Identification of Mullerian Chromosomal Elements in Hawaiian Drosophila by in situ DNA Hybridization

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ABSTRACT: We have hybridized Drosophila melanogaster DNA sequences to polytene chromosomes of D. silvestris. The results support Muller's hypothesis that the chromosomal elements have been largely conserved in the evolution of the genus Drosophila. As originally suggested by Carson, D. melanogaster elements X, 2L, 2R, 3L, and 3R appear to correspond to chromosomes X, 3, 2, 5, and 4, respectively, in D. silvestris and the Hawaiian picture-winged species.

As early as 1940, H. J. Muller proposed that chromosomal arms (elements) in Drosophila have remained essentially intact throughout evolutionary history. The primitive karyotype of the genus, he proposed, consisted of five rod-shaped chromosomes (which he designated A–E) and a small dot chromosome (F). The subsequent evolution of the genus seems to have been accompanied by many paracentric inversions and a number of centric fusions, but relatively few translocations or pericentric inversions. Although inversions occurring through evolutionary time would shuffle the order of syntenic genes along an element, genes on a specific element in one species would generally be expected to be on the same element in all other species.

Muller's hypothesis has been tested by several types of interspecific studies: linkage relationships among genes thought to be homologous, banding patterns of salivary gland chromosomes, chromosomal location of nucleolar-organizer regions, and chromosomal locations of rDNA (e.g., Stuart et al. 1981, Sturtevant and Novitski 1941). It is often equivocal, however, whether inferred homologies are real; e.g., is the gene that is mapped as the white locus in one species the same gene that causes white eyes in other members of the genus? In situ DNA hybridization can establish homologies with much less ambiguity.

We have hybridized recombinant plasmids carrying Drosophila melanogaster DNA from each of the five large chromosomal elements to polytene chromosomes of D. silvestris, one of the Hawaiian picture-winged species. Since the polytene banding pattern homology of elements in the picture-winged species has been described exhaustively (e.g., Carson and Yoon 1983), the use of D. silvestris allows us to tie the D. melanogaster elements to that entire large Hawaiian series.

MATERIALS AND METHODS

The recombinant plasmids containing Drosophila melanogaster DNA were obtained from G. Rubin (pm12.8, white locus, polytene chromosome position 3C), T. Barnett (pYP3, a yolk protein locus, 12BC), J. E. Natzle (DTBI and DTB3, beta-tubulin loci, 97EF and 60C, respectively), M. Higgins via R. MacIntyre (p7R6, a putative vitelline membrane gene, 26A), and J. Lis (aDm63BC.1, hsp83 locus, 63BC). Probes and chromosomes were prepared, hybridized, and stained as described by Pliley et al. (1986).

RESULTS

The results of the hybridizations are summarized in Table 1. Each probe hybridized to

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a precise site on an element. This suggests that in situ hybridization is very specific and demonstrates genic homology. Further, there seems to have been neither deletion nor obvious duplication of the loci involved. No element in *Drosophila silvestris* hybridized with probes from more than one *D. melanogaster* element. This is consistent with the hypothesis that there have been no translocations involving the genes represented by these probes.

DISCUSSION

Gene homologies between *Drosophila melanogaster* and several other congeneric species were studied by Sturtevant and Novitski (1941). Their work compared mutant alleles that displayed similar phenotypes, and suggested that chromosomal elements are indeed conserved in evolution as Muller (1940) proposed.

A number of studies using in situ DNA hybridization have added additional evidence of element conservation. A notable early study is that of Wimber and Wimber (1977), involving the hybridization of 5S RNA to polytene chromosomes of six species of the *virilis* group. Kubli (1984) and Steinemann et al. (1984) provide both basic data and references to other work. Research to date has centered primarily on the *melanogaster*, *virilis*, and *obscura* groups. As a general summation (to this point), these studies have demonstrated that single-copy genes are linked in ways that support Muller’s original proposal of linkage conservation. Genes involving repeated sequences, however, appear to have undergone rearrangements (e.g., translocations) that are not consistent with Muller’s hypothesis. The present study has employed only single-copy sequences.

Based on his extensive experience with polytene banding patterns of the Hawaiian picture-winged species, Carson (personal communication, 1982) tentatively suggested that Hawaiian elements X, 3, 2, 5, and 4 correspond to *Drosophila melanogaster* elements X, 2L, 2R, 3L, and 3R, respectively. The *D. silvestris* homologies we have determined are indeed in precise agreement with this suggestion. The identification is strengthened by the finding of Brennan et al. (1984) that the *Adh* locus, known to be on 2L in *D. melanogaster* (Lindsley and Grell 1968) is, as would be predicted, on chromosome 3 in the Hawaiian picture-winged species.

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LITERATURE CITED


