# *PASTEURIA*: A HOST-SPECIFIC BACTERIAL PARASITE OF PLANT-PARASITIC NEMATODES WITH DIFFERENT LIFE HISTORIES

Bacteria in the genus *Pasteuria* have many of the attributes required of a useful biocontrol agent of nematodes: a multiplicity of strains capable of parasitising all important nematode pests; specificity towards particular nematodes; resilience to environmental stresses; and a capacity to reduce the fecundity of the host nematode. This fact sheet provides an overview of the genus.

**General life cycle and development of *Pasteuria***

*Pasteuria* and *Bacillus* are closely related bacterial genera. One of their characteristics is that they produce endospores, a survival structure which allows them to lie dormant for many years and survive dryness, high temperatures, and other harsh conditions in the soil. *Pasteuria* produces endospores 3-5 µm in diameter that are shaped like a flying saucer, and its life cycle begins when the endospores adhere to the cuticle of a nematode as it moves through the soil (Fig. 1). The attached endospores germinate, a germ tube penetrates the cuticle (Fig. 2), and then the bacterium proliferates throughout the nematode's body, preventing it from reproducing. Sporulation then occurs, and so the body is eventually filled with large numbers of endospores (Fig. 3).

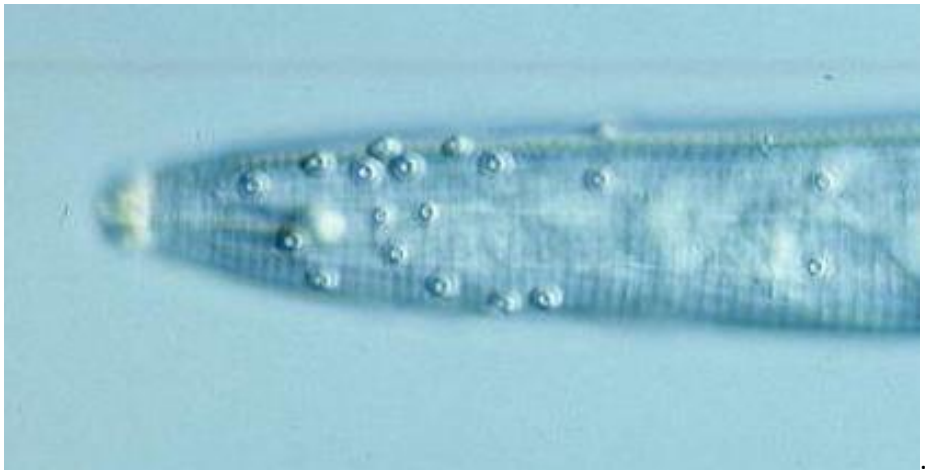

Fig. 1 Numerous *Pasteuria* endospores attached to the cuticle of a nematode

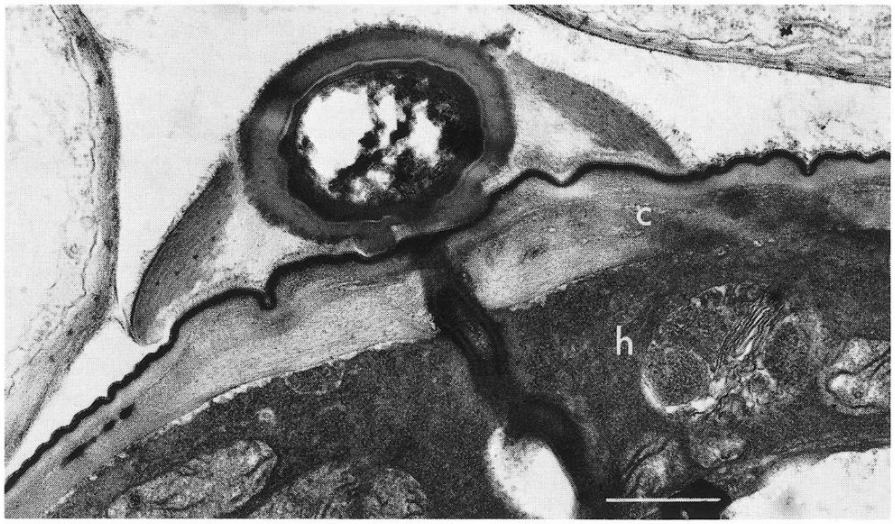


Fig. 2. A cross section through a germinated endospore of *Pasteuria penetrans*, showing the germ tube penetrating the cuticle (c) and hypodermis (h) of its host: a root-knot nematode juvenile. Bar = 0.2 µm.

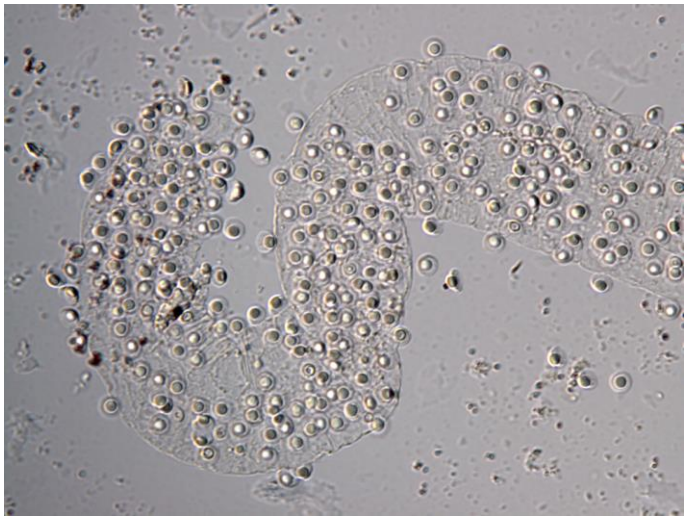

Fig. 3. Endospores of *Pasteuria* in a cadaver of root-lesion nematode (*Pratylenchus zeae*)

**Distribution, host range and diversity**

*Pasteuria* occurs throughout the world and has been found in association with many different nematodes, including all the plant-parasitic nematodes that cause damage to food and fibre crops. However, studies have shown that *Pasteuria* species and strains are host specific, which means they will only infect one or a limited range of nematode species.

Plant-parasitic nematodes have several different feeding habits or lifestyles and are often classed as sedentary endoparasites, migratory endoparasites or ectoparasites (see Fact sheet PSN 001). However, all these nematodes spend at least some of their lives in soil and can become encumbered with *Pasteuria* endospores as they migrate through the soil to feed on roots. The way *Pasteuria* interacts with three nematodes that have quite different lifestyles is covered below.

***PASTEURIA PENETRANS*, A PARASITE OF ROOT-KNOT NEMATODE (*MELOIDOGYNE* SPP.)**

*Pasteuria penetrans* is the most widely studied *Pasteuria* species, as it is hosted by root-knot nematode, the world's most widespread and damaging nematode pest. The life cycle of *P. penetrans* is similar to other *Pasteuria* species, but because its nematode host enters a root and then becomes an obese female about 1 mm in diameter, *P. penetrans* has a much larger body in which to multiply. Consequently, as many as two million endospores may be produced in an infected female.

Because huge numbers of endospores are produced in a parasitised nematode, *P. penetrans* is relatively easy to mass produce. A host plant such as tomato is inoculated with spore-encumbered juveniles, and when the female nematodes have developed to maturity and are filled with endospores, the root systems are dried, ground into a fine powder and stored for future use. Spores in root systems can be quantified in different ways, but concentrations greater than $1\times 10^8$ endospores/g root are consistently obtained with this method.

This *in vivo* production method has been widely used to produce inoculum for greenhouse and field experiments and the results of this work suggest that spore concentrations greater than $10^5$ spores/g soil are required to achieve a high level of root-knot nematode control. Other studies have shown that the number of juveniles entering roots declines as the spore concentration in soil increases. When nematodes are encumbered with more than about 15 endospores, their capacity to move is inhibited and they are often unable to enter a root.

Although most research on *P. penetrans* has focused on inundative methods of control, research in Australia has shown that naturally occurring to populations provide some control of root-knot nematode in perennial crops such as grapevines and sugarcane. Details can be found in Fact sheet PSN 008.

***PASTEURIA THORNEI*, A PARASITE OF ROOT-LESION NEMATODE (*PRAYLENCHUS* SPP.)**

Root-lesion nematode (*Pratylenchus*) is a migratory endoparasite, which means that it enters a root and feeds on root tissue as it moves through the root. There are more than one hundred species in the genus *Pratylenchus*, and collectively they are an important group of plant-parasitic nematodes, with most food and fibre crops being attacked by at least one species.

The *Pasteuria* species which attacks root-lesion nematode is known as *Pasteuria thornei* and an Australian study showed that it is occasionally present at levels which provide some control of *Pratylenchus zeae*, a damaging pest of sugarcane. When this occurs, about 50% of the nematodes extracted from soil are

either parasitised or have endospores attached. Infected females are unable to produce eggs and their cadavers are eventually filled with 400-650 endospores (Fig. 3).

Although *Pasteuria thornei* is present in most sugarcane soils, tillage is thought to be the reason that it only occasionally controls *Pratylenchus zeae*. Most sugarcane soils in Australia are aggressively cultivated during the replanting process and this reduces the endospore concentration by mixing soil from the root zone (where most endospores are located), with soil from other parts of the profile. This hypothesis is supported by observations made in a tillage trial in a Spanish greenhouse following a crop of French beans. More than 75% of the *Pratylenchus neglectus* were encumbered with *Pasteuria* endospores but the percentage of nematodes with spores attached was significantly higher in untilled than tilled plots.

## *CANDIDATUS* PASTEURIA USGAE PARASITIC ON STING NEMATODE (*BELONOLAIMUS LONGICAUDATUS*)

Sting nematode (*Belonolaimus longicaudatus*) is an ectoparasitic nematode that is widespread in the sandy soils of the south-eastern region of the United States. It is a devastating pest of turfgrass on golf courses, home lawns and other recreational areas and also causes yield losses on many crops, including carrot, maize, cotton, peanut, potato, soybean, and strawberry. When *Pasteuria* was first found on *B. longicaudatus* it was designated as the 'large-spored' isolate because its endospores were much larger than those found on other nematodes. Initial studies showed that it was relatively host-specific, as endospores attached to *Belonolaimus* species but not to other nematode genera. As phylogenetic analyses showed that the isolate from *B. longicaudatus* differed from other strains of *Pasteuria*, it was described as a new species and given the name *Candidatus* Pasteuria usgae.

### Ecology and biological control potential

Studies of *Candidatus* Pasteuria usgae on turfgrass in Florida have shown that up to 80% of the sting nematodes at a site may be encumbered with endospores; that spore-filled cadavers usually contain between 2,000 and 5,000 spores; and that infection levels at some locations are high enough to supress populations of the nematode. However, observational evidence suggests the level of control could possibly be increased if more was known about the following issues.

- **Release of endospores from cadavers**. *Pasteuria* endospores do not become available to infect the next generation of nematodes until the cadaver of a parasitized nematode disintegrates and the endospores are released into the soil. Thus, factors which influence the disintegration process may affect the level of control obtained. In highly managed environments such as golf course turf, we need to know whether the fungicides and other commonly used pesticides affect the soil microflora that degrade the nematode cuticle, thereby influencing the rate of endospore release.
- **Downward movement of endospores**. Numerous studies have shown that *Pasteuria* endospores are leached downwards by water flow in coarse-textured soils. This leaching process is particularly important in the ecology of *Candidatus* Pasteuria usgae because the host nematode is only found in sandy soils, and these soils are irrigated regularly and are also subject to the intense rainfall events that occur in a subtropical environment. As endospores can move downwards at least 30 cm when a golf putting green is irrigated, we need to know whether irrigation practices or heavy rainfall events influence the biocontrol capacity of *Candidatus* Pasteuria usgae.

### Further reading

Stirling GR (2014) Biological control of plant-parasitic nematodes. 2nd edition. Soil ecosystem management in sustainable agriculture. CAB International, Chapter 7 (pages 193-222) and Chapter 12 (pages 370-375).


**Author:** Graham R Stirling, Plant and Soil Nematodes. **Contact details:** graham.stirling@biolcrop.com.au