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Occurrence of *Pasteuria* spp. in Florida[1]

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Abstract: Two years of data collected from the Florida Nematode Assay Laboratory of the Florida Cooperative Extension Service and 4 years of data from the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, were compiled to find out the distribution of *Pasteuria* spp. on nematodes in Florida soils. Information recorded came from 335 samples and included nematode genera with *Pasteuria* endospores attached, host plants associated with the samples, and the origins of the samples. *Pasteuria* spp. were detected on 14 different plant-parasitic nematode genera in 41 Florida counties and associated with over 39 different plant species and in seven fallow fields. *Pasteuria*-infected nematodes were associated with a wide range of plant hosts, although frequency of associations with these hosts reflected the sample bias of the laboratories involved. *Meloidogyne* and *Hoplolaimus* spp. were the two nematode genera most frequently associated with *Pasteuria*. *Pasteuria* spp. were observed attached to members of these two genera in 176 and 59 soil samples, respectively.

Key words: bacterium, biological control, endospore, Florida, lance nematode, *Meloidogyne, Hoplolaimus,* nematode, *Pasteuria penetrans, Pasteuria* spp., root-knot nematode

Pasteuria spp., obligate parasites of plant-parasitic nematodes, have potential as economically and environmentally practical biological control agents. These organisms have been found on a variety of nematode hosts and in many different climates and environmental conditions throughout the world (11). Recent field observations (1,6,8) and many successful greenhouse and microplot experiments (2–5,9), demonstrate that these organisms can provide effective control of plant-parasitic nematodes. Their commercial development as nematode biological control agents is limited because methods of mass production have not been developed.

The Florida Nematode Assay Laboratory (FNAL), University of Florida, and the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Bureau of Entomology, Nematology and Plant Pathology-Nematology Section (DPI), both located in Gainesville, Florida, routinely process soil samples for detection and identification of plant-parasitic nematodes. Until recently, the presence of nematodes infected with *Pasteuria* spp., though often observed, was not recorded by either laboratory.

The frequency of occurrence of *Pasteuria* spp. as related to their nematode hosts and the nematodes' host plants is important to establish if they are to be developed as commercial biological control agents. This is a compilation of data collected by the FNAL and DPI laboratories in Gainesville on the host association and distribution of *Pasteuria* spp. in Florida.

Materials and Methods

The FNAL laboratory provides soil analysis primarily to aid growers in management of existing nematode problems or advisory information on potential nematode problems. Soil and root samples from turfgrasses, vegetables, and agronomic crops made up approximately 86% of the samples received by FNAL during the 2 years *Pasteuria* data were recorded. The FNAL laboratory analyzed an average of 6,242 samples each year; however, only one of the technicians (R. Cox) recorded the incidence of *Pasteuria* spp. The DPI laboratory analyzes soil samples for detection of plant-parasitic nematodes for growers who need certification to ship plants out of state. Approximately 65% of their samples come from nurseries producing ornamental plants, and the laboratory analyzed an average of 18,000 samples per year during the 4 years *Pasteuria* data were

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recorded. The occurrence of *Pasteuria* spp. was recorded by only one of the four nematologists at the DPI laboratory beginning in 1990. Workers from both laboratories did not actively search for the presence of *Pasteuria* spp., but recorded observations when they were noticed.

Both laboratories extract nematodes from soil by modifications of the flotation-centrifugation technique (7). Nematodes were extracted from roots by incubating them in a modified Baermann funnel (10) or submerging them in water in a glass jar. Nematodes in sample extracts were observed with dissecting, inverted, or compound light microscopes. Frequencies and densities of plant-parasitic nematode genera, origins of soil samples, and host plant associated with the soil or root samples were recorded. Information for this report includes all data collected by FNAL over a 2-year period (1992–93) and by DPI over a 4–year period (1990–93).

Results and Discussion

Pasteuria spp. endospores were observed attached to nematodes in 64 samples from DPI and in 271 samples from FNAL. *Pasteuria* endospores were observed on 14 different plant-parasitic nematode genera (Table 1) in 41 counties of Florida (Fig. 1), associated with over 39 different plant species (Table 2) and in seven fallow fields. *Pasteuria*-infected plant-parasitic nematodes were also found in 10 samples associated with members of the Gramineae and 37 mixed-root nursery samples for which the generic names were not recorded. *Pasteuria*-infected *Meloidogyne* spp. juveniles and *Hoplolaimus* spp. occurred most frequently in 176 and 59 soil samples, respectively. The most common host plants associated with *Pasteuria*-infected nematodes were members of the Gramineae, *Stenotaphrum* spp. (102 samples), and *Cynodon* spp. (52 samples). Researchers at both laboratories often observe *Pasteuria* spp. endospores on soil nematodes other than plant parasites, but they did not record these observations.

Table 1. Compilation of nematode genera observed to have *Pasteuria* spp. endospores attached and frequency of occurrence in soil and root samples recorded by the Florida Cooperative Extension Service 1992–93, and the Florida Department of Agriculture and Consumer Services, Division of Plant Industry 1990–93.

Genera	Frequency of occurrence
Belonolaimus	24
Criconemella	5
Helicotylenchus	12
Hemicycliophora	1
Heterodera	12
Hoplolaimus	59
Hypsoperine	1
Meloidodera	1
Meloidogyne	176
Paratrichodorus	4
Pratylenchus	21
Tylenchorhynchus	10
Gylenchulus	4
Xiphinema	1

The high frequencies of endospore-infested nematodes observed in *Stenotaphrum* spp. and *Cynodon* spp. soil samples were partially due to the types of samples received by the FNAL laboratory. Soil from turfgrasses with soilborne disease problems made up 27% of the samples received in this laboratory during the period these data were recorded. The most common plant-parasitic nematodes observed in these samples were *Meloidogyne* spp. (56%) and *Hoplolaimus* spp. (29%).

Until recently, the presence of *Pasteuria*-infected nematodes was of little interest and often not detected because the endospores are small, ca. 2.0–6.0 μm, requiring high-power magnification to verify their presence. This compilation of data suggests that *Pasteuria* spp. are common in Florida soils. Researchers at the University of Florida (Dickson and Hewlett, unpubl.) have found *Pasteuria* spp. on plant-parasitic and fungivorous feeding nematodes in all agronomic, turfgrass, and vegetable research fields sampled. The frequency and occurrence of nematodes parasitized by *Pasteuria* spp. in Florida soils is underestimated by these data because workers in both laboratories did not systematically survey for *Pasteuria* spp. Con-

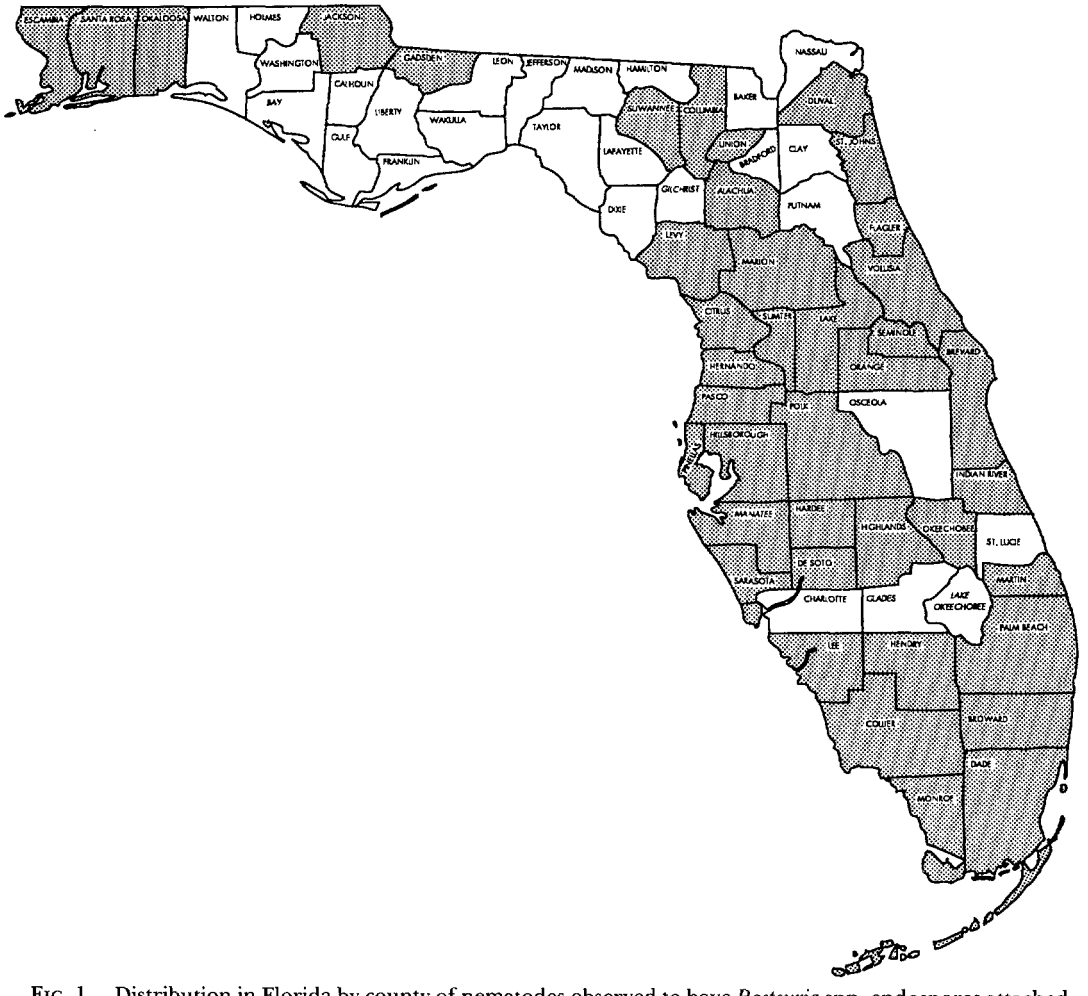

FIG. 1. Distribution in Florida by county of nematodes observed to have *Pasteuria* spp. endospores attached (shaded counties).

TABLE 2. Compilation of host plants associated with nematodes infected with *Pasteuria* spp. and frequency of occurrence in soil and root samples assayed by the Florida Cooperative Extension Service 1992–93, and the Florida Department of Agriculture and Consumer Services, Division of Plant Industry 1990–93.

Genera	Frequency of occurrence	Genera	Frequency of occurrence
Abelmoschus	1	*Ligustrum*	4
Arachis	13	*Liriope*	5
Arecastrum	3	*Lycopersicon*	2
Azalea	1	*Musa*	1
Brassica	2	*Nicotiana*	22
Buxus	4	*Paspalum*	1
Camelia	1	*Phaseolus*	6
Citrus	11	*Philodendron*	1
Cocos	1	*Photinia*	1
Crucifer	1	*Privet*	1
Cucumis	1	*Radermachera*	1
Cucurbita	1	*Sabal*	1
Cynodon	52	*Saccharum*	5
Daucus	2	*Solanum*	4
Dracaena	2	*Sorghum*	14
Ficus	1	*Stenotaphrum*	102
Gossypium	2	*Syagrus*	4
Impatiens	1	*Trifolum*	1
Iris	1	*Zea*	2
Ixora	2		

tinued observation of the occurrence of this nematode parasite will undoubtedly reveal that it is present in all Florida counties, infecting nematodes associated with numerous crops.

Literature Cited

1. Bird, A. F., and P. G. Brisbane. 1988. The influence of *Pasteuria penetrans* in field soils on the reproduction of root-knot nematodes. Revue de Nématologie 11:75–81.

2. Brown, S. M., J. L. Kepner, and G. C. Smart, Jr. 1985. Increased crop yields following application of *Bacillus penetrans* to field plots infested with *Meloidogyne incognita*. Soil Biology and Biochemistry 17:483–486.

3. Brown, S. M., and G. C. Smart, Jr. 1985. Root penetration by *Meloidogyne incognita* juveniles infected with *Bacillus penetrans*. Journal of Nematology 17: 123–126.

4. Channer, A. G., and S. R. Gowen. 1988. Preliminary studies on the potential of *Pasteuria penetrans* to control *Meloidogyne* species. Proceedings of Brighton Crop Protection Conference, Pests and Diseases. Surrey, England: The British Crop Protection Council.

5. Davies, K. G., B. R. Kerry, and C. A. Flynn. 1988. Observations on the pathogenicity of *Pasteuria penetrans*, a parasite of root-knot nematodes. Annals of Applied Biology 112:491–501.

6. Dickson, D. W., D. J. Mitchell, T. E. Hewlett, M. Oostendorp, and M. F. Kannwischer-Mitchell. 1991. Nematode-suppressive soil from a peanut field. Journal of Nematology 23:526 (Abstr.).

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

8. Minton, N. A., and R. M. Sayre. 1989. Suppressive influence of *Pasteuria penetrans* in Georgia soils on reproduction of *Meloidogyne arenaria*. Journal of Nematology 21:574–575 (Abstr.).

9. Oostendorp, M., D. W. Dickson, and D. J. Mitchell. 1991. Population development of *Pasteuria penetrans* on *Meloidogyne arenaria*. Journal of Nematology 23:58–64.

10. R. Rodríquiz-Kábana, P. S. King, and M. H. Pope. 1981. Combinations of anhydrous ammonia and ethylene dibromide for control of nematodes parasitic on soybeans. Nematropica 11:27–41.

11. Sayre, R. M., and M. P. Starr. 1988. Bacterial diseases and antagonism of nematodes. Pp. 69–101 *in* G. O. Poinar and H. B. Jansson, eds. Diseases of nematodes, vol. 1. Boca Raton, FL: CRC Press.