

A scientific note on rare parasitism of the bumble bee pollinator, *Bombus impatiens*, by a mermithid nematode, *Pheromermis* sp. (Nematoda: Mermithidae)

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Nematodes in the family Mermithidae are parasites of diverse insects, spiders, leeches, and other invertebrates worldwide (Nickle 1972). Insects are the most common hosts, and at least 15 insect orders are parasitized by mermithids. Parasitism by mermithids is usually fatal to the host, and hence, mermithids have been considered as potential biological control agents for pest species such as yellow jackets, *Vespula* spp. and hornets, *Vespa* spp. (Moller et al. 1991; Martin 2004; Villemant et al. 2015). However, mermithids can also parasitize beneficial insects such as insect pollinators. Honey bees, *Apis mellifera* L., were reported to be parasitized by the mermithid *Agamomermis* sp. in Ithaca, New York (Morse 1955), and by *Mermis subnigrescens* Cobb in Urbana Champagne in IL (Milum 1938). *M. subnigrescens* is, however, a parasite of grasshoppers (Nickle 1972), and hence, the identity of this nematode needs confirmation. Less is known about mermithid associations with bumble bee pollinators. A single unidentified bumble bee was observed to be parasitized by an unknown mermithid in Lafayette, Indiana (MacLean 1966).

Here, we present the first report of mermithid parasitism of the bumble bee pollinator *Bombus impatiens*

Cresson. In July 2015, dead bumble bees were observed under trees of little leaf linden (*Tilia cordata* Mill.; family Tiliaceae) in the town of Wakefield, MA, in eastern USA. There was an interest in determining the basis for the bumble bee deaths as mortality of bumble bees associated with linden trees treated with neonicotinoid insecticides has been reported annually in the USA since 2013 (Argoti and Rao 2015). Besides neonicotinoids, other factors such as nectar toxins are speculated to kill bumble bees foraging on linden (Crane 1977; Rao 2016) while pathogens and parasites have been implicated in recent bumble bee population declines (Cameron et al. 2011).

For analysis of potential mortality factors of bumble bees collected in Wakefield, 68 dead bumble bees were shipped to the Oregon State University where each bee was regurgitated for analysis of nectar and then dissected for detection of pathogens and parasites. In one worker *B. impatiens*, a single white nematode (Figure 1) was observed coiled inside the abdomen, nearly filling it. The host bumble bee looked like all others in the shipment, and there was no external indication that the bee was parasitized. The nematode was preserved in 30 % ethyl alcohol, fixed in 5 % formalin, and processed to glycerin for further study. The specimen is 46 mm in length and 40 µm in greatest width. It aligns with *Pheromermis* sp. based on the presence of the following characters: cuticle with cross fibers, no lip papillae, four cephalic papillae in submedial positions, cup-shaped amphids placed anteriorly, ventrally

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Figure 1. Mermithid parasite recovered from a dead *Bombus impatiens* worker collected under a linden tree in Wakefield, MA, USA.

displaced mouth opening, and no cuticular projection on tail. Without the adult stage, it is not possible to confidently assign the bumble bee mermithid to a species, and it could represent an undescribed species.

Pheromermis spp. are parasites of yellow jackets in North America and Europe with a unique life cycle (Poinar 1981; Kaiser 1987). Typically, mermithid nematodes develop in a single host. However, in *Pheromermis* spp., a second paratenic or transport host is involved (Poinar et al. 1976). The paratenic host becomes infected when eggs that are laid in or near water sources are ingested (Molloy et al. 1999). The eggs hatch in the host midgut, and the emerging juveniles penetrate the peritrophic membrane to enter the hemocoel. They migrate to various tissues such as the gut epithelium, hypodermis, muscle, connective tissue, and fat bodies, where they coil and remain quiescent. Multiple juveniles can be present in a single paratenic host. They remain viable throughout the life of the paratenic host even during its metamorphosis to the adult stage. They do not develop further and cause minimal damage to the paratenic host. The eggs cannot hatch in the gut of an adult wasp, and hence, the paratenic host is an obligatory step in the life cycle of the *Pheromermis* nematodes. When an infected adult is caught by a yellow jacket or hornet and fed to its larva, the nematodes become active and feed on non-vital tissues of the immature wasp but rarely kill the host. The adult wasp

emerges and the mermithid matures in its abdomen. It does not kill the adult right away but causes sterility in both males and females (Poinar et al. 1976). When the infected wasp visits a water source, the mature *Pheromermis* leaves its host, which it kills in the process, molts into the adult stage, mates and lay eggs, and thus completes the life cycle.

In the mermithid-parasitized bumble bee collected in the current study, the infection route is not known. The bumble bee could have acquired a *Pheromermis* egg while seeking a water source. Based on the large size and location of the mermithid, it must have developed in the bumble bee, in which case, this would be the first report of *Pheromermis* developing in hosts other than *Vespa* spp. or *Vespula* spp., and having no paratenic host! It is possible that the mermithid could represent a new species of *Pheromermis* that is adapted to bumble bees. Future recoveries of mermithids from bumble bees are needed for further insights of the mermithid-bumble bee parasitism observed in the current study.

The bumble bee *B. impatiens* is a common native pollinator in eastern USA (Colla et al. 2011) though commercial colonies are also placed in agricultural fields for augmenting crop pollination. In a 2-year survey of bumble bee parasites in western MA in eastern USA, >1000 bumble bees, including 574 *B. impatiens* workers and males were dissected for detection of natural enemies. Conopid parasitoids and the pathogens *Crithidia bombi* Gorbunov (Kinetoplastida: Trypanosomatidae) and *Nosema bombi* Fantham and Porter (Microsporidia: Nosematidae) were detected in nine bumble bee species including *B. impatiens* (Gillespie 2010). No mention was made of mermithids or of *Sphaerularia bombi* Dufour, a nematode that has been detected in other regions in the USA (Poinar and van der Lann 1972; Maxfield-Taylor et al. 2011). While *S. bombi* is a common nematode parasite of bumblebees, mermithid parasitism of bumble bees is rare and has been reported earlier only once (MacLean 1966).

The current detection of the mermithid in a bumblebee may be a rare event. It may represent a new *Pheromermis* species with a different life history or adaptation and evolution of *Pheromermis* spp. that infect *Vespa* and *Vespula* spp. to a new host which differs greatly in feeding habits compared to the original wasp host. Our detection of the mermithid is of concern as *B. impatiens* is an important pollinator in eastern USA, and pathogens and parasites have been implicated in recent reports of bumble bee declines (Cameron et al. 2011). Mermithid infections are typically fatal to the host (Poinar et al. 1976), thus *Pheromermis* infections

can negatively impact bumble bee pollinator populations. Hence, more research is needed to determine the life cycle of the mermithid detected in the current study, and its prevalence within bumble bee populations.

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Note scientifique sur un cas rare de parasitisme du bourdon pollinisateur, *Bombus impatiens*, par un nématode, *Pheromermis* sp. (Nematoda: Mermithidae)

Eine wissenschaftliche Notiz über seltene Parasitierung der Hummelbestäuberart *Bombus impatiens* durch einen Nematoden, *Pheromermis* sp. (Nematoda: Mermithidae)

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