Cytogenetic analysis and breakpoint distribution of radiation-induced interchanges in Hylemya antiqua Meigen

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Abstract

Over seventy chromosomal rearrangements have been isolated in the onion fly Hylemya antiqua with X-rays and fast neutrons on the basis of reduced fertility measurements and cytological analysis. Most rearrangements were asymmetrical reciprocal translocations, a few were triple translocations and one quadruple was observed. Two pericentric inversions were established. Both the meiotic and somatic pairing configurations were utilized. In seven out of 42 asymmetric translocations 'duplication' larvae were observed carrying a large duplication and a small deficiency resulting in a significantly higher egg hatch. The presence of such karyotypes can be disadvantageous for the genetic control of insect pests where the larval stage does the damage.

Relatively more breakpoints were established in chromosomes 2 and 6. It could be concluded from sib-crosses of reciprocal translocations in the onion fly that homozygotes can be produced without the use of morphological markers. The cytological analysis of adults following the assessment of extra reduced fertility compared to the testcross fertility is essential for the isolation of translocation homozygous individuals.

Introduction

Radiation induction of chromosomal rearrangements for use in genetic control has been carried out in a variety of insect species: Aslamkhan & Aaqil (1970), Curtis et al. (1972), Dennhöfer (1974), Van Heemert & Wijnands-Stäb (1975), Jost & Laven (1971), Maudlin (1976), Rabbani & Kitzmiller (1975), Sakai et al. (1971) and Wagoner et al. (1969). Recognition of translocations, inversions and other structural chromosome rearrangements can be achieved by pseudo-linkage, semi-sterility measurements, or cytological analysis. In the onion fly, Hylemya antiqua (Meigen), only the latter two methods can be employed due to the absence of sufficient morphological mutants. Chromosome analysis could be carried out easily in this insect in several tissues such as larval brains, embryos, ovaries and testes (meiotic and mitotic stages) and over seventy chromosomal rearrangements have been isolated.

In this report results of cytological analysis of the radiation-induced chromosomal rearrangements and their breakpoint distribution will be given. In some translocation stocks 'duplication' larvae were observed which carry a reasonably long additional segment and lack a small deficiency; such larvae are the product of adjacent-1 orientation. Due to the occurrence of 'duplication' larvae the egg semisterility in these translocation stocks is reduced, a neglected factor which might interfere with their application for insect pest control.

Testcrosses of several translocations were carried out and the ratio normal versus translocation heterozygotes was established following cytological analysis of the progeny. In sibercesses showing an increased sterility the relationship between the ratio of normal to translocation heterozygotes and the
occurrence of translocation homozygous larvae was investigated.

Material and methods

Cytological analysis of karyotypes could be carried out in young eggs (10 hours), brain cells of well fed larvae (5–10 days) and testes or ovaries of just eclosed flies. Staining of the tissues with 2% lacto-acetic orcein was carried out without prior fixation. Further details on cytological methods have been published before (Van Heemert, 1974). For the calculation of the expected breakpoint distribution along the chromosomes, the idiogram as developed by Boyes (1954) was used. Details on rearing, irradiation and fertility measurements can be found in previous reports (Van Heemert & Wijnands-Stäb, 1974 and Robinson & Van Heemert, 1975).

Results

Cytology of translocations and inversions

Over seventy chromosomal rearrangements have been isolated following irradiation with X-rays or fast neutrons. A small number of about ten rearrangements, included in this report, have been isolated and described in previous papers. The rearrangements were established cytologically in the progenies of testcrossed F_1 or F_2 parents. Testes of young adult males were used for the analysis of meiotic multivalents (Fig. 1B), so that translocations involving small translocated segments or segments of a similar size could also be identified. In later generations, mitotic analysis was mostly sufficient to discriminate the translocation from the normal karyotype (Fig. 1A). Most translocations were reciprocal (59) of which 42 were asymmetrical and 17 symmetrical. Symmetrical in this context means translocated segments of about equal size. Somatic pairing (in prometaphase) in the onion fly is important for the establishment of translocation multivalents (Fig. 1C). This is especially so in the case of symmetrical translocations in which the difference in size between the normal and translocated segments is rather small, or where translocated chromosomes become similar in size to the normal chromosomes involved in the translocation (symmetrical or asymmetrical).

Nine triple translocations were observed of which six were cyclic (three breakpoints, Fig. 1F) and three non-cyclic (four breakpoints or three-chromosome double type, Fig. 1G). One quadruple translocation (Fig. 1H) was observed and in one case two independent translocations were produced by a single mutation event. Compared to the large number of translocations (70) isolated only 2 inversions, both pericentric, were observed; one in chromosome 3 (Fig. 1I) and one in chromosome 6, both in the progenies of semi-sterile females. Since males have no crossing-over, duplication/deficiency gametes were not formed and thus males carrying the inversion show no semi-sterility. In three cases a combination between a translocation and an inversion was established, but no stocks with these rearrangements could be reared. Two sex-linked translocations were isolated, one X- and one Y-linked (Van Heemert, 1974 and Van Heemert & Vosselman, 1979) (Figs. 1D and 1E). Further, interesting features included karyotypes with a duplication which survived even as older larvae (Fig. 1K), karyotypes with a deficiency (Fig. 1L), haploid (androgenetic) eggs (Fig. 1M), triploid males (Fig. 1N), translocation trisomics (Fig. 1O) and compound chromosomes (Fig. 1P).

'Duplication' larvae

In the progenies of seven asymmetric translocations (total 42), larvae (mostly over 5 days old) were observed carrying a duplication of reasonable length and apparently a small deficiency (Fig. 1K) (no such 'duplication' larvae were observed among the progenies of 17 symmetrical translocation stocks as expected). As a result of adjacent-I segregation a type of gamete is produced which carries one normal chromosome and one translocated chromosome with a relatively long duplication and a short deficiency which can produce a viable larva after fertilization with a normal gamete from the other parent. The average egg fertility of asymmetrical translocation stocks with 'duplication' larvae is higher than stocks without 'duplication' larvae. The difference between these two categories is 10.1% (73.7–63.6) which is significant (P < 0.005; t_{34} = 2.939).