Cytogenetic analysis of three genetic sexing strains of Ceratitis capitata

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Summary. Polytene chromosomes of three genetic sexing strains of Ceratitis capitata were analyzed. The genetic sexing mechanism is based on a pupal color dimorphism (white – brown) and is the result of a reciprocal translocation between the Y chromosome and the autosome bearing the w locus (white pupal case). The analyzed polytene chromosomes were derived from two different pupal tissues, the orbital bristle and fat body cells. The Y chromosome is visible in both tissues, while the autosomes present a different banding pattern. Based on these features, the autosome breakpoints in the three Y; autosome translocations were mapped, and the homology of the translocated autosome in both tissues was established. In addition, the location of the break-points was compared to the stability of these three strains.

Key words: Genetic sexing – Polytene chromosome – Ceratitis capitata

Introduction

The advantages of a genetic sexing (GS) system for Ceratitis capitata for improving the efficiency of the sterile insect technique (SIT) have been extensively pointed out (Lachance 1979; Rossler 1979; Robinson and Van Heevelt 1982).

In such a program, understanding the genetics of the target species is essential. In recent years knowledge of the genetics of C. capitata has rapidly increased and a considerable number of mutants have been obtained (Medfly Genetics Information Circular 1987). Moreover, polytene chromosomes of C. capitata are now available, thereby providing material for cytogenetic analysis. Polytene maps have been made from pupal orbital trichogen cells (Bedo 1986, 1987) and larval salivary glands (Zacharopoulou 1987, 1990). Chromosome maps of both tissues are necessary because autosomes in each tissue have quite different banding patterns (Bedo and Zacharopoulou 1988).

Cytogenetic analysis is useful to understand the behavior and genetic stability of a GS strain. One of the problems in the existing strains is the breakdown of the GS mechanism, probably due to the recombination between the autosome breakpoint and the locus on which this mechanism is based.

Although the recombination occurs infrequently in males of C. capitata, it increases in the presence of chromosomal rearrangements (Rossler 1982). The occurrence of breakdown of the GS mechanism is a major concern when these strains are mass reared and released for population control by the SIT. Replacing a contaminated colony in which the sexing mechanism has broken down by a new “clean” population in the factory might interrupt the program and increase the costs of rearing, if several “clean” back-up colonies are maintained ready for replacement.

In the present study, polytene chromosomes from orbital trichogen and fat body cells of three GS strains based on puparial color were cytogenetically analyzed and mapped to determine the autosomal breakpoints. Based on this map, the homology of the translocated autosome between the two tissues was established. Since fat body polytene chromosomes have the same banding pattern as salivary gland (SG) chromosomes, we could correlate the translocated autosome between the polytene chromosomes of the trichogen cells (TC) and salivary glands.
Moreover, we tried to correlate the different stabilities of these strains to their autosomal breakpoints; hypothesis have been provided to explain these differences.

Materials and methods

Strains

With all three of the genetic sexing strains used, the separation mechanism is based on the puparial color. The male puparia are brown whereas female puparia are white. The strains are designated wp23, wp101 (Robinson and Van Heemert 1982), and wp30C (Bush-Petersen and Southern 1987).

Cytology

Mitotic preparations. Mitotic neuroblast metaphases were examined using the same technique as previously reported (Zacharopoulou 1987).

Polytene chromosome preparations. Polytene chromosome preparations from pupal orbital trichogen cells were made as described by Bedo (1987); for pupal fat body cells, the same method was used with a minor modification of the squash. The orbital trichogen cells were gently squashed as more pressure was applied to the fat body cells, since these are very condensed and not easily spread out. The orbital trichogen polytene chromosomes were interpreted on the basis of the standard chromosome maps for the trichogen chromosomes (Bedo 1987), while the salivary gland chromosome maps (Zacharopoulou 1990) were used for the fat body cells.

Results and discussion

Mitotic chromosome analysis of the three strains revealed that there is a reciprocal translocation between the Y chromosome and chromosome 5, as it was arbitrarily designated in previous work (Zacharopoulou 1990). Figure 1 shows that the Y breakpoint is on the long arm close to the centromere. The autosome breakpoint is also on its long arm, near the centromere. From the same figure it is also clear that both breakpoints are similar in all strains.

Detailed mapping of the autosome breakpoints was made by analysis of the polytene chromosomes. The Y breakpoint could not be determined since the sex chromosomes do not polypenize in Ceratitis capitata (Bedo 1987; Zacharopoulou 1987).

The Y chromosome is represented in pupal trichogen cells as a spherical dark body and a nucleolus (Bedo 1987). A similar structure can also observed in pupal fat body cells but not in larval fat body cells and salivary glands (Zacharopoulou 1987; Bedo and Zacharopoulou 1988). Whereas the sex chromosome structures of larval and pupal fat body cells are different, the autosomes have a banding pattern similar to the salivary gland polytene chromosomes. This observation is important because it could be used to identify homologous chromosomes from tissues where they cannot otherwise be recognized.

The structure of a Y; autosome translocation in polytene chromosomes depends mainly on the Y chromosome breakpoint. Bedo (1987) suggested that the Y nucleolar organizer is located at the secondary constriction of the short arm of the Y chromosome. If this chromosomal region is present in the karyotype, the nucleolus or the spherical body may be attached to the autosome breakpoint. This depends mainly on the chromosome pairing. Figure 2 shows that in the orbital trichogen polytene chromosomes of the three strains, the nucleolus was attached to the autosome for strains wp30C (Fig. 2a) and wp101 (Fig. 2b), while the spherical body was connected to the autosome in strain wp23 (Fig. 2c). It must be emphasized that in the first two strains the nucleolus was always attached to the autosome in all preparations examined. In contrast, in wp23 the spherical body or nucleolus was connected to the autosome. We could not explain this observation. Perhaps small differences in the Y breakpoints between the strains or artifacts could have