
*Radopholus similis*, the burrowing nematode colonizes and reproduces in roots and rhizomes of *Anthurium andraeanum* Linden ex Andre in Madeira, Portugal. Histological examination of nematode-infected rhizomes shows necrosis and cavities extending from the cortical parenchyma into the vascular bundles. Nematode feeding and migration caused disruption of the vascular bundles. All nematode life stages, coiled juveniles, adults, including gravid females, and eggs, occurred in the phloem. Nematode specimens were also observed in metaxylem elements.

**Key words**: *Anthurium andraeanum*, burrowing nematode, histopathology, Madeira, *Radopholus similis*, rhizomes.

**RESUMEN**


*Radopholus similis*, el nemá­todo barrenador, coloniza y se reproduce en las raíces y los rizomas de *Anthurium andraeanum* Linden ex Andre, en Madeira, Portugal. Examinación histológica de rizomas infectados con el nemá­todo indica necrosis y cavidades que se extienden del parénquima cortical a los receptáculos vasculares. La alimentación y migración del nemá­todo causaron rotura de los receptáculos vasculares. Todos los estados del nemá­todo, juveniles espirales, adultos, incluido hembras hinchadas, y huevos, ocurrieron en el floema. Ejemplares del nemá­todo también fueron observados en elementos del metaxilema.

**Palabras clave**: *Anthurium andraeanum*, nemá­todo barrenador, histopatología, Madeira, *Radopholus similis*, rizomas.

**INTRODUCTION**

The burrowing nematode *Radopholus similis* (Cobb) Thorne, is recognized as a serious economic pest of banana and citrus (Du Charme and Price, 1966; Gowen and Quénéhervé, 1990; O’Bannon, 1977). This nematode is also a damaging pest for the ornamental industry in many tropical countries because it infects and reproduces on many plant ornamentals (Esser et al., 1988).

Anthurium, *Anthurium andraeanum* Linden ex Andre, is very susceptible to and damaged by this pest in tropical and sub-tropical areas such as: Hawaii and Jamaica (Aragaki et al., 1984; Huton et al., 1980; Sipes and Litchy, 1998); Florida (Esser et
al., 1988); and Trinidad and Tobago (Bala and Hosein, 1966). In recent years, the production of this plant ornamental has been hampered by burrowing nematode infection in the island of Madeira, Portugal (Vovlas et al., 1998; Vovlas et al., 2000). Nematode-infected anthurium showed extended decay of roots and rhizomes. The burrowing nematode is commonly a root feeder but it can also infect other plant organs such as leaves and rhizomes (Lehman et al., 2000). The anatomical alterations induced by R. similis in root tissues are well known (Blake, 1961; Du Charme, 1959; Vallette et al., 1997). A recent study reports extensive damage of leaf tissues of anubias infected by R. similis (Lehman et al., 2000). There is a scarcity of reports on the anatomical alterations caused by R. similis in the rhizomes of ornamental plants. Rhizomes are underground stems, which in the case of anthurium are damaged by the nematode. The objective of the present study was to determine the nematode parasitic habits on anthurium rhizomes.

MATERIAL AND METHODS

Roots and rhizomes were collected from infected anthurium plants growing in greenhouse under plastic cover. Rhizomes with nematode lesions were cut into 3-5 mm pieces, placed in petri dishes containing tap water and incubated for 24 h. The emerged nematodes were counted, and population densities estimated. Rhizomes used for histological studies were selected from those that showed high nematode numbers after 24 h. Selected rhizomes were cut into 5 × 5 × 5 mm slices, fixed in FAA (formaldehyde, acetic acid, ethanol), dehydrated in a tertiary butyl alcohol series, and embedded in 58°C melting point paraffin. Embedded material was sectioned 10-12 µm thick, stained in safranin and fast green, and mounted permanently in Dammar xylene. Selected sections were examined and photographed (Johansen, 1940).

RESULTS AND DISCUSSION

Biological and histological observations:

All life stages (eggs, juveniles and adults) of R. similis emerged from both roots and rhizomes after incubation in water. The highest numbers recovered were 185 and 288 nematodes per g root and rhizome tissues, respectively, indicating that the nematode invades and colonizes both type of plant organs. Examination of stained plant tissues confirmed these findings. Histological examination of cross and longitudinal sections of infected roots and rhizomes showed that the nematodes were able to invade the cortical parenchyma by moving intracellularly. In the rhizomes, they also reached and penetrate into the vascular bundles colonizing metaxylema elements (Fig. 1B,E-G). Nematode feeding and migration induced large cavities in the phloem. Phloematic tissues constitute the preferred trophic site by the nematode, which, inside the bundles, causes disruption of vascular elements (Fig. 1C,D). Necrosis was also observed in the cavities (Fig. 1C,D). As noted in other studies, necrotic lesions are also a consequence of the subsequent invasions of secondary organisms (Du Charme and Price, 1966, Lehman et al., 2000).

Remarks:

Radopholus similis behaves as a cortical root feeder on the majority of its hosts. Peripheral damage of the central cylinder of citrus roots has been reported by Du Charme (1959), and of the vascular bundles of anubias leaves by Lehman et al. (2000). Vallette et al. (1997) observed that
Fig. 1. Histology of uninfected (A) and nematode-infected anthurium rhizomes (B-G). A) Cross section showing two healthy vascular bundles (HVB). B) Cross sections showing nematodes inside two metaxylem elements (arrows). Note a cavity (CA) in the phloem. C, D) Cross sections showing cavities (CA), nematodes (N), and necrosis (dark stained cell walls) in the phloem of the vascular bundles. E-G) Longitudinal sections showing nematodes (N) into and around metaxylem elements. Scale bars: A-D = 100 µm; E-G = 50 µm.
the nematode invasion of vascular elements (metaxylema) occurred in roots of susceptible banana cv. Poyo, but not in resistant banana cv. Yangambi, where the nematode remained confined to the cortical tissues. Vallette et al. (1997) concluded that host susceptibility and absence of resistance factors of chemical and anatomical nature such as constitutive β-1,3-glucans and suberization of the endodermal cell walls are essential requirements for the nematode invasion of the vascular tissues and consequent increased plant damage. O’Bannon (personal communication) found invasion of vascular tissues by \textit{R. similis} citrus race in susceptible citrus rootstocks. The burrowing nematode parasitizes many aroids (ornamental plant species in the Araceae family), which have different geographical origin in the world (Bailey and Bailey, 1976). Some of these foliage ornamentals such as \textit{Epipremnum} spp. originated and co-evolved as hosts with the nematode in the Far East, which also is the center of origin of \textit{R. similis} (Ryss and Wouts, 1997; Sher, 1968). However, other aroid species, such as anthuriums, originated in the tropical America and became hosts of the nematode at a later time. It is reasonable to assume that, in spite of the great geographical distance from the center of origin of \textit{R. similis}, the burrowing nematode adapted and became able to parasitize this new plant species when the nematode was introduced to tropical America with infected banana propagative material (Marin et al., 1998). The destructive effect of the nematode on anthuriums extended to the rhizome vascular system, as it does in susceptible banana and citrus cultivars.

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LITERATURE CITED


Parasitism of anthurium rhizomes by *R. similis*: Vovlas et al.


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