

Chromosome number of Populations of *Radopholus similis* from North, Central, and South America, Hawaii, and Indonesia ⁽¹⁾

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SUMMARY

Chromosome numbers were determined in seventeen populations of *Radopholus similis* from widely separated geographic regions of the world, viz. Honduras, Costa Rica, Panama, Mexico, Ecuador, Guatemala, Hawaii (U.S.A.), Indonesia and Florida (U.S.A.). All specimens examined had haploid chromosome numbers of either $n = 4$ or $n = 5$, the same numbers found, respectively, in the banana and citrus race of *R. similis* from Florida. Five populations had been characterized previously as possible biotypes of these races based on differences in their reproductive rates. No variation in chromosome numbers was observed among biotypes. The consistency in chromosome numbers further demonstrates the reliability of the karyotype for distinguishing the banana race ($n = 4$) from the citrus race ($n = 5$).

RÉSUMÉ

Nombre chromosomique de populations de Radopholus similis originaires d'Amérique du Nord, Centrale et du Sud ainsi que des Hawaii et d'Indonésie

Le nombre de chromosomes a été déterminé chez dix-sept populations de *Radopholus similis* provenant de régions géographiques bien distinctes : Honduras, Costa-Rica, Panama, Mexique, Equateur, Guatemala, Hawaii (U.S.A.), Indonésie et Floride (U.S.A.). Pour quelques pays, plusieurs populations ont été examinées. Dans tous les spécimens observés, le nombre chromosomique était $n = 4$ ou $n = 5$, ce qui correspond aux nombres haploïdes trouvés respectivement chez les races « banane » et « citrus » de *R. similis* en Floride. Cinq de ces populations avaient déjà été caractérisées comme biotypes probables de ces deux races en raison de différences observées dans leur reproduction. Les résultats obtenus montrent qu'à l'intérieur de chaque biotype il n'existe pas de variations dans le nombre de chromosomes. Ceci confirme que le caryotype est un critère valable pour établir la distinction entre la race « banane » ($n = 4$) et la race « citrus » ($n = 5$).

Uniformity in the number of chromosomes seems to be characteristic in all bisexual nematodes species thus far examined (Triantaphyllou & Hirschmann, 1980). For example, the chromosome numbers within three bisexual species of *Pratylenchus* were $n = 5$, 6, and 7 (Roman & Triantaphyllou, 1969). Populations of these *Pratylenchus* spp. were from several locations, yet their chromosome numbers were consistent. Differences in chromosome numbers within or between populations of a nematode species would indicate a major genic change that would be of evolutionary importance. White (1978) pointed out that 90-95% of all speciation events have been accompanied

by karyotypic changes. Such karyotypic differences are also of considerable taxonomic value in many other groups of animals.

The banana and citrus races of *Radopholus similis* from Florida were found to have a chromosome number of $n = 4$ and $n = 5$, respectively (Huettel & Dickson, 1981). This difference in chromosome number between the two races may indicate an evolutionarily significant mutational event. It is probable that either a chromosome fusion or a dissociation occurred in one race to give rise to the other. However, because nematodes have either holocentric or polycentric chromosomes (White, 1974; Fiiil, Goldstein

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& Moens, 1977), the mechanics of which are not well understood, the most probable direction of the mutation cannot be elucidated currently.

The literature on physiological races of *R. similis* is complicated by the description of biotypes of each race (Pinochet 1978, 1979; O' Bannon & Ford, 1979; Tarte & Pinochet 1981). An "isolate" was defined by Pinochet (1979) as a population of the banana race that differs in reproductive capabilities from other populations of the race. O' Bannon and Ford (1979) described two possible biotypes of the citrus race as populations that can break resistance in root-stocks of *Citrus* spp. The terms "biotype", "isolate", and "race" are often used interchangeably, thus a clarification of their definitions is necessary before describing populations of *R. similis*. "Race" will be used here to denote a selective difference in host preference within a species of plant parasitic nematode (e.g., citrus race). "Biotype" will be used to denote any unusual characteristic exhibited by a population of a described race (e.g., reproductive differences or resistance breaking of a resistant variety of its normal host). Four biotypes of the banana race described by Pinochet (1979) and one citrus race biotype described by O' Bannon and Ford (1979) were included in this study.

The objectives of this study were to determine *i*) the existence of karyotypic uniformity among populations of the banana race ($n = 4$), *ii*) the karyotype of populations of *R. similis* from other host plants from both Florida and other locations worldwide, and *iii*) the occurrence of karyotypic differences within biotypes of the same race.

Materials and Methods

Seventeen populations of *R. similis* from widely separated geographic regions of the world were maintained by carrot disc culture (Huettel, 1982) for cytogenetic analysis. Six populations of the banana race of *R. similis* were from collections maintained on disc culture at the Tropical Research Division, United Brands Fruit Co., La Lima, Honduras. The populations had been previously described as "biotypes" by Pinochet (1979) and were originally collected from *Musa* sp. from the following locations: Tapachula, Mexico; La Lima, Honduras; Coto, Costa Rica; Armuelles, Panama; Changuinola, Panama; and Machala, Ecuador. Another population of *R. similis* from Central America was cultured from a shipment of quarantined *Musa* sp. from Guatemala. Its exact origin is unknown. One additional population of the banana race was obtained from *Musa* sp. growing in an abandoned commercial plantation in Dade County, Florida.

Two populations of the citrus race, one of which was considered to be a biotype by O' Bannon and Ford (1979), were obtained from the U.S.D.A. Horticultural Laboratories, Orlando, Florida. Two populations originating from infected citrus roots growing in Polk County were obtained, also from the Florida Department of Agriculture and Consumer Service (FDACS), Burrowing Nematode Laboratory, Lake Alfred, Florida.

Other populations used in this study were from quarantined shipments of *Philodendron* sp. and *Maranta* sp., FDACS, Division of Plant Industry, Nematology Section, Gainesville, Florida, and *Anthurium andraeanum* L. and *Musa* sp., Department of Plant Pathology, University of Hawaii, Honolulu, Oahu. An Indonesian population from black pepper (*Piper nigrum* L.) was examined at Rothamsted Experimental Station, Harpenden, Herts., England.

The method for determining chromosome numbers was modified from Triantaphyllou (1975) and reported previously (Huettel & Dickson, 1981). Approximately 200 to 500 female nematodes were examined for each population.

Observations

The number of chromosomes established for each population examined is listed in Table 1. All populations from banana had four chromosomes (examples illustrated in Fig. 1). The Indonesian population from black pepper had four chromosomes as did populations from the ornamentals, *Philodendron* sp. and *Maranta* sp. The four populations from *Citrus* spp. and the one from *A. andraeanum* had five chromosomes (examples illustrated in Fig. 2).

Discussion

Karyotypic uniformity within the banana and citrus races of *R. similis* is important in clarifying their taxonomic status. Eight populations that originated from banana and three populations from *Philodendron* sp., *Maranta* sp., and black pepper were determined to have four chromosomes. Although many ornamentals are known to be good hosts of both races (Poucher *et al.*, 1976), both populations obtained from quarantined ornamental shipments from outside of Florida had four chromosomes. Populations from *Citrus* spp. from Florida and *A. andraeanum* from Hawaii had five chromosomes.

The Hawaiian population of *R. similis* from *A. andraeanum* had five chromosomes like the Florida citrus race. This is the first report of a five chromosome population of *R. similis* outside the state of Florida. Therefore the five chromosome populations

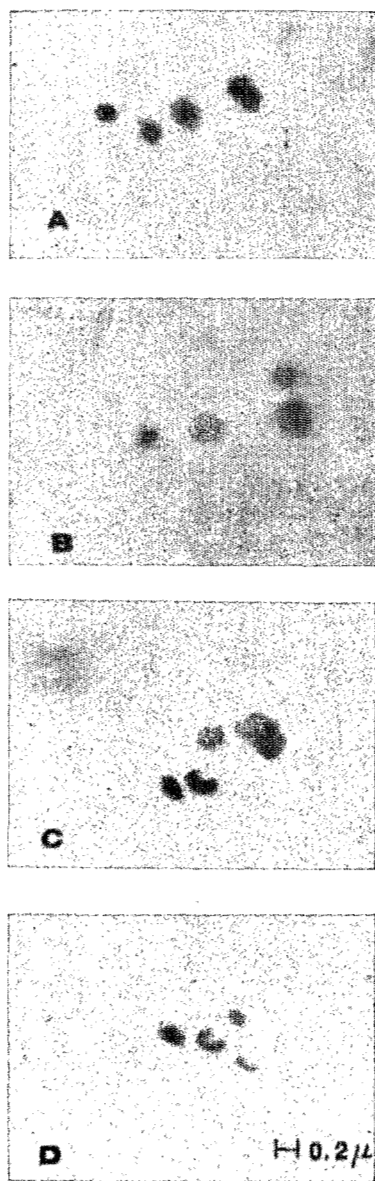


Fig. 1. Photographs of metaphase I, $n = 4$ chromosomes of the banana race of *Radopholus similis* from : A : Tapachula, Mexico, B : La Lima, Honduras, C : Armuelles, Panama, and D : Machala, Ecuador. (Chromosomes darkened to enhance resolution).

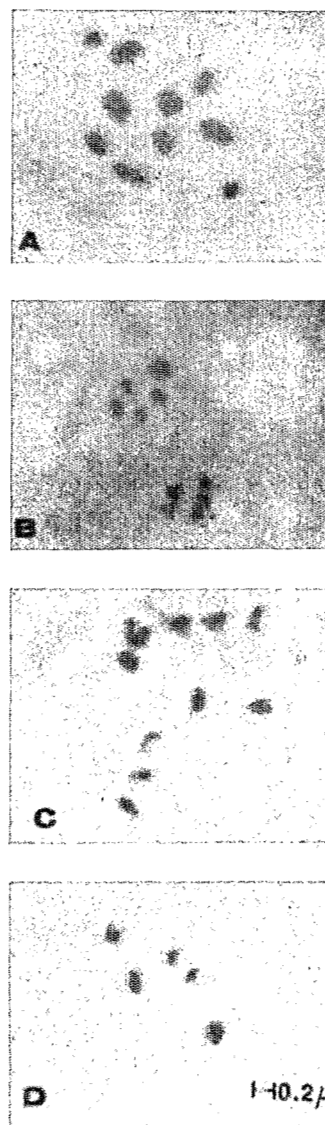


Fig. 2. Photographs of the chromosomes of four populations of the citrus race of *R. similis*. A : Citrus, Polk County, FL, oogonial metaphase, $n = 10$, B : Citrus, Polk County, FL, metaphase I, $n = 5$, C : Orlando, FL, metaphase I, $n = 5$, and D : *Anthurium*, Hawaii, metaphase I, $n = 5$. (Chromosomes darkened to enhance resolution.)

are not restricted to Florida as previously assumed. Consequently, five chromosome races of *R. similis* may have evolved with the four chromosome race in another area of the world and was spread subsequently with crops and ornamentals other than *Citrus* spp.

Even though there is a difference in chromosomal number between the citrus and banana races, no such differences were found within the races. The biotypes of either race examined had the chromosomal number expected for that race. Therefore, chromosomal numbers are not implicated in the way each biotype responds physiologically. This is not to say that the reported differences among the biotypes within *R. similis* populations are not genetically induced. Alpha karyology (counts of number of chromosomes and their approximate size) does not allow one to draw conclusions about other possible genetic mechanisms that could bring about the differentiation of biotypes. The minute size of the chromosomes also prevents observation of any types of chromosomal rearrangements that may exist among biotypes of the same race.

TABLE 1

Origin, host, and haploid chromosome number of seventeen populations of *Radopholus similis*

Origin	Host	Haploid Chromosome Number
Tapachula, Mexico	banana	4
Guatemala	banana	4
La Lima, Honduras	banana	4
Coto, Costa Rica	banana	4
Armuellas, Panama	banana	4
Chanquinola, Panama	banana	4
Machala, Ecuador	banana	4
Dade County, Florida	banana	4
Unknown	<i>Philodendron</i> sp.	4
Unknown	<i>Maranta</i> sp.	4
Hawaii	banana	4
Indonesia	black pepper	4
Florida	citrus	5
Florida	citrus	5
Polk County, Florida	citrus	5
Polk County, Florida	citrus	5
Hawaii	<i>Anthurium</i>	5

Karyotypic uniformity is expected in sexually reproducing diploid species (White, 1978). Differences in chromosome number indicate that the two races are distinct species (White, 1978). The use of cytogenetic techniques is a quick and reliable method for identification of populations of *R. similis*. The technique may be of value also in understanding phylogenetic relationships between races.

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