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Distribution, Hosts, and Morphological Characteristics of *Tylenchulus palustris* in Florida and Bermuda

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Abstract: Studies on the geographical distribution and hosts of *Tylenchulus palustris* were conducted over a 3-year period in Florida and Bermuda. *Tylenchulus palustris* was found on *Aster elliottii* and *Liquidambar styraciflua* roots in swamps of northern and central Florida. It was detected also on *Borrichia arborescens* and *B. frutescens* roots in tidal marshes of northern Florida and coastal rocklands of southern Florida and Bermuda. Posterior bodies of *T. palustris* swollen females from Bermuda did not differ from those of the paratypes; however, second-stage juvenile bodies and male tails from Bermuda were longer than those of the paratypes. Greenhouse host tests indicated that *Mikania scandens* is a host of *T. palustris* but not of *T. semipenetrans*.

Key words: aster, *Aster elliottii*, Bermuda, *Borrichia arborescens*, *Borrichia frutescens*, citrus nematode, climbing hempweed, ecology, Florida, host range, *Liquidambar styraciflua*, *Mikania scandens*, sea oxeye, sweet gum, *Tylenchulus palustris*, *Tylenchulus semipenetrans*.

Tylenchulus palustris Inserra et al. was described from native plants in northern Florida (5). Pop ash (*Fraxinus caroliniana* Mill.) and salt bush (*Baccharis halimifolia* L.) were the first described hosts (4). Nematode habitats included hammocks and waterlogged soils (wooded swamps), which may be under 30 cm of fresh water 3--5 months annually. Recently, *T. palustris* was found infecting peach (*Prunus persica* (L.) Batsch.) in Alabama, Arkansas, and Georgia (6), and noncultivated plants along the coast of Bermuda (unpubl.). There has been regulatory interest in *T. palustris* in Florida because of its close morphological similarity to the citrus nematode, *T. semipenetrans* Cobb. *Tylenchulus palustris* was known as a "grass" race of the citrus nematode and was subjected to the same restrictions as *T. semipenetrans*. For regulatory purposes it is important to define the host range and distribution of this nematode and to differentiate it from that of *T. semipenetrans*.

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MATERIALS AND METHODS

A survey was conducted in Florida and Bermuda in 1986–89 to obtain more information about the host range and geographical distribution of *T. palustris*. In Florida the survey of 800 samples was limited to native broadleaf plants of northern, central, and southern regions of the state because previous studies (4) indicated that native dicots from swampy habitats and tidal marshes were the preferred hosts of this species. Surveyed sites with plants characteristic of Florida flora (8) were selected on the basis of *Tylenchulus* sp. infestation records from the files of the Florida Bureau of Nematology (Table 1). In Bermuda 265 samples were collected from cultivated and uncultivated inland, coastal, and small island sites. Plant species sampled in the coastal areas of Bermuda (1) are listed in Table 1.

Samples consisting of 1 kg soil and associated roots were collected from each site, placed in plastic bags, and stored at 7–10 C for up to 10 days before nematode extraction. Soil was processed by the centrifugal flotation method (7) to collect *T. palustris* second-stage juveniles (J2) and males. Roots from sites infested with J2 and males were separated by plant species, washed, and examined with the aid of a stereomicroscope for swollen females. Live nematodes were mounted in water agar (3) and identified with a compound microscope.

TABLE 1. Surveyed plants from coastal rocklands, swampy habitats, and tidal marshes of Florida and from coastal areas and small islands of Bermuda.

Florida	Bermuda
Acer sp.	*Borrichia* sp.
Aster sp.	*Citharexylum spinosum* L.
Baccharis sp.	*Coccoloba uvifera* L.
Borrichia sp.	*Conocarpus erectus* L.
Conoclinium coelistinum (L.) DC.	*Erigeron darrellianus* Hensl.
Diospyros virginiana L.	*Euphorbia buxifolia* Lam.
Fraxinus caroliniana Mill.	*Ipomoea* sp.
Juniperus sp.	*Schinus terebinthifolius* Raddi
Laguncularia racemosa (L.) Gaertn. f.	*Sesuvium portulacastrum* L.
Liquidambar styraciflua L.	*Sisyrinchium* sp.
Magnolia virginiana L.	*Solidago sempervirens* L.
Myrica cerifera L.	
Persea sp.	
Pinus elliottii Engelm.	
Quercus sp.	
Q. virginiana Mill.	
Rhapidophyllum histrix (Pursh) Wendl. & Drude.	
Sabal sp.	
Salicornia virginica L.	
Salix sp.	
Sesuvium portulacastrum L.	
Vitis spp.	

Morphological characteristics of *T. palustris* populations from new hosts in Florida and Bermuda were compared with those of paratypes. Selected morphological data for females, males, and J2 were subjected to Student's *t*-test.

A separate survey was conducted on climbing hempweed, *Mikania scandens* (L.) Willd. (= *M. batatifolia* DC.), which grows in the habitats preferred by *T. palustris* and was found in the past to be infected by *T. semipenetrans* in hammocks of southern Florida (2). The *M. scandens* survey, which included 60 samples mainly from northern and central Florida, was conducted in order to determine the association of *T. semipenetrans* and *T. palustris* with this plant.

To confirm the host suitability of *M. scandens* to *T. semipenetrans* and to determine its host status to *T. palustris*, 10 *M. scandens* seedlings were transplanted, each in 15-cm-d plastic pots containing 1,800 cm^3 soil. Soil from five pots was infested with two *T. palustris* J2/cm^3, and soil from the other five pots was infested with three *T. semipenetrans* J2/cm^3. In each pot containing *T. semipenetrans* infested soil, one 6-month-old sour orange (*Citrus aurantium* L.) seedling was transplanted in combination with climbing hempweed. Pots were arranged in a completely random design on a greenhouse bench and maintained at 20–30 C. Three and five months after transplanting, the seedlings were removed from pots infested with *T. semipenetrans* and *T. palustris,* respectively, and the nematode densities of both parasites in soil were determined (7). Males and J2 from roots were obtained by root incubation (9). Adult females were recovered from roots by root maceration and centrifugal-flotation (7).

RESULTS AND DISCUSSION

Both herbaceous and woody plants were found as hosts of *T. palustris* (Table 2). *Aster elliottii* T. & G. and *Liquidambar styraciflua* L. grow in wooded swamps often inundated with fresh water and rich in organic matter (Table 2). *Borrichia arborescens* (L.) DC. and *B. frutescens* (L.) DC. infected with *T. palustris* were found along the coastal areas of southern Florida and Bermuda and also in tidal marshes subject to periodic inundation with salt water along the coast

TABLE 2. New hosts and habitats of *T. palustris* in Florida and Bermuda.

Host		Habitat
Aster elliottii T. & G.	Aster	River bank, Florida (Ichetucknee River)
Borrichia arborescens (L.) DC.	Sea oxeye	Coastal rockland, Florida (Biscayne Bay), and Bermuda
B. frutescens (L.) DC.	Sea oxeye	Tidal marsh, Florida (Jacksonville), coastal rockland, Florida (Biscayne Bay), and Bermuda
Liquidambar styraciflua L.	Sweet gum	Swamp, Florida (Aucilla wildlife management area)
Mikania scandens (L.) Willd.	Climbing hempweed	Greenhouse pot, Florida (Gainesville)

of northern Florida. No evidence was found of *T. palustris* infecting other plants growing inland in Bermuda. In the small rocky islands of Bermuda, sea oxeye plants were growing in association with a few other halophilic plants in shallow soil (2.5–10 cm deep) on narrow plateaus located in somewhat elevated positions or in crevices where the plants were protected from the direct action of ocean waves. All were exposed regularly to ocean spray. In tidal marshes of northeastern Florida and in the environments of Bermuda, *T. palustris* populations were often associated with marine nematodes. *Tylenchulus palustris* distribution in Florida includes Columbia, Dixie, Duval, Escambia, and Taylor counties in northern Florida, Polk in central Florida, and Dade in southern Florida. In Bermuda *T. palustris* is widespread on sea oxeye along the coastal areas. Nine of fifteen sea oxeye sites sampled were infested with *T. palustris*.

The morphological characteristics of *T. palustris* populations detected on these new hosts in Florida and Bermuda did not differ from those reported in the original description or from other populations collected from other hosts and peach (5,6). Swollen females of *T. palustris* from sea oxeye in Bermuda had conoid postvulval bodies as do paratypes and populations from Florida (Fig. 1A–D). Widths of the postvulval body and postvulval body core of specimens from Bermuda were similar to those reported for *T. palustris* paratypes (11.7–18.6 and 7.8–14.7 vs. 11.2–17.3 and 5.1–12.2 μm) (5). Mucros (0.6–2.0 μm long) were observed at the body terminus of swollen females (Fig. 1B) collected from both sea oxeye and sweet gum in Florida and Bermuda. *Tylenchulus palustris* males from Bermuda had cylindrical tails with rounded termini similar to those of paratypes; however, in some specimens tails were longer ($P = 0.05$) than those of paratypes (39.2–48.0 vs. 33.6–43.8 μm, with c values of 7.6–9.0 vs. 8.1–11.1) (5). Body widths were smaller ($P = 0.05$) in some specimens from Bermuda (11.3–13.7 μm) than those of paratypes (12.2–14.2 μm) (5). No differences were found in other morphological characters of males compared with the paratypes. *Tylenchulus palustris* J2 from Bermuda had longer ($P = 0.05$) bodies than the paratypes and other populations from Florida (334.1–390.0 vs. 277.4–354.9 μm) (5). Their body length did not differ, however, from that of *T. palustris* J2 from peach, which ranged from 313.6 to 398.8 μm (6). Tail lengths of J2 were greater ($P = 0.05$) than those of paratypes (49.0–52.9 vs. 45.0–50.9 μm with c values of 7.1–7.3 vs. 7.2–8.0) (5), but did not differ from those of peach populations (37.2–55.8 μm, with c values of 6.3–10.3) (6). The rectum and anus were visible in ca. 45% of the J2 specimens examined from Bermuda compared with 70% and 60% of the J2 from Florida and peach, respectively (6).

Tylenchulus palustris appears to be adapted to different soil conditions of inland fresh and coastal saline areas. In the small Cock Rock Island of Bermuda, where the nematode was found in small patches of sea oxeye plants growing on the top of the island, the ecosystem receives more salt water by ocean waves than fresh water by atmospheric precipitation, as indicated by the exclusive presence of halophilic plants.

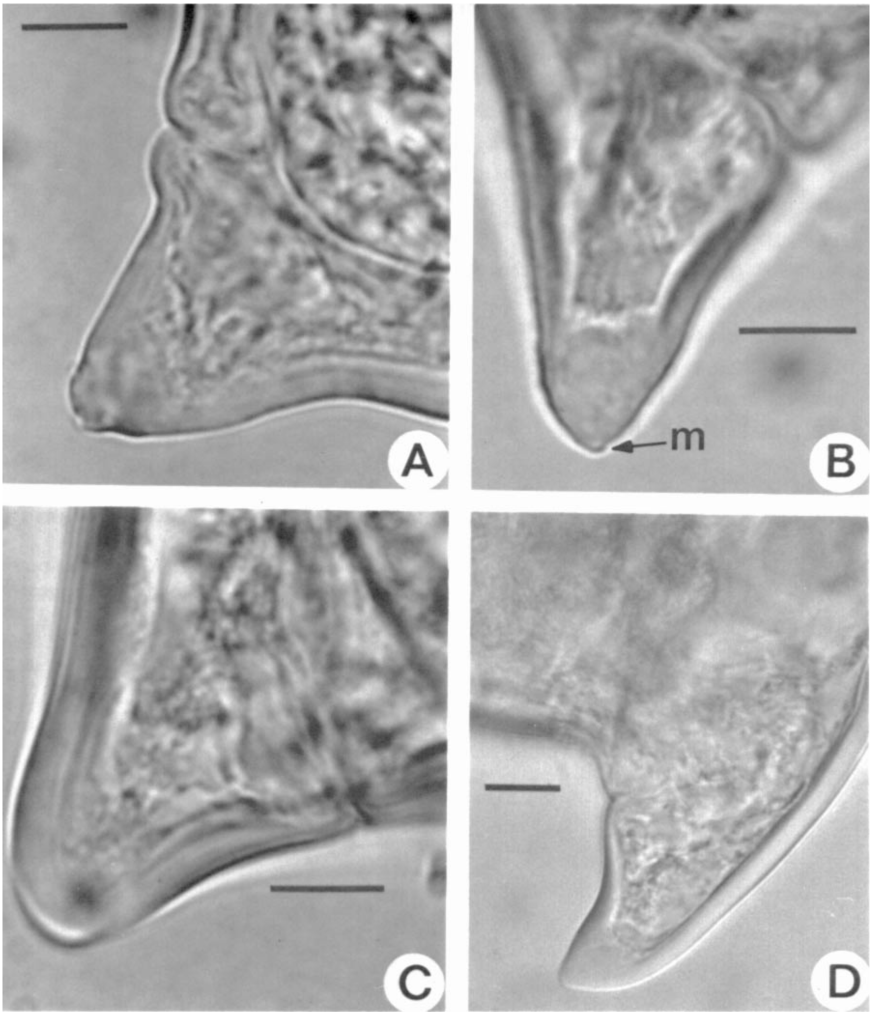

FIG. 1. Posterior bodies of *Tylenchulus palustris* swollen females. A, B) Specimens from sea oxeye in Bermuda. m = mucro. C) Specimen from sweet gum in Florida. D) Paratype specimen from pop ash in Florida. Note the conoid shape of these body portions in all populations. Scale bars = 10 μm.

These conditions of high salinity did not prevent *T. palustris* infection and reproduction on sea oxeye plants. Because *T. palustris* occurs on sea oxeye along the coastal areas of Florida and Bermuda, we cannot exclude the possibility that sea oxeye plants infected with *T. palustris* were transported by the northeasterly flowing Gulf Stream from Florida or other infested sites of the Caribbean basin to the more recently formed islands of Bermuda.

There was no evidence of *T. semipenetrans* infestations in uncultivated hammocks where *M. scandens* grows, but *M. scandens* is a host of *T. palustris.* Five months after transplanting, *T. palustris* soil density in pots with climbing hempweed remained at 2 J2/cm^3, whereas the *T. palustris* density in roots was 35 J2 and 5 females/g fresh roots. Three months after transplanting, *T. semipenetrans* soil density in the pots with the combination of *M. scandens* and sour orange seedlings increased to 7 J2/cm^3 from an initial population density of 3 J2/cm^3. No *T. semipenetrans* infection was detected on *M. scandens* roots, whereas *T. semipenetrans* levels on sour orange seedlings were 102 J2 and 85 females/g fresh roots. *Tylenchulus palustris* densities on *M. scandens* were lower than those of *T. semipenetrans* on sour orange and similar to *T. palustris* densities found on other hosts (4,6). The host list reported here and in previous papers (4,5) suggests that *T. palustris* prefers plants of the Compositae. Aster, climbing hempweed, salt bush (4), and sea oxeye belong to this botanical family; however, the nematode detection on hosts of other families such as Hamamelidaceae (sweet gum), Rosaceae (peach), and Oleaceae (pop ash) indicates a botanically broad host range of this tylenchulid.

Literature Cited

1. Britton, N. L. 1965. Flora of Bermuda. London: Hafner Publishing.

2. Chitwood, B. G., and W. Birchfield. 1957. Citrus-root nematode a native to Florida soils. Plant Disease Reporter 41:525.

3. Esser, R. P. 1986. A water agar en face technique. Proceedings of the Helminthological Society of Washington 53:254–255.

4. Inserra, R. N., J. H. O'Bannon, K. R. Langdon, and W. M. Keen. 1988. Hosts of *Tylenchulus graminis* and *T. palustris.* Nematology circular No. 154, Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville.

5. Inserra, R. N., N. Vovlas, J. H. O'Bannon, and R. P. Esser. 1988. *Tylenchulus graminis* n. sp. and *T. palustris* n. sp. (Tylenchulidae) from native flora of Florida, with notes on *T. semipenetrans* and *T. furcus.* Journal of Nematology 20:266–287.

6. Inserra, R. N., N. Vovlas, A. P. Nyczepir, E. J. Wehunt, and A. M. Golden. 1990. *Tylenchulus palustris* parasitizing peach trees in the United States. Journal of Nematology 22:45–55.

7. Jenkins, W. R. 1964. A rapid centrifugal-flotation method for separating nematodes from soil. Plant Disease Reporter 48:692.

8. Long, R. W., and O. Lakela. 1971. A flora of tropical Florida. Coral Gables: University of Miami Press.

9. Young, T. W. 1954. An incubation method for collecting migratory endoparasitic nematodes. Plant Disease Reporter 38:794–795.