable error. These results indicate that the effects of radiation must be much the same as in the autosome.

Early workers used loci at the left end of the first chromosome and found decreased crossover percentages, leading them to believe that the sex chromosome and the autosomes were opposite in reaction to the effects of X-radiation. Later it was found that the increase in crossing-over in the autosomes was limited to the region near the spindle-fiber attachment and that the regions near the ends of the autosomes were resistant to changes resulting from radiation.

Muller, Plough, and Schwab each have conducted experiments with third chromosome characters which range from the Roughoid locus at 0.0 to the Claret locus at 100.7, and they agree in finding an increase of crossover percentage near the attachment of the spindle-fiber only. Mavor, Muller, and Plough each subjected flies with second chromosome characters to radiations, and again each found crossover increases near the center of the chromosomes only.

Stern used Bar-Bobbed factors of the first chromosome in measuring effects of temperature on crossing-over in this region, which is near the attachment of the spindle-fiber. He found a significant increase, and this led him to believe that the crossing-over mechanism was susceptible to change near the point of the spindle-fiber attachment only.

The present work with ultra-violet irradiation involving loci scattered almost the entire length of the first chromosome seems to corroborate the work of both Mavor and Stern. Regions distant from the spindle-fiber attachment showed decreases in crossing-over that were, however, not significant, whereas the region nearest the spindle-fiber attachment showed an increased crossover percentage.

Comparison of the results reported in this paper with work of Mavor, Muller, Plough, Rifenburgh, Rifenburgh and Paradise, and Stern seems to indicate that, in general, electro-magnetic radiations cause an increase in crossing-over in the various chromosomes which is most pronounced near the points of spindle-fiber attachment.

Summary

This work was undertaken in order to discover the effects of long-time low-intensity ultra-violet radiation on crossing-over in the first chromosome of *Drosophila melanogaster*. The regions tested were between the Yellow and White, White and Miniature, and Miniature and Bar loci.

1. No significant effects on crossing-over between the Yellow and White and between the White and Miniature loci were found.

2. Crossing-over in the Miniature-Bar region was significantly increased.

3. These results agree with the results of other workers with other types of radiation, who found that crossover increase occurred principally or entirely near the point of spindle-fiber attachment.

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