On the Tetraploid Spermatocytes produced by Irradiation in *Podisma mikado* (Acrididae)

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In the course of work on the effect of irradiation on the chromosome structure in *Podisma* (Acrididae: Orthoptera), a number of tetraploid spermatocytes were found in the testes from three individuals of *P. mikado*. The chromosomes contained in these tetraploid spermatocytes are quite regular both in their behaviour and in their structural condition. This is not the usual state of affairs, since in Orthoptera, such chromosomal aberrations as fragmentation, translocation and multivalent formation, have been reported

as the usual phenomena resulting from irradiation (White '35, Helwig '38). Though the evidence is not very remarkable, however, publishing these notes may not be entirely uncalled for.

Figs. 1-5. Microphotographs. 1, section of the testis, containing a tetraploid cyst (late diplotene) shown by arrow. $\times 250$. 2, auxocyte of tetraploid (pachytene) shown by arrow. $\times 480$. 3, tetraploid spermatid shown by arrow. $\times 480$. 4, side view of tetraploid primary spermatocyte metaphase. Two X's go to one pole. $\times 950$. 5, metaphase polar view of tetraploid secondary spermatocyte. $\times 1200$.

Nymphs of *P. mikado* Bolivar were irradiated applying a uniform dosage, namely, the water-cooling Coolidge tube; 15 milliamperes; 50 kilovolts; 30 cm. target distance; 7 minutes exposure. After exposure they were allowed to develop until they reached the last nymphal instar stage at which the testes were fixed. Before irradiation, only spermatogonial cells were present in the testes of nymphs, so that the subsequent observations were made on the descendants of these irradiated cells.

The tetraploid spermatocytes occur abundantly in the testes at various stages in the growth period, also in the process of division of the primary and secondary spermatocytes, as well as in the stages

of spermatid formation (Figs. 1-8). In a few cases they constitute a cyst, the content of which is all in tetraploid condition (Fig. 1), while in a number of cases observed the tetraploid cells were found isolated among the normal cells in the cysts (Figs. 2-3). These tetraploid spermatocytes show no greater tendency to degenerate than the normal ones. They seem to be capable of forming giant spermatozoa. No multipolar spindles were ever found.

The fact that the tetraploid spermatocytes were found amongst the descendants of the irradiated spermatogonia indicates with high probability that syndiploidy had occurred at the last spermatogonial division.

A normal chromosome complex in the spermatogonial division of this species consists of 21 elements, 10 pairs of autosomes and a single unpaired X chromosome, all of the telomitic type. The normal primary spermatocyte contains 11 chromosomes, 10 autosome bivalents and an X element. The tetraploid complement of the primary spermatocyte consists of 22 chromosomes, 20 of which are autosome bivalents and the remaining two are X chromosomes univalent in nature (Fig. 6). In all the cases examined the formation of multivalents was entirely absent in this material, the occurrence of multivalent associations not being observed either in the nuclei of the growth stages or in the equatorial chromosomes. The two X chromosomes are, so far as the observations go, never united to form a bivalent in meiosis but remain unpaired as two distinct elements through the meiotic stages (Figs. 4, 6 and 7). In the first division either the two X chromosomes go by chance to one pole (Fig. 4) or one goes to each pole (Fig. 6). As a result, it may be expected that there should be produced three kinds of secondary spermatocytes as regards the distribution of the X element. Fig. 5 shows the polar view of the secondary spermatocyte metaphase in which 22 chromosomes, probably consisting of 20 autosomes and two X elements, are observable. In Fig. 8 is shown the anaphasic complement of the secondary spermatocyte containing 21 chromosomes which may include an X chromosome together with 20 autosomal elements.

Figs. 6-8. Camera lucida drawings. $\times 2500$. 6, side view of tetraploid primary spermatocyte metaphase, showing two X's moving to opposite poles. 7, two heteropycnotic X elements from the pachytene nucleus. 8, anaphasic complement of secondary spermatocyte. x, X-chromosome. n, nucleolus.

The evidence that the two X chromosomes in the tetraploid spermatocyte of the present species remain separate quite conforms with the observations of White ('33) in a locust, *Schistocerca*, and of Wilson ('32) in a bug, *Archimerus*. These two X chromosomes appear as two distinct pycnotic bodies during the growth period of the spermatocytes. The reason of this behaviour, it is believed, is the fact that they undergo a precocious condensation due to a process of earlier spiralisation than occurs with the autosomes, which, as we know, is characteristic of the sex chromosome. The fact demonstrated in *Archimerus* (Wilson '32), *Schistocerca* (White '33) and *Podisma*, that heteropycnosis of the X chromosome takes place in a tetraploid spermatocyte which contains the X in a coupled state, seems to offer an unfavourable evidence to the suggestion of Mohr ('15, '16) that heteropycnosis of the X during the growth period is owing to the absence of an homologous mate for this chromosome in the heterogametic sex.

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Literature

- Helwig, E. R. 1938. The frequency of reciprocal translocations in irradiated germ cells of *Circotettix verruculatus* (Orthoptera). Arch. Biol. **49**: 143-158.
- Mohr, O. L. 1915. Sind die Heterochromosomen wahre Chromosomen? Arch. Zellf. **14**.
- 1916. Studien über die Chromatinreifung der männlichen Geschlechtszellen bei *Locusta viridissima*. Arch. Biol. **29**.
- White, M. J. D. 1933. Tetraploid spermatocytes in a locust, *Schistocerca gregaria*. Cytologia **5**: 135-139.
- 1935. The effects of X-rays on mitosis in the spermatogonial divisions of *Locusta migratoria* L. Proc. Roy. Soc. London, Ser. B, No. 812, Vol. **119**: 61-84.
- Wilson, W. B. 1932. Polyploidy and metaphase patterns. Jour. Morph. **53**: 443-471.

和 文 摘 要

牧野佐二郎： X 線處理によつて生じたフキバツタの四倍性精母細胞

X 線にて處理せるフキバツタ (*Podisma mikado*) 3 個體の精巢内に四倍性の精母細胞が多數見受けられた。正常細胞に混じて見出される場合もあり(第 2-3 圖), 又 1 個の cyst 全部が四倍性細胞なる事もある(第 1 圖)。四倍性第一精母細胞の染色體數は 22 (正常の場合の 2 倍で, 多價染色體の形成はない)で, X 染色體は 2 個存在するが決して接合することなく, 第一分裂では機會的に分離する(第 4 及び 6 圖)。第一, 第二分裂を通じて染色體の分裂行動には異常なく, 結局四倍性精子細胞が作られるやうである。2 個の X 染色體が第一精母細胞の成長期を通じて接合せず異常濃縮をなして存在することは性染色體の異常濃縮現象を考へる上に参考となる。