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**SEASONAL DYNAMICS OF THE ACTIVITY
OF ENTOMOPATHOLOGICAL NEMATODES
(STEINERNEMATIDAE AND HETERORHABDITIDAE)
IN SELECTED GREENS OF SZCZECIN**

**SEZONOWA DYNAMIKA AKTYWNOŚCI NICIENI OWADOBÓJCZYCH
STEINERNEMATIDAE I HETERORHABDITIDAE
W WYBRANYCH ZIELEŃCACH SZCZECINA**

Abstract: Seasonal dynamics of the activity of entomopathogenic nematodes belonging to the families Steinernematidae and Heterorhabditidae in four town greens in Szczecin was examined between April and October 2008. The density of nematodes in the soil and the occurrence of potential hosts at individual sites were analysed. Four species of nematodes were isolated from the sites: *Steinernema feltiae*, *S. affine*, *S. bicornutum* and *Heterorhabditis megidis*. *S. feltiae* occurred at the four sites and was the most common species. The greatest density of nematodes ranging from 7 000 ind./m² to 50 000 ind./m² was observed in the autumn, which may be connected with an increased availability of hosts in the soil. A relationship was observed between the occurrence of *H. megidis* and the presence of *Otiorrhynchus rotundatus* in tree plantings with oaks. The highest density (over 25 000 ind./m²) of *H. megidis* was recorded in the autumn. Beetles were among insects that dominated at the study sites with the exception of tree plantings with horse chestnut (*Aesculus hippocastanum*) which were parasitised by the leaf miner belonging to moths.

Keywords: entomopathogenic nematodes, Steinernematidae, Heterorhabditidae, occurrence nematodes, seasonal dynamics nematodes, soil, town greens

The activity of entomopathogenic nematodes (Steinernematidae, Heterorhabditidae) may be limited by a variety of biotic and abiotic factors. However, suitable hosts must be present for parasitic populations of nematodes to survive in the soil. Infective larvae

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of entomopathogenic nematodes use the resources stored in the fat bodies in unfavourable environmental conditions, thus protecting themselves from starvation.

A low species diversity of insects is observed in urban green areas. As anthropopressure increases, the frequency of the soil fauna decreases. Impoverishment of the fauna upsets the circulation of the matter in ecosystems and contributes to an increase in the frequency of phytophages.

Studies on the seasonal biological activity of entomopathogenic nematodes were conducted in selected town greens in Szczecin. Changes in the frequency of parasitic populations of nematodes depending on the observation date were recorded.

Material and methods

Field studies were conducted between April and October 2008 in four selected town greens in Szczecin in which a mass occurrence of phytophagous insects that come into contact with soil during their developmental cycle was observed. The selected greens have linear plantings that form either a hedge (M3) or a set of tree rows. A detailed description of the sites is given in Table 1.

Table 1

Description of sites for research

Sign of site	Place of soil sample	Distance of a site from the road [m]	Type of green area	Dominant of foliophage insect	Wintering stage of insect
M3	Moniuszki street, Jasne Błonia, Park Kasprowicza	0.5	hedge with the common privet <i>Ligustrum vulgare</i>	<i>Otiorrhynchus rotundatus</i> , <i>Coleoptera</i>	larvae and imago in the soil
M5	Park Kownasa 1 (left site)	50	walking alley with sessile oak <i>Quercus sessilis</i> and common oak <i>Quercus robur</i>	<i>Curculio glandium</i> , <i>Coleoptera</i>	larvae and imago in the soil
M6	Park Kownasa 2 (right site)	50	walking alley with sessile oak <i>Quercus sessilis</i> and common oak <i>Quercus robur</i>	<i>Curculio glandium</i> , <i>Coleoptera</i>	larvae and imago in the soil
M8	Wojska Polskiego street	0.5	walking alley with the white horse chestnut <i>Aesculus hippocastanum</i> along tram	<i>Cameraria ohridella</i> , <i>Lepidoptera</i>	pupa in deciduous leaves or in the soil

Soil (ca 600 cm³) was sampled from a depth of 20–30 cm at monthly intervals. Entomological nematodes were isolated from the soil with the baiting method using *Galleria mellonella* [1, 2]. Containers with the soil and insects (six containers for each soil sample, three insects in each container) were incubated at 22–24 °C. Dead insects were selected to estimate the number of mature nematodes inside the host's body. The number of all nematodes recorded in the insects from a single soil sample was added up and the density of nematodes per 1 m² was calculated (ind./m²). Nematodes isolated from the soil were determined to the species level using morphological and morphometric characters of male insects and infective larvae (J₃).

Results

Four nematodes: *Steinernema feltiae*, *S. affine*, *S. bicornutum* and *Heterorhabditis megidis* were isolated from the soil collected from four town greens. The greatest species diversity was observed in the town green with wild privet (*Ligustrum vulgare*) (M3) where *Otiorrhynchus rotundatus* (lilac weevil) dominated and with tree plantings with oaks where *Curculio glandium* (acorn weevil) occurred (M5, M6), (Table 1, Fig. 1–3). The occurrence of three out of four nematode species was recorded at these sites (Fig. 1–3). The lowest diversity of nematode species was observed in a narrow set of two rows of trees with horse chestnut that separated transport routes with a high traffic rate (Fig. 4). Only *S. feltiae* was recorded at the site.

The density of nematodes in the soil changed depending on the date and the soil sampling site, and was not continuous. The highest density of the parasites ranging from 7000 ind./m² (Fig. 1) to 50 000 ind./m² (Fig. 2) was recorded at the sites in October (Fig. 1–4). The mean density of nematodes in the soil at individual sites varied and

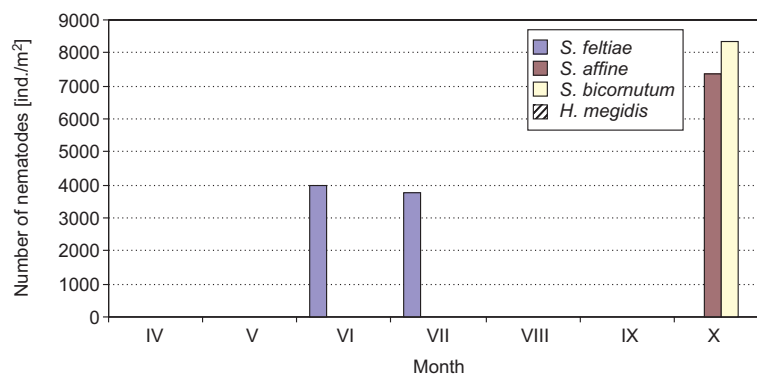


Fig. 1. The trend of numbers of individual entomopathogenic nematodes (Steinernematidae, Heterorhabditidae) in the soil on the M3 site during the season (from April to October 2008)

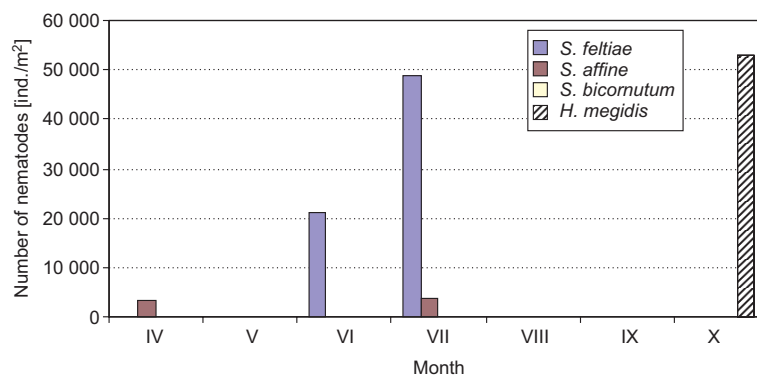


Fig. 2. The trend of numbers of individual entomopathogenic nematodes (Steinernematidae, Heterorhabditidae) in the soil on the M5 site during the season (from April to October 2008)

ranged from 6000 ind./m² in the town green with wild privet (site M3) and ca 9000 ind./m² in the oak alley (site M6) to ca 25 000 ind./m² in plantings with horse chestnut (site M8) and oaks (site M5).

Observations show that the occurrence of *Heterorhabditis megidis* nematodes was strictly related to the feeding environment of *Curculio glandium* beetles whose imago winters in the soil (sites M5 and M6) (Fig. 2 and 3). A high density and the domination of the species were recorded in the autumn during an intensified contact between larvae of *Curculio glandium* and the substrate when damaged acorns fell from the trees onto the soil.

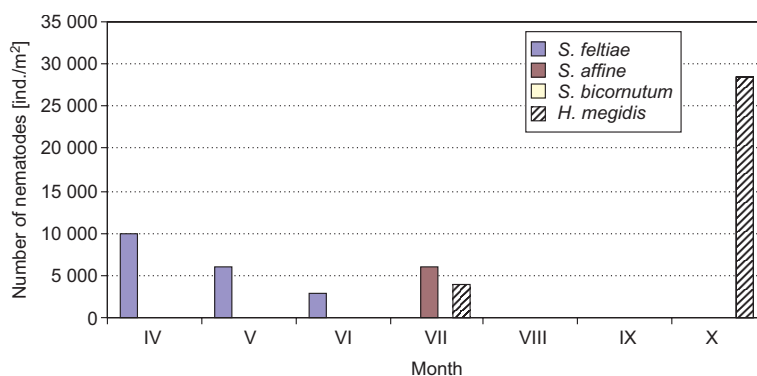


Fig. 3. The trend of numbers of individual entomopathogenic nematodes (Steinernematidae, Heterorhabditidae) in the soil on the M6 site during the season (from April to October 2008)

Steinernema feltiae commonly occurred at all of the sites. It was recorded most frequently in the greens during the spring and summer activity of insects (Fig. 1–3). Observations show that the species has a broad range of hosts and is not strictly related to a specific environment. However, it was the only species that occurred together with the leaf miner at the site with horse chestnut (M8) (Fig. 4). It was recorded in April and

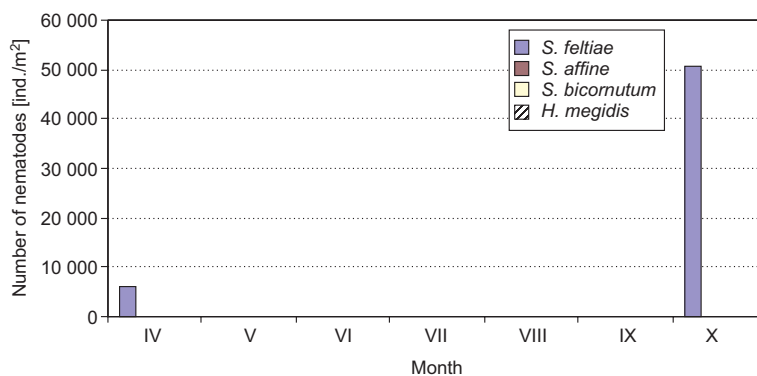


Fig. 4. The trend of numbers of individual entomopathogenic nematodes (Steinernematidae, Heterorhabditidae) in the soil on the M8 site during the season (from April to October 2008)

a high density of *S. feltiae* (50 000/m²) was observed in October during an increased availability of pupae of the leaf miner in the soil (Fig. 4).

Steinernema affine nematodes were isolated from the majority of the sites. However, their density in the soil remained at a low level that did not exceed 8 000 individuals per m². The species often co-occurred with other nematodes: *S. bicornutum* (Fig. 1), *S. feltiae* (Fig. 2) and *H. megidis* (Fig. 3).

S. bicornutum was the least frequently recorded species. It occurred in October at only one site (with wild privet) where beetles of the family Curculionidae, *Otiorrhynchus rotundatus*, dominated.

Discussion

The life cycle of parasitic nematodes belonging to the family Steinernematidae and Heterorhabditidae is strictly correlated with the host development. A high density of nematodes in the soil is a response to insect gradations in the environment [3]. In practice, however, the parasites encounter a natural resistance of the environment that restricts their activity [4–7].

Entomopathological nematodes (Steinernematidae, Heterorhabditidae) commonly occur in the soil. Individual species, however, exhibit different environmental preferences [8, 9]. For instance, *Steinernema kraussei* is mostly associated with tree plantings while *Steinernema feltiae* and *S. affine* are associated with open areas.

Observations show that *S. feltiae*, the most frequently recorded species in Polish soils [6, 11], is very well adapted to diverse environmental conditions and probably has a broad range of hosts. The activity of entomopathogenic nematodes in the soil fluctuated seasonally and was not continuous. Changes in the population density depended on the date and the soil sampling site as well as on food availability. A clear increase in the population density at all the sites was observed in the autumn when insects move into the soil to winter there. It is noteworthy that the greens were characterised by a poor species differentiation of phytophages where one insect species usually dominated and the potential nutritional base mostly consisted of single hosts. In the Czech Republic, a high density of entomopathogenic nematodes was recorded only in the spring at the beginning of the season, followed by a drop in the parasites' density which later remained at a steady level until the end of the season [10]. The occurrence of the host in the soil was considered to be the most important factor conditioning the seasonal activity of nematodes at the study site. This is confirmed by the present observations conducted in town greens where a high density of *Heterorhabditis megidis* in tree plantings with English oak (*Quercus robur*) and sessile oak (*Quercus petraea*) (sites M5, M6) was probably associated with the presence of *Curculio glandium* beetles whose imago winters in the soil and larvae fall on the soil with damaged acorns, enabling contact between entomopathogenic nematodes and potential hosts.

The species composition of entomopathogenic nematodes in town greens is relatively rich [11]. The greatest species diversity of nematodes (three species out of four) was observed in the green with wild privet where *Otiorrhynchus rotundatus* (Coleoptera) fed intensively and in tree plantings with oaks in which *Curculio glandium* (Coleoptera) occurred.

The lowest species diversity was recorded in a narrow set of two tree rows with horse chestnut that separated transport routes with a high intensity rate of traffic. Only *Steinernema feltiae* was recorded at the site. As generally observed, nematodes of the family Steinernematidae dominate in the temperate climate zone while thermophilic nematodes belonging to the family Heterorhabditidae occur less frequently [8–12]. To sum up, ecological relationships of entomopathogenic nematodes can be analysed using examinations of their seasonal activity.

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SEZONOWA DYNAMIKA AKTYWNOŚCI NICIENI OWADOBÓJCZYCH STEINERNEMATIDAE I HETERORHABDITIDAE W WYBRANYCH ZIELEŃCACH SZCZECINA

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Abstrakt: Sezonową dynamikę aktywności nicieni owadobójczych z rodziny Steinernematidae i Heterorhabditidae badano od kwietnia do października 2008 r. w czterech zieleńcach Szczecina. Analizowano

zagęszczenie nicieni w glebie oraz występowanie potencjalnych żywicieli na poszczególnych stanowiskach. Z badanych stanowisk wyizolowano cztery gatunki nicieni: *Steinernema feltiae*, *S. affine*, *S. bicornutum* i *Heterorhabditis megidis*. Najpospolitszym gatunkiem okazał się *S. feltiae*, który wystąpił we wszystkich zielenicach. Najwyższe zagęszczenie nicieni zanotowano jesienią od 7 000 os./m² do 50 000 os./m², co może mieć związek ze zwiększoną dostępnością żywiciela w glebie. Stwierdzono wyraźny związek między występowaniem nicieni *H. megidis* i obecnością słonika żołędziowca w zadrzewieniach z dębem. Najwyższe zagęszczenie (ponad 25 000 os./m²) tego nicienia zanotowano jesienią. Wśród owadów, które dominowały w badanych środowiskach, były chrząszcze, z wyjątkiem zadrzewień z kasztanowcem białym, gdzie żerował szrotówek kasztanowcowiaczek należący do motyli.

Słowa kluczowe: nicienie owadobójcze, *Steinernematidae*, *Heterorhabditidae*, występowanie nicieni, sezonowa dynamika nicieni, gleba, zielenice miejskie