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Entomopathogenic nematodes in agriculture – potential threat to protected beetle species

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Abstract: *Entomopathogenic nematodes in agriculture – potential threat to protected beetle species*. Entomopathogenic nematodes are the most important insect parasites, therefore they are used in the production of biopreparations. Application of nematode based biopreparations in biological methods of pest control has many positive and negative features, some of them, however, raise some doubts. Particularly doubtful features are the selectivity in colonising and killing potential hosts by nematodes. Apart from pests, the ecosystems to which entomophilous nematodes have been introduced are inhabited by beneficial insects and those that are legally protected. One of such species is the hermit beetle (*Osmoderma eremita*), very endangered and strictly protected species according to the Bern Convention, listed in the second and fourth appendix to the Habitat Directive and mentioned in many European Red Books e.g. in Red List of Nearly Extinct and Endangered Animals in Poland and in Polish Red Book of Animals. The marbled rose chafer *Protaetia lugubris*, in spite of its rarity it is not the protected species. Its habitat preferences are similar to those of the hermit beetle, which makes it potentially endangered in the same way as *O. eremita*.

Key words: entomopathogenic nematodes, biological plant protection, EPN, protected Coleoptera, *Osmoderma eremita*, *Protaetia lugubris*.

INTRODUCTION

Many methods including most popular chemical insecticides are used to control various insect plant pests. Chemicals are highly effective, kill the pests quickly but may possess toxic and mutagenic properties (Bauman 1996). At present, a tendency is observed of searching alternative ways of pest control (Pezowicz, Sandner 1983). Biological methods commonly considered safe for the environment are such alternative ways (Franz, Krieg 1975). Species of the families Steinernematidae and Heterorhabditidae (Rhabditida) called entomopathogenic nematodes (Brzeski, Sandner 1974; Poinar 1979) are important in controlling the density of insects. Entomopathogenic nematodes are the most important insect parasites, therefore they are used in the production of biopreparations. Application of nematode based biopreparations in biological methods of pest control has many positive and negative features (Gaugler 1988; Webster 1980), some of them, however, raise some doubts. Particularly doubtful features are the selectivity in colonising and killing potential hosts by nematodes. Apart from pests, the ecosystems to which entomophilous nematodes have been introduced are inhabited by beneficial insects and those that are legally protected. Beetles are the

best studied group of nematodes' hosts. As given in Poinar (1975), nearly 50% of papers on nematodes found in the class Insecta are devoted to the order Coleoptera. Various families are being infected (Luckmann, Poinar 2003) but particularly interesting cases are those concerning rare and protected species. Recognising their enemies and natural mortality would help to better evaluate their risk status.

One of such species is the hermit beetle (*Osmoderma eremita*), very endangered and strictly protected species according to the Bern Convention, listed in the second and fourth appendix to the Habitat Directive (Szwałko 2004) and mentioned in many European Red Books e.g. in Red List of Nearly Extinct and Endangered Animals in Poland (Pawłowski et al. 2002) and in Polish Red Book of Animals (Szwałko 2004). Since many years it has been strictly protected in our country. The hermit beetle *Osmoderma eremita* is a representative of the family *Scarabaeidae inhabiting nearly all Europe. It achieves 40 mm of length and 2.5 g body mass* (Stebnicka 1978; Hedin, Ranius 2002). Despite its widespread occurrence all over the continent it has never been reported as numerous species. In places of its occurrence it forms local island populations associated mainly with deciduous and mixed tree stands (Ranius 2000). Polish population of the hermit beetle is estimated at several thousand individuals (Szwałko 1992), recent studies, however, have suggested that it might be more numerous (Oleksa et al. 2003; Szwałko 2004).

The marbled rose chafer *Protaetia lugubris* is smaller (17–24 mm) than the former beetle. In spite of its rarity it is not the protected species. Its habitat preferences are similar to those of the hermit beetle (both species are often reported from the same feeding grounds) which makes it potentially endangered in the same way as *O. eremita*.

MATERIAL AND METHODS

Thirty five larvae in the L3 growth stage and 20 coccolites of *O. eremita* and *P. lugubris* were collected in May 2005 from south-western part of the Cedynia Landscape Park within the Mieszkowickie Forests complex (UTM: VU54). Most of those that had fallen out from cut-off trunks of the locust tree were already dead – dried in the sun or killed by mites and ants. Touchwood from the surrounding and from tree hollows in the locust trees was also collected to serve as a substrate for culture. From this material 10 imagines of *O. eremita* and 7 of *P. lugubris* were obtained and released in the place of their finding (Kucharski, Żmihorski 2006). Part of the beetles laid eggs before release since several dozen new larvae were found in the rotten wood. These were further cultured in the same material.

RESULTS AND DISCUSSION

The larvae showed unexpectedly high mortality which was quite a riddle. Most died in the L3 stage or at the stage of pupae. Finally, only 2 imagines of *O. eremita* and 10 of *P. lugubris* were obtained from this generation. The hermit beetles died not later than a week after pupation, before, however, they had normally taken food, defecated and maintained daily cycle of activity. Adult individuals of *P. lugubris* died not earlier than after 3–6 months having reproduced before.

Dissection of dead individuals showed the reason of their high mortality. In all cases a large number of entomopathogenic nematodes that filled the whole body cavity of the beetles were observed. From two dissected females of the hermit beetle 1766 and 880 nematodes *Steinernema feltiae* (Fig. 1) were obtained, respectively. From one female of the marbled rose chafer 2305 nematodes of the same species were obtained. Part of these nematodes was preserved as an inoculum for further cultures. No Steinernema were found in 3 dead larvae collected directly in the field in 2005. The larvae probably died of desiccation.

Reported observation is one of a few in which nematode species could be identified attacking both rare species from the family Scarabaeidae. Ranius in his paper (2005) mentioned a possibility of killing the hermit beetle by entomopathogenic nematodes. Nematodes, despite their wide range of hosts, can only sporadically be found in insects infected in their natural habitats. The main reason of such situation is rapid growth cycle of nematodes in their host and fast decomposition of their prey's body. From among many species of Insecta susceptible to nematodes, natural infections were found only several times e.g. in species such as: *Zabrus tenebrioides*, (Coleoptera: Carabidae) (Poinar 1979), *Agriotes lineatus*, (Coleoptera: Elateridae) (Poinar, Veremcuk 1970), *Melolontha hippocastani* and *M. melolontha*, (Coleoptera: Melolonthidae) (Poinar et al. 1971), *Heliothis punctigera*, (Lepidoptera: Noctuidae) (Poinar 1979), *Helicoverpa zea* (Lepidoptera: Noctuidae) (Khan et al. 1976).

Observed nematodes may remain in the environment for years able to attack all growth stages of beetles (except for eggs). In the culture of *P. lugubris* and *Netocia metallica* (species related to *P. cuprea*) the parasite was kept for over three years (at its constant passaging) and retained high pathogenicity towards many representatives of Cetoniinae,

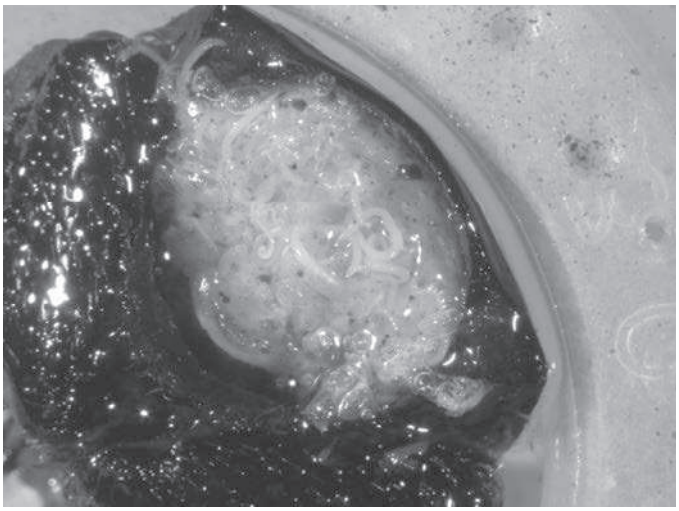

FIGURE 1. *S. feltiae* nematodes filling cavity of the thoracic part of hermit beetle (*O. eremita*)

Lucanidae, Tenebrionidae, Geotrupidae, Carabidae and even to spiders (Kucharska, Kucharski, unpublished). Having in mind rare occurrence of appropriate habitats for and limited dispersion of *O. eremita* (Hedin, Ranius 2002), colonisation of the same tree hollows by entomopathogenic nematodes may strongly limit local populations of the beetle. As shown in up-to-date observations, the presence of old trees with hollows of appropriate exposition to solar radiation does not itself guarantee survival of the hermit beetle in a given environmental patch. Noteworthy is also the possibility of attacking by nematodes other touchwood eating Scarabaeoidea including very rare and protected species like: *Lucanus cervus*, *Ceruchus chrysomelinus*, *Protaetia aeruginosa*. Nematoda may decrease survival of representatives of these species to a degree much larger than it is now expected. Further field observations and laboratory experiments are needed. Additional problem is that we know little on spreading and maintenance of introduced nematode species and on the possibility of their transfer to habitats colonised by rare and protected insect species. Timper et al. (1988) found a possibility of nematode transfer over large distances by infected butterflies *Spodoptera exigua*. In our culture infected imagines of the beetles lived for several days. Infection of new habitats sometimes several kilometres apart is thus quite possible.

CONCLUSIONS

Application of nematode based biopreparations in biological methods of pest control can be potential threat and one has to consider limitation of the use of biopreparations in areas close to habitats valuable for nature protection (e.g. parks with old tree stands with hollows). This is worthy of special attention in view of the more common use of biopreparations in the national agriculture.

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Streszczenie: *Nicienie entomopatogeniczne w rolnictwie – potencjalne zagrożenie dla chronionych gatunków chrząszczy.* Nicienie entomopatogeniczne należą do najważniejszych pasożytów owadzich, dlatego też znalazły swoje zastosowanie w produkcji bioprepataów. Stosowanie biopreparatów na bazie nicieni w metodach biologicznych posiada szereg cech pozytywnych i negatywnych, jednak niektóre cechy budzą zastrzeżenia. Szczególnie wątpliwymi są wybiórczość i selektywność zasiedlania i zabijania potencjalnego żywiciela przez nicienie. W ekosystemach do których introdukowano nicienie entomofilne, oprócz szkodników, zagrożone są również owady pożyteczne oraz te objęte ochroną gatunkową. Jednym z gatunków zarażanych przez nicienie jest pachnica dębowa (*Osmoderma eremita*), gatunek o kategorii „bardzo zagrożony i ściśle chroniony" wg Konwencji Berneńskiej, wpisany do drugiego i czwartego załącznika Dyrektywy Habitatowej oraz wymieniany w wielu europejskich Czerwonych Księgach. Podobnie dzieje się z wepą marmurkową (*Protaetia lugubris*) o preferencjach siedliskowych bardzo podobnych do tych wybieranych przez pachnicę, co czyni ją również zagrożoną.

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