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OCURRENCE OF STYLET-BEARING NEMATODES ASSOCIATED WITH AQUATIC VASCULAR PLANTS*

ABSTRACT: In the underground parts of three *Potamogeton* species the occurrence and density of *Hirschmanniella* spp., *Calolaimus ditlevseni*, *Chrysonemoides limigenus* and Dorylaimidae have been analysed in 32 lakes. *Hirschmanniella gracilis* is the most common species. *Calolaimus ditlevseni* and *Chrysonemoides limigenus* occur more frequently in *Potamogeton lucens* than in *P. perfoliatus* and only sporadically in *P. pectinatus*. Factors responsible for mass development of plant feeding *Hirschmanniella gracilis* in *P. pectinatus* are discussed.

KEY WORDS: Freshwater nematodes, density, frequency, plant feeders, lakes.

1. INTRODUCTION

The underground parts of aquatic vascular plants are inhabited abundantly by stylet-bearing nematodes of the genera *Hirschmanniella*, *Calolaimus* (syn. *Dorylaimoides*), *Chrysonemoides*, *Dorylaimus* and *Laimydorus* (Prejs 1977, Gagarin 1978). The density of the three first genera is usually much higher in plant roots and rhizomes than in the surrounding sediments (Prejs 1977). *Hirschmanniella gracilis* (de Man) and *Calolaimus ditlevseni* (Micoletzky) are found aggregated close to different types of tissue damage (Prejs 1986). However, density of these nematodes in different *Potamogeton* species has varied considerably. High density of *Hirschmanniella gracilis* in *Potamogeton pectinatus* L., being several times higher than in *P. lucens* L. and *P. perfoliatus* L., suggest that only *P. pectinatus* is a good host for this plant feeder (Prejs 1986). This suggestion was based mainly on the data from one lake.

In present study, the material from 32 lakes is being analysed. The aim here, apart from an analysis of the occurrence of stylet-bearing nematodes in three *Potamogeton* species, is an estimation of the extent of infestation of these plants by nematodes.

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2. AREA, MATERIAL AND METHODS

The investigations were conducted between 1975 and 1985 in 31 lakes of northern Poland (Masurian and Pomeranian Lakelands) and in one Venezuelan lake (Table 1). In these lakes a survey of the extent of infestation of the underground parts of three pond weed species (*Potamogeton lucens*, *P. perfoliatus* and *P. pectinatus*) by nematodes

Table 1. Morphometric data of lakes and characteristics of macrophyte stands on sites from which samples were taken

a — *P. pectinatus*, b — *P. perfoliatus*, c — *P. lucens*

No.	Lake	Surface area (ha)	Max. depth (m)	Plants analysed	Density of macrophyte stands and dominant species
1	Beldany	940.6	46.0	a, b	dense, <i>P. pectinatus</i> *
2	Białe	96.3	21.6	a	sparse, <i>P. pectinatus</i>
3	Boczne	183.3	17.0	a	dense, <i>P. pectinatus</i> *
4	Buwełno	360.3	49.2	a	dense, <i>P. pectinatus</i> *
5	Charzykowskie	1365.8	30.5	b	sparse, <i>P. perfoliatus</i>
6	Gardyńskie	82.6	11.5	b	sparse, <i>P. perfoliatus</i>
7	Guzianka Wielka	59.6	22.5	b	sparse, <i>P. perfoliatus</i>
8	Dejguny	765.3	45.0	a	sparse, <i>P. pectinatus</i>
9	Dgał Wielki	94.5	17.6	a	sparse, <i>P. pectinatus</i>
10	Drawsko	1781.5	79.7	a	sparse, <i>P. pectinatus</i>
11	Goldopiwo	862.5	26.9	a, b, c	dense, multispecific
12	Jagodne	942.7	37.4	b	sparse, <i>P. perfoliatus</i>
13	Juno	380.7	33.0	a, b	sparse, multispecific
14	Komorze	416.7	34.7	c	sparse, multispecific
15	Lampackie	198.6	38.5	a, b	sparse, multispecific
16	Łaśmiady	882.0	43.7	a, b	dense, multispecific
17	Liptowskie	134.9	29.0	a	sparse, multispecific
18	Luterskie	691.1	20.7	a	sparse, multispecific
19	Majcz Wielki	163.5	16.4	a, b	sparse; multispecific
20	Mamry	2504.0	43.8	a, b, c	dense, multispecific
21	Mikołajskie	460.0	27.8	a, b, c	site I — dense, multispecific site II — dense, <i>P. pectinatus</i> *
22	Niegocin	2600.0	39.7	b	sparse, <i>P. perfoliatus</i>
23	Piłakno	259.0	56.6	b, c	dense, multispecific
24	Roś	1887.7	31.8	b, c	dense, multispecific
25	Rydzówka	490.3	16.7	a, b	sparse, multispecific
26	Śniardwy	11340.3	23.4	a, b	dense, <i>P. pectinatus</i> *
27	Święcajty	869.4	28.0	b, c	sparse, multispecific
28	Tałtowisko	326.9	39.5	a, b	sparse, multispecific
29	Tały-Ryńskie	1831.2	50.8	a, b	dense, multispecific*
30	Valencia (Venezuela)	35000.0	39.0	a	sparse, <i>P. pectinatus</i>
31	Warnoły	127.0	7.0	a, b, c	dense, multispecific
32	Wigry	2118.3	73.0	c	sparse, multispecific

* Sites affected by municipal wastes.

was made. Samples of rhizomes and roots taken from 10 different plant specimens were collected at the depth of 0.5–0.7 m in July or August. The underground parts of plants, after rinsing and drying on blotting paper, were weighed. Nematodes were extracted using Young's (1954) incubation method after 7 days. The inverted microscope was used for preliminary quantitative and taxonomic analyses. For more detailed species identifications 50 individuals were extracted at a time in order to prepare permanent slides in glycerine.

3. RESULTS

Hirschmanniella. Among nematodes of this genus in Polish lakes *H. gracilis* was the dominant species. Apart from that species some individuals of *H. behningi* (Micoletzky) and *Hirschmanniella* sp. were found. In Lake Valencia (Venezuela) *H. oryzae* (Soltwedel) occurred.

Table 2. Density of nematodes (indiv.·g⁻¹ fresh weight) penetrating underground parts of *Potamogeton pectinatus*
Frequency in lakes – in brackets

Lake	Taxon		Total numbers
	<i>Hirschmanniella</i> (95.0%)	Dorylaimidae (100%)	
Beldany	202.3	4.1	221.0
Biale *	6.4	14.7	21.4
Boczne	56.5	7.6	70.1
Buwelno	117.3	12.5	150.0
Dejguny	1.9	2.6	20.0
Dgał Wielki	4.9	14.9	40.0
Drawsko	27.6	3.9	51.3
Goldopiwo	0.9	2.7	8.0
Juno	16.9	23.4	60.4
Lampackie	–	6.3	20.5
Łaśniady	4.0	28.6	120.0
Majcz Wielki	2.0	3.0	30.0
Mamry	0.9	3.3	9.3
Mikołajskie *	93.9	12.2	150.0
Rydzówka	24.0	27.5	100.0
Śniardwy	58.5	1.2	67.3
Tałtowisko	2.7	11.7	36.0
Tały	55.0	4.0	96.0
Valencia *	5.1	2.0	9.0
Warnołty	1.5	21.0	54.6

*Sporadic occurrence of *Calolaimus* and *Chrysonemoides*.

Table 3. Density of nematodes (indiv. · g⁻¹ fresh weight) penetrating underground parts of *Potamogeton perfoliatus*
Frequency in lakes – in brackets

Lake	Taxon				Total numbers
	<i>Hirschmanniella</i> (68.2%)	<i>Calolaimus</i> (31.8%)	<i>Chrysonomoides</i> (45.4%)	Dorylaimidae (100%)	
Beldany	2.1	—	—	3.4	10.6
Charzykowskie	2.1	—	—	7.4	16.5
Gardyńskie	—	—	0.5	16.3	36.3
Goldopiwo	6.1	27.8	2.4	4.6	47.6
Guzianka	1.5	—	0.3	6.7	15.0
Jagodne	—	—	—	14.1	70.5
Juno	—	—	—	2.8	8.1
Lampackie	0.2	—	—	1.7	7.1
Łaśmiady	5.7	—	—	16.0	11.0
Liptowskie	1.9	—	2.6	17.8	39.5
Luterskie	—	—	—	6.4	10.5
Majcz Wielki	—	—	—	5.0	17.2
Mamry	3.7	2.0	0.5	0.3	8.6
Mikołajskie	1.0	0.9	0.8	1.0	6.7
Niegocin	—	12.6	0.5	17.1	52.4
Piłakno	—	7.0	0.2	0.4	9.0
Rydzówka	1.1	1.7	—	0.6	4.0
Śniardwy	8.9	—	—	4.0	24.1
Święcajt	0.5	—	0.3	3.2	32.6
Tałtówisko	2.5	—	—	5.8	20.4
Tały	1.8	—	—	9.3	30.0
Warnoły	16.6	0.1	0.4	5.2	50.7

In the majority of lakes *H. gracilis* occurred in three species of pond weeds (Tables 2–4). In *Potamogeton pectinatus* it was recorded in 19 out of 20 lakes examined (frequency 95.0%), in *P. perfoliatus* – in 15 out of 22 lakes (frequency 68.2%), and in all lakes in *P. lucens*.

The numbers of *Hirschmanniella* ranged from about 0.1 to 202.3 indiv. · g⁻¹ fresh weight. The widest range of numbers was found in *P. pectinatus*, but a very high density (over 50 indiv. · g⁻¹ fresh weight) was recorded in six lakes only: Beldany, Boczne, Buwerno, Mikołajskie, Śniardwy and Tały (Table 2). In the other two species of *Potamogeton* the density of *Hirschmanniella* was usually much lower and did not exceed 16.6 indiv. · g⁻¹ fresh weight (Tables 3, 4).

The percentage of *Hirschmanniella* in *P. pectinatus* was generally higher and in the majority of lakes exceeded 20% of all nematodes. But, in *P. lucens* and *P. perfoliatus* the numbers of *Hirschmanniella* constituted less than 10% of total in more than half of all lakes. The highest percentage of *Hirschmanniella* was 91% of all nematodes penetrating

Table 4. Density of nematodes (indiv. · g⁻¹ fresh weight) penetrating underground parts of *Potamogeton lucens*
 Frequency in lakes – in brackets

Lake	Taxon				Total numbers
	<i>Hirschmanniella</i> (100%)	<i>Calolaimus</i> (88.8%)	<i>Chrysonemoides</i> (100%)	<i>Dorylaimidae</i> (88.8%)	
Gołdopiwo	<0.1	5.9	0.4	0.3	9.7
Komorze	0.1	—	0.2	0.1	7.0
Mamry	<0.1	5.7	1.2	<0.1	11.4
Mikołajskie	1.9	2.6	1.2	0.5	8.6
Piłakno	0.1	5.5	0.2	—	7.2
Roś	0.6	0.5	0.1	0.2	5.2
Święcajty	0.7	0.3	0.6	0.2	4.5
Warnoity	<0.1	0.2	0.7	0.7	8.1
Wigry	<0.1	24.6	0.9	<0.1	29.3

the tissues of *P. pectinatus*, in case of *P. perfoliatus* it was 37% and for *P. lucens* only 22%.

Calolaimus ditlevseni. In *P. pectinatus* this species occurred only sporadically. In *P. perfoliatus* *C. ditlevseni* was found in 7 of 22 lakes examined (frequency 31.8%), whereas in *P. lucens* in the majority of lakes examined (frequency 88.8%). The density of *C. ditlevseni* ranged from 0.1 to 27.8 indiv. · g⁻¹ fresh weight in *P. perfoliatus*, and from 0.2 to 24.6 indiv. · g⁻¹ fresh weight in *P. lucens*, and in majority of lakes did not exceed 5 indiv. · g⁻¹ (Tables 2–4). The highest proportion of *C. ditlevseni* was 83.9% of total numbers, exceeding in the majority of cases 20%.

Chrysonemoides limigenus Siddiqi. This species, similarly as *C. ditlevseni*, practically did not occur in *P. pectinatus*. It was found in less than half of all lakes in *P. perfoliatus* (frequency 45.4%), and in all lakes examined in *P. lucens* (Tables 2–4).

The density of *C. limigenus* ranged from 0.2 to 2.6 indiv. · g⁻¹ fresh weight in *P. perfoliatus*, and from 0.1 to 1.2 indiv. · g⁻¹ in *P. lucens*. The density of this species in the majority of cases was low, not exceeding 0.5 indiv. · g⁻¹ fresh weight. The highest percentage of *C. limigenus* did not exceed 14% of all nematodes.

Dorylaimidae. Among the Dorylaimidae only *Dorylaimus* and *Laimydorus* occurred frequently. Apart from them some individuals of *Mesodorylaimus* were found. Dorylaimidae had the highest frequency of occurrence in all *Potamogeton* species (Tables 2–4). The density of Dorylaimidae ranged from 0.1 to 28.6 indiv. · g⁻¹ fresh weight, being 0.6–45% of all nematode numbers. The density of Dorylaimidae in *P. lucens* was lower than in *P. perfoliatus* and *P. pectinatus*.

4. DISCUSSION

The results obtained support the earlier statement (Prejs 1983, 1986) that the underground parts of three *Potamogeton* species are mostly colonized by *Hirschmanniella* and Dorylaimidae. *Calolaimus ditlevseni* and *Chrysonemoides limigenus* are the most common in *P. lucens*, less common in *P. perfoliatus* and sporadic in *P. pectinatus*.

Both present and earlier data (Prejs 1986) have shown that the density of *H. gracilis* in *P. pectinatus* in Lake Mikołajskie was several tens higher than in the two other species of pond weeds. High density of *H. gracilis* in *P. pectinatus* was found only in five other lakes, whereas in half of the lakes examined the density of these nematodes was of the same order as in *P. lucens* and *P. perfoliatus*. Thus the question is, what other factors, apart from the possibly greater susceptibility to infestation by the plant feeder, may influence the mass development of *Hirschmanniella* in *P. pectinatus*. It was found that all these plants with high density of *Hirschmanniella* were taken from dense, monospecific stands of *P. pectinatus* situated in the littoral zone polluted by domestic sewage. It is known that *P. pectinatus* prefers fertile environments and is not very sensitive to pollution (Ozimek 1978, Ozimek and Kowalczeński 1984). In such environments, and especially on shallow sites, it forms monospecific aggregations. Plants growing in such environments can be compared rather to monocultures than to natural diverse plant communities. Studies on soil nematodes (Minderman 1956, Wasilewska 1979) show that nematode communities in natural ecosystems and those slightly transformed by man (e.g., grasslands) are more diverse than in agrocoenoses. On the other hand, studies on phytophagous insects in agrocoenoses show that polycultures of interplanted crops often support fewer insect pests at lower densities than monocultures (Pimentel 1961, Tahvanainen and Root 1972, Root 1973, Risch 1981). The resource concentration hypothesis presented by Root (1973) and confirmed by Risch (1981) explains to a considerable extent the abundant growth of plant feeders in monocultures. Probably, dense homogeneous stands of *P. pectinatus* represent great concentration of resources suitable for mass development of such plant feeder as *H. gracilis*.

It is worth pointing out that the maximum density of *Hirschmanniella* in *P. pectinatus* recorded here can be compared with the density of these nematodes in rice roots (Yamsonrat 1967).

5. SUMMARY

The investigations were carried out in 31 lakes of northern Poland (Masurian and Pomeranian Lakelands) and in one Venezuelan lake (Table 1). Density and frequency of occurrence of *Hirschmanniella* spp., *Calolaimus ditlevseni*, *Chrysonemoides limigenus* and Dorylaimidae were analysed in the underground parts of *Potamogeton pectinatus*, *P. lucens* and *P. perfoliatus* (Tables 2–4).

Hirschmanniella gracilis and Dorylaimidae occurred most frequently in three species of *Potamogeton*.

Other nematode species colonized most frequently *P. lucens*, less frequently *P. perfoliatus* and sporadically *P. pectinatus*.

The density of *Hirschmanniella* ranged from about 0.1 to 202 indiv. · g⁻¹ fresh plant weight. The highest density of these nematodes were found in dense aggregations of *P. pectinatus* situated in the littoral zone polluted by domestic sewage. Here, factors responsible for mass development of *H. gracilis* in underground parts of *P. pectinatus* are discussed.

6. POLISH SUMMARY

Badania prowadzono w 31 jeziorach północnej Polski (Pojezierze Mazurskie i Pojezierze Pomorskie) i w 1 jeziorze w Wenezueli (tab. 1). Analizowano zageszczenie i frekwencję występowania *Hirschmanniella* spp., *Calolaimus ditlevensi*, *Chrysonemoides limigenus* i *Dorylaimidae* w częściach podziemnych *Potamogeton pectinatus*, *P. lucens* i *P. perfoliatus* (tab. 2–4).

W częściach podziemnych badanych gatunków *Potamogeton* najczęściej spotykane były *Hirschmanniella gracilis* i *Dorylaimidae*. Pozostałe gatunki nicieni najczęściej zasiedlały *P. lucens*, nieco rzadziej były spotykane w *P. perfoliatus* i tylko sporadycznie w *P. pectinatus*.

Zageszczenie *Hirschmanniella* zawierało się w granicach od ok. 0.1 do 202 osobn. · g⁻¹ św. masy roślin. Wysokie liczebności tych nicieni stwierdzono tylko w *P. pectinatus* rosnących w gęstych agregacjach, poddanych wpływowi ścieków komunalnych. W pracy dyskutowane są czynniki wpływające na możliwość masowego rozwoju *Hirschmanniella gracilis* w częściach podziemnych *P. pectinatus*.

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