Pachytene Karyotype Analysis of Tetraploid *Meloidogyne hapla* Females by Electron Microscopy

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**Abstract.** Pairing of homologous chromosomes results in the formation of 34 synaptonemal complexes (SC) at pachytene, corresponding to the 34 bivalents at metaphase I. No multivalent associations were observed and pairing occurs two-by-two. The modified SC, which lacks a central element, does not affect the pairing process. Only one end of the SC is attached to the nuclear envelope, although either end can attach. Total SC length and the number of recombination nodules in the tetraploid were about 1.5 times greater than in the diploid.

**Introduction**

The synaptonemal complex (SC) has been described in a wide variety of organisms during the pachytene stage of meiotic prophase I (for review see Westergaard and von Wettstein, 1972; Gillies, 1975). This tripartite structure is usually limited to those organisms that undergo meiosis and its presence has been confirmed in the root-parasitic nematode *Meloidogyne hapla*, diploid strain (Goldstein and Triantaphyllou, 1978a). Two races of *M. hapla* have been recognized in this species (Triantaphyllou, 1966): Race A comprises diploid populations that reproduce by cross-fertilization or meiotic parthenogenesis (Automixis) and have 17 synaptonemal complexes (Goldstein and Triantaphyllou, 1978b); Race B comprises populations which are diploid or triploid and reproduce exclusively by mitotic parthenogenesis (Apomixis) (Triantaphyllou and Hirschmann, 1980). Synaptonemal complexes have been observed only in Race A and they are modified in that they lack a central element. It has been suggested that the modified SCs may represent an evolutionary step toward ameiotic type of maturation of oocytes and, consequently, a step toward mitotic parthenogenesis (Goldstein and Triantaphyllou, 1978a). It is interesting to note that SCs without central elements have also been reported in the amphimictic green algae *Chlamydomonas* (Storms and Hastings, 1977) and *Ulea* (Braten and Nordby, 1973).
The SCs of diploid (Goldstein and Triantaphyllou, 1979), aneuploid, and tetraploid forms (Goldstein and Triantaphyllou, 1980) of the plant-parasitic nematode *Heterodera glycines* have been described. *H. glycines*, a close relative of *Meloidogyne*, is amphimictic and has a normal, tripartite SC. There are no multivalent chromosomal associations at pachytene in the tetraploid. The SCs of the diploid form of the meiotic parthenogenetic *M. hapla* have also been described (Goldstein and Triantaphyllou, 1978a). Although zygotene pairing cannot be followed because unpaired axial cores of SCs of nematodes cannot be observed, the SCs at early pachytene are completely formed and remain so through late pachytene with no apparent changes.

The present study describes the pachytene karyotype as revealed by three-dimensional reconstruction of SCs in autotetraploid oocytes of *M. hapla*.

**Materials and Methods**

The tetraploid population (n=34) of the present study was propagated from an egg mass of a single female from a diploid population of *M. hapla* (n=17) which was observed to have 34 bivalent chromosomes in oocytes at metaphase. It had been propagated for two years as a fertile culture (low incidence of males, thus, reproduction occurs mainly via meiotic parthenogenesis) under controlled greenhouse conditions (Figs. 1, 2).

The methods employed for preparation of materials for electron microscopy, karyotype analysis and determination of nuclear volume have been described previously (Goldstein and Triantaphyllou, 1978a, b).

Four oocyte nuclei were selected in the pachytene stage of meiosis and completely reconstructed following electron microscopy of serial sections. Nuclei no. 1 and no. 2 were from two adjacent oocytes in the same ovary and were at early pachytene. Nuclei no. 3 and no. 4 were from two other females and were in mid-pachytene (Table 1). Staging of oocytes in early-, mid-, or late-

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**Figs. 1 and 2.** Photomicrographs of prometaphase chromosomes of maturing oocytes of *Meloidogyne hapla*. **Fig. 1.** Diploid form with 17 bivalents. **Fig. 2.** Tetraploid form with 34 bivalents. Bar equals 2 μm