

Entomopathogenic Nematodes of Thrips *Thripinema* spp. (Nematoda: Tylenchida: Allantonematidae)¹

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Introduction

Several species of entomopathogenic nematodes in the genus *Thripinema* are known to naturally parasitize thrips (Thysanoptera). *Thripinema fuscum* Tipping and Nguyen is the most common species in Florida (Figure 1). *Thripinema fuscum* is economically important because it is a natural enemy of the insect pest, the tobacco thrips, *Frankliniella fusca* (Hinds).

Taxonomy

The first observation of parasitic nematodes of thrips was made by Uzel (1895) in Europe when an unnamed nematode was reported in the body cavity of *Thrips physapus* L. A nematode inhabiting bean thrips, *Heliothrips fasciatus* L., was reported in California by Russell (1912), but not described.

The first description of parasitic nematodes of thrips was not made until 1932 by Sharga, who described the nematode *Tylenchus aptini* from *Aptinothrips rufus* Gmelin in England. Following that, Lysaught (1936) proposed the name *Anguillulina aptini* for this species (Tipping 1998).

In 1986, the genus *Thripinema* was erected by Siddiqi during a taxonomic revision of the species, *Howardula* (Mason and Heinz 2012). The genus revision included renaming the nematode species described by Sharga (1932) as *Thripinema aptini*.

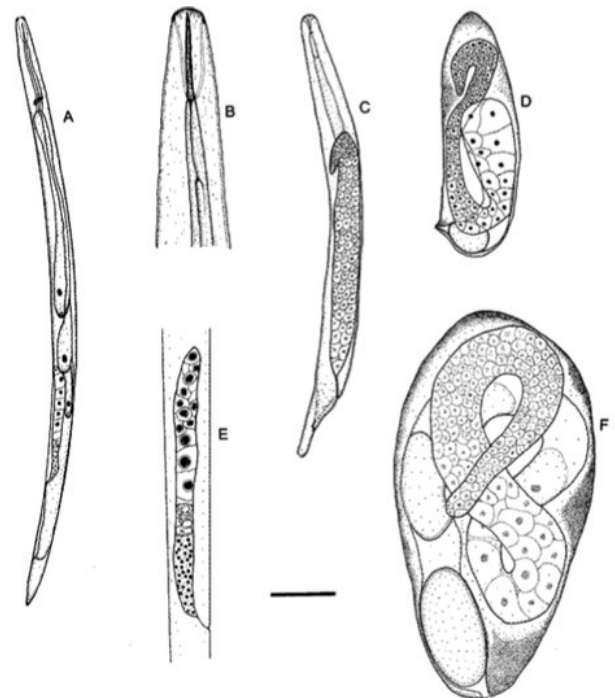


Figure 1. *Thripinema fuscum*, female. A) Infective female. B) Anterior region of infective female. C, D, F) Progressive enlargement of parasitic female. E) Gonad of infective female. Photograph from Tipping C, Nguyen KB, Funderburk JE, Smart GC. 1998. *Thripinema fuscum* n. sp. (Tylenchida: Allantonematidae), a parasite of the tobacco thrips, *Frankliniella fusca* (Thysanoptera). *Journal of Nematology* 30: 232–236. Used with permission.

Currently, there are five species in the genus *Thripinema*: *Thripinema aptini* (Sharga 1932), *Thripinema nicklewoodi* (Nickle and Wood 1964), *Thripinema reniraoi* (Reddy et al.

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1982), *Thripinema khrustalevi* (Chizhov et al. 1995), and *Thripinema fuscum* (Tipping et al. 1998).

Host Range and Distribution

Nematodes in the genus *Thripinema* are host specific. Currently, the five described species of *Thripinema* have been recovered from twelve species among eight genera of thrips: *Thrips physapus* L., *Aptinothrips rufus* Gmelin, *Frankliniella vaccinia* Morgan, *Frankliniella occidentalis* Pergande, *Frankliniella fusca* Hinds, *Taeniothrips vaccinophilus* Hood, *Stenothrips graminium* Uzel, *Catinathrips vaccinophilus* Hood, *Heliiothrips* species, and *Megaluriothrips* species (Arthurs 2005).

The distribution of *Thripinema* most likely reflects where surveys have been conducted, not necessarily the global distribution of the nematodes. Today, *Thripinema* species are known to occur in Canada, Germany, India, Russia, the United Kingdom, and the United States (Arthurs 2005).

Life Cycle and Biology

Thripinema species are obligate parasites but unlike other entomopathogenic nematodes in the families Steinernematidae and Heterorhabditidae, *Thripinema* species must keep their host alive for their survival (Funderburk and Latsha 2005). The current understanding of *Thripinema* biology suggests that the life cycle of each species is similar (Mason and Heinz 2002).

The total development time from egg to adult is 9 days upon entering the host (Sims et al. 2012). The infective female nematode enters the thrips host and becomes vermiform within the thrips hemocoel (Sims et al. 2012). Within 4–5 days of entering the hemocoel, female nematodes oviposit eggs. Eggs hatch into juveniles within 6–8 days of parasitization and feed on fluids within the host's abdominal cavity (Figure 1) (Mason and Heinz 2002, Sims et al. 2012). Fourth-stage juveniles migrate to the hindgut, where males inseminate females before emergence from the anus or ovipositor (Sims et al. 2012).

Little is known about *Thripinema* species after they emerge from the host. However, free-living *Thripinema* appear to attack thrips in the moist microclimate within flowers, leaf galls, and the terminal ends of developing foliage (Loomans et al. 1997).

Thripinema species do not kill their host and infected thrips do not show obvious signs of parasitism (Arthurs 2005). However, adult female thrips parasitized as larvae do not produce eggs and female thrips parasitized as adults stop

laying eggs within 2–3 days (Sims et al. 2005). Parasitism also reduces the feeding of the thrips host (Arthurs and Heinz 2003) and ability of thrips to transmit plant viruses (Sims et al. 2005, 2009).

All stages of thrips are susceptible to parasitism by *Thripinema* species. Sims et al. (2005) reported that the larval and adult stages are the most susceptible to parasitism whereas Mason and Heinz (2002) found the pupal stage to be the most susceptible. Both male and female thrips may be parasitized by *Thripinema* species; however, *Thripinema* show a preference for female thrips (Tipping et al. 1998, Mason and Heinz 2002).

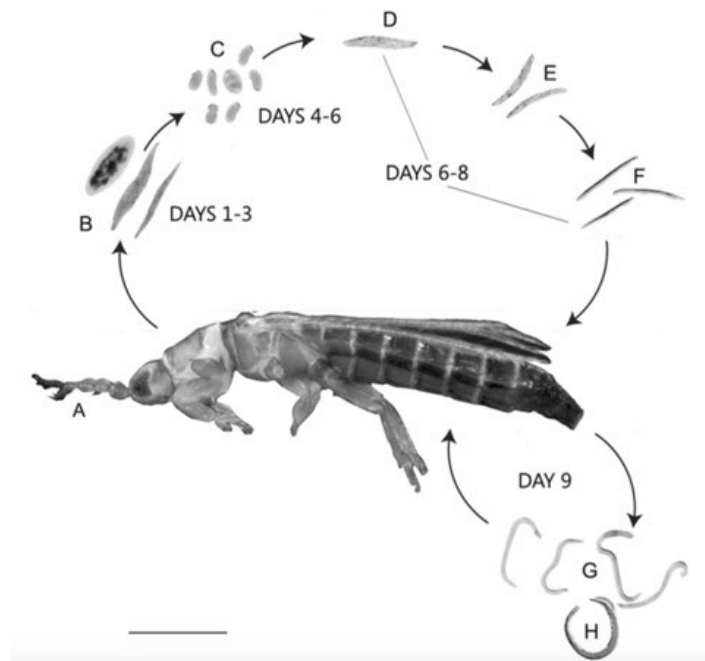


Figure 2. The life cycle of *Thripinema fuscum* in (A) an adult female *Frankliniella fusca* host; (B) the enlargement of the parasitic female from right to left (vermiform); (C) eggs (=J1) produced by the parasitic female; (D–F) J2-stage through J3-stage juveniles; (G) infectious free-living females; (H) free-living male; (G) ingress of a free-living female regenerates the cycle. Photograph from Sim KR, Becnel JJ, Funderburk JE. 2012. The morphology and biology of the entomophilic *Thripinema fuscum* (Tylenchida: Allantonematidae), and the histopathological effects of parasitism on the host *Frankliniella fusca* (Thysanoptera: Thripidae). *Journal of Natural History* 46: 1111–1128. Used with permission.

Economic Importance

The Western flower thrips, *Frankliniella occidentalis* and the tobacco thrips, *Frankliniella fusca*, have the potential to cause significant yield losses in agronomic, fruit, vegetable, and ornamental crops in the United States, including Florida. Both species cause injury to crops through feeding and the transmission of tospoviruses such as *Tomato spotted wilt virus*. *Thripinema nicklewoodi* parasitizes *Frankliniella occidentalis* and *Thripinema fuscum* parasitizes *Frankliniella fusca*.

A study conducted by Mason and Heinz (2002) in Texas found that *Thripinema nicklewoodi* suppressed populations of *Frankliniella occidentalis* on infested greenhouse chrysanthemum plants. They concluded that augmentative applications of *Thripinema nicklewoodi* may provide an alternative to current control strategies. Arthur and Heinz (2003) reported that *Frankliniella occidentalis* parasitized by *Thripinema nicklewoodi* were less active transmitters of *Tomato spotted wilt virus* and disease transmission was reduced by 50%.

In Florida peanut production, populations of *Frankliniella fusca* are naturally suppressed by *Thripinema fuscum*. Tipping et al. (1998) reported that parasitism of *Frankliniella fusca* by *Thripinema fuscum* was 51% in 1995 and 68% in 1996. Additional studies found that parasitism of *Frankliniella fusca* reduced feeding by 65% and disease transmission by 50% (Sims et al. 2009). To maximize biological control of thrips in peanut production, planting dates may be delayed as flowers are primary sites of parasitism and peanuts flower for the remainder of the growing season (Funderburk and Latsha 2005).

Although *Thripinema* species have not been commercially mass-produced, they have potential as biological control agents. They are important natural enemies capable of regulating field populations of thrips (Funderburk et al. 2002a, b).

Sampling

Thrips may be collected from the field by selecting flowers, then either striking flowers against a board or exhaling on each flower to extract thrips (Funderburk et al. 2016; Florida Tomato Scouting Guide 2008). *Thripinema* may be extracted from thrips by placing thrips in a dish of distilled water and gently swirling them (Tipping 1998) or by cutting open the thrips' abdomen (Funderburk et al. 2002a; 2002b).

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