X-RAY INDUCTION OF Y-CHROMOSOME LOSS MOSAICS IN MATURE SPERM OF *DROSOPHILA MELANOGASTER* UNDER OXYGEN OR NITROGEN CONDITION

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ABSTRACT

A comparison was made on the relative frequencies of the mosaic and whole-body losses (of either B^s or y^+ marker, and of both B^s and y^+ markers from the Y) induced by X-rays in mature sperm under oxygen or nitrogen condition. The results indicate that the yield of mosaic losses is not affected (where the marker y^+ or both B^s and y^+ markers are concerned) or affected only a little (where the marker B^s is concerned) by the difference in the irradiation condition, while that of whole-body losses is affected to a considerable extent. This picture of the mosaic losses is nearly similar to that previously noted for *dumpy* mosaics.

INTRODUCTION

In *Drosophila*, the presumptive origin of mosaicism at the genic level, e.g. *dumpy* mosaics (Carlson and Southin 1962; Carlson and Oster 1962; Inagaki *et al.* 1977a; Miyamoto 1978; Fujikawa and Inagaki 1979), has often been discussed in terms of the strandedness of the DNA molecule of the gene (Muller *et al.* 1961; Carlson and Southin 1962; Carlson and Oster 1962; Inagaki and Nakao 1966; Matsudaira *et al.* 1967; Muñoz 1972; Fujikawa *et al.* 1975), although this was not so for the mosaicism at the chromosome breakage level, e.g. marker-loss mosaics (Novitski 1963; Oster 1963; Suter 1973) and gynandromorphs (Bonnier *et al.* 1949). Recently, Inagaki *et al.* (1977b) have revealed that the dose-effect relationship of the marker-loss mosaics (the ones involving the Y-chromosome marked with B^s and y^+) induced by X-rays in mature sperm seems to be very similar to that elucidated for the *dumpy* mosaics (Inagaki *et al.* 1974; Fujikawa *et al.* 1975). Based on this parallelism, they have proposed that the arguments which can be put forward to explain mosaicism at the genic

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level could be generalized to involve mosaicism at the chromosome breakage level.

In the course of the author's re-investigation on the X-ray induction of the various kinds of *dumpy* mutations in *Drosophila* mature sperm in oxygen or in nitrogen (unpublished), mosaic losses of either B^s or y^+ marker, and of both B^s and y^+ markers from the marked Y-chromosome were detected. It was decided to test whether or not the parallelism similar to that noted in the dose-effect relationship might hold true for the frequency patterns of the above two types of mosaicism under the two different irradiation conditions such as oxygen and nitrogen. This is considered in the present report.

MATERIALS AND METHODS

The experimental procedures are wholly the same as those employed by Miyamoto (1978) except for the strain of flies used. 7-day-old males with the genetic constitution sc^{sl} *B In*49 sc^8/B^s Y $sc^8(y^+)$ were X-ray irradiated with an exposure of 3000 R in oxygen or in nitrogen, at a dose rate of 110 R/min (200 kV 25 mA, filter 1.0 mm Al plus 1.5 mm Cu). The flies were pre-treated with each gas for 15 min. The gasses used were oxygen (99.5% purity) and nitrogen (99.999% purity), and both were let to flow at a rate of 1.0 *l*/min during irradiation. Immediately after irradiation, the males were mated individually with 4 virgin females with the constitution *y w m f*; *dp* for a 24 h period. The following three types of marker losses were detected in the F_1 progeny (see Inagaki *et al.* 1977b):

(1) Loss of both B^s and y^+ from Y
(Loss of Y or X): XO males, hemizygous *y*, *w*, *m*, *f*.

(2) Loss of B^s from Y: showing as y^+, *w*, *m*, *f* males.

(3) Loss of y^+ from Y: showing as *y*, *w*, *m*, *f*, B^s males.

These losses were recovered as either mosaically-expressed or whole-body changes.

The statistical tests of data obtained in the present study were made by using Kastenbaum and Bowman's tables (Kastenbaum and Bowman 1970).

RESULTS AND DISCUSSION

The results on the induction of mosaic and whole-body losses (of either B^s or y^+ marker, and of both B^s and y^+ markers from the Y) by 3000 R of X-rays in mature sperm under two different irradiation conditions, oxygen and nitrogen, are presented in Table 1. Parallel unirradiated series were not undertaken in the present study, since it had been reported that alteration of the oxygen tension in the absence of irradiation had no detectable effect on the mutation process in spermatozoa (Oster 1958). As shown in the table, the total frequency of mosaic losses of the marker B^s under oxygen condition is significantly

higher than that under nitrogen. Further, throughout the five replicates, the frequencies of this type of losses are consistently higher in oxygen series than in nitrogen series. These findings are not unexpected in view of the earlier study of Oster (1963) which revealed that a considerable number of these losses, when fertile, exhibited a variegated distribution of Bar and normal eyes among their offspring in further breeding tests, suggesting that the majority of such variegated Bar-eyed individuals were due to position effects caused by radiation-induced chromosome breakage events. In the total yield of the mosaic losses of the marker y^+, however, no significant difference exists between the two different irradiation conditions. The same seems to hold for the frequency pattern of the mosaic losses of both B^s and y^+ markers detected under different irradiation conditions, although the yield of this type of losses recorded under oxygen series is very low.

In the meantime, in the total yield of each of the above three classes of losses expressed as whole-body changes there exist highly significant differences between the two irradiation series.

The data presented in Table 1 also permit comparisons of the relative frequencies of mosaic types losses (mosaic ratios among total losses) under two different irradiation conditions. Such frequencies for the B^s losses are 13.5% and 8.0%, under nitrogen and under oxygen, respectively; for the y^+ losses, 26.1% and 14.4%; and for both B^s and y^+ ones, 3.4% and 0.5%. These findings indicate that X-irradiation of mature sperm in nitrogen yields high relative frequency of mosaic type losses. This tendency is quite similar to that noted for the *dumpy* mosaics (Oster 1963; Muñoz 1972; Miyamoto 1978).

Recently, Miyamoto (1978) has revealed that the yield of *dumpy* mosaics induced by X-rays is not affected by the difference in the irradiation condition such as oxygen and nitrogen, and that the relative frequency of such mosaics (mosaic ratios among total *dumpy* mutations) is high under nitrogen as compared to that under oxygen. Present results have made clear that the frequency of mosaic type losses is not affected (where the marker y^+ or both B^s and y^+ markers are concerned) or affected only a little (where the marker B^s is concerned) by such differences. Further, it has been also noted that the relative frequency of mosaic losses is higher under nitrogen condition than under oxygen. It is clearly indicated that a certain consistency exists in the oxygen enhancement pattern between these two types of mosaicism. Such consistency closely resembles that elucidated in the dose-effect relationship between them (Inagaki *et al.* 1977b).

By the way, it has been demonstrated that many of the *dumpy* mosaics are point mutations (Carlson and Southin 1962; Carlson and Oster 1962; Inagaki *et al.* 1977a; Miyamoto 1978; Fujikawa and Inagaki 1979), while the ones involving the marker losses are associated with structural changes (Novitski

Table 1. Frequencies of mosaic and whole-body losses of either B^s or y^+ marker, and of both B^s and y^+ markers from the Y-chromosome induced by 3000 R of X-irradiation under O_2 or N_2 condition in *Drosophila* mature sperm

	Expt. No.	Frequency (%)					
		Mosaic			Whole-body		
		Under O_2 condition	Under N_2 condition	P(O_2 versus N_2 2-sided test)	Under O_2 condition	Under N_2 condition	P(O_2 versus N_2 2-sided test)
Loss of B^s	1	0.0904 (4/4427)	0.0353 (3/8501)		1.6716** (74/4427)	0.6352 (54/8501)	
	2	0.2219 (9/4055)	0.1199 (11/9178)		1.7509** (71/4055)	0.5448 (50/9178)	
	3	0.1491 (5/3353)	0.0513 (3/5851)		1.9386** (65/3353)	0.3760 (22/5851)	
	4	0.1750 (7/4001)	0.1184 (9/7603)		1.8495** (74/4001)	0.5656 (43/7603)	
	5	0.1292 (6/4643)	0.0528 (5/9470)		1.5723** (73/4643)	0.3168 (30/9470)	
	Total	0.1514 (31/20479)	0.0763 (31/40603)	<0.05	1.7432 (357/20479)	0.4901 (199/40603)	<0.001
Loss of y^+	1	0.0452 (2/4427)	0.0588 (5/8501)		0.5873* (26/4427)	0.3058 (26/8501)	
	2	0.0740 (3/4055)	0.0763 (7/9178)		0.7152** (29/4055)	0.2942 (27/9178)	
	3	0.1193 (4/3353)	0.1367 (8/5851)		0.5965** (20/3353)	0.2051 (12/5851)	
	4	0.1250 (5/4001)	0.0658 (5/7603)		0.4499* (18/4001)	0.1841 (14/7603)	
	5	0.1077 (5/4643)	0.1056 (10/9470)		0.4308* (20/4643)	0.2112 (20/9470)	
	Total	0.0928 (19/20479)	0.0862 (35/40603)	>0.70	0.5518 (113/20479)	0.2438 (99/40603)	<0.001
Loss of both B^s and y^+	1	0.0226 (1/4427)	0.0588 (5/8501)		3.8852** (172/4427)	1.4822 (126/8501)	
	2	0.0247 (1/4055)	0.0545 (5/9178)		3.8718** (157/4055)	1.7106 (157/9178)	
	3	— (0/3353)	0.0171 (1/5851)		4.1157** (138/3353)	1.3844 (81/5851)	
	4	— (0/4001)	0.0921 (7/7603)		3.4241** (137/4001)	1.5257 (116/7603)	
	5	0.0431 (2/4643)	0.0528 (5/9470)		3.3814** (157/4643)	1.7951 (170/9470)	
	Total	0.0195 (4/20479)	0.0566 (23/40603)	>0.05	3.7160 (761/20479)	1.6009 (650/40603)	<0.001

*, ** Significant at the 5 and 1% level from the nitrogen condition, respectively.

1963; Oster 1963; Suter 1973). The above parallelism between these two types of mosaicism may be interpreted to mean that primary or potential lesions leading to two such kinds of mosaics may not be different from one another, although their finally reaching points are quite different (gene mutations vs. chromosome breakage events). However, it should be noted that explantations of this kind are purely speculative at present, since available information on such parallelism is still very limited.

An additional point of interest is seen in Table 2. This table gives the frequencies of gynandromorphs which were simultaneously detected in conjunction with scoring of marker losses in the present study. These exceptions have been classified as another type of mosaics originating from breaks in the X-chromosome (Bonnier *et al.* 1949). As can be seen from the table, the total

Table 2. Frequencies of gynandromorphs induced by 3000 R of X-irradiation under O_2 or N_2 condition in *Drosophila* mature sperm

Expt. No.	Frequency (%)		P(O_2 versus N_2 2-sided test)
	Under O_2 condition	Under N_2 condition	
1	—	0.0201	
	(0/5748)	(2/9945)	
2	0.0723	0.0353	
	(4/5532)	(4/11319)	
3	0.0498	0.0594	
	(2/4018)	(4/6732)	
4	0.0604	0.0460	
	(3/4970)	(4/8705)	
5	0.0520	0.0273	
	(3/5774)	(3/10989)	
Total	0.0461	0.0356	>0.50
	(12/26042)	(17/47690)	

frequency of 0.0461% under oxygen is far from being significantly different relative to that of 0.0356% observed after the same exposure under nitrogen. Such oxygen enhancement pattern is also in line with that noted for the *dumpy* mosaics (Miyamoto 1978). This provides further evidence that as with the mosaics at the genic level, the frequency of mosaically expressed exceptions due to breakage events does not exhibit dependency on the irradiation condition such as oxygen and nitrogen.

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