Studia Quaternaria, vol. 38, no. 2 (2021): 143–148 DOI: 10.24425/sq.2021.136831

SPECIES COMPOSITION AND STRUCTURE OF THE NEMATODE COMMUNITIES OF EPIPHYTIC MOSSES IN THE LEFT-BANK POLESIE (UKRAINE)

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Abstract:
Species and generic composition of nematode communities from the epiphytic mosses in the Left-bank Polesie were studied. Nematodes were extracted by a modified Baermann's method. A total of 47 species was found and they belonged to 34 genera, 21 families and 8 orders. The average number of nematodes was 4077 per 100 g of the moss. Rhabditida, Tylenchida, Plectida and Dorylaimida composed had more species richness (12, 10, 8 and 7 species, respectively). Species of these four orders comprised 78.7%. Representatives of three order Plectida, Dorylaimida and Monhysterida were the most numerous within the considered communities (proportion in the communities were 40.75, 21.30 and 18.65%, respectively). The majority of the identified species were subrecedent (31 or 65.95% of species composition) and accidental species (37 or 78.72%). Three species: Plectus parietinus Bastian, 1865, Mesodorylaimus bastiani Bütschli, 1873 and Geomonhystera villosa Bütschli, 1873 composed the core of nematode communities from epiphytic mosses in the Left-bank Polesie. They were found in 70.21, 57.45 and 53.19% of the samples, proportion in the community of 15.21, 10.03 and 17.96%, respectively.

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Key words: species diversity, nematodes, frequency of occurrence, epiphytic mosses, Left-bank Polesie.

Manuscript received 28 December 2020, accepted 19 July 2021

INTRODUCTION

Nematodes are among the most the most diverse, abundant and widely distributed animals. They occur in any environment, in every soil type, under all climatic conditions and in a wide range of habitats, from extremely polluted to pristine (Bongers, 1990). Among the moss biocoenoses, nematodes are the most abundant Metazoa (Sayre and Brunson, 1971; Steiner, 1994a; Glime, 2012). Nematode communities from mosses on particular substrates have been analyzed in different countries with respect to total abundance, species composition and diversity (Gadea, 1988; Georgievska, 1990; Lazarova *et al*., 2000).

The total number of species of nematodes found in the European mosses growing on different substrates is 234 (Barbuto and Zullini, 2006). The nematode fauna of the mosses growing on soil, stones and rocks has been better recognized. Several studies demonstrated a utility of nematode assemblages inhabiting mosses as indicators of air pollution (Zullini and Peretti, 1986; Steiner, 1994a, b, c, 1995). Abundance and species richness of epiphytic moss-dwelling nematodes can be affected by changes in the environment and they may be therefore, of value in determining changes in air.

There are few studies dealing with moss-dwelling nematodes in the Ukraine. A recent study on the subject was that of Shevchenko and Zhylina (2016), which determined a taxonomic structure of nematode communities of epiphytic mosses in green plantations of Chernihiv. However, there has been no comprehensive study of nematode communities inhabiting epiphytic mosses in the Left-bank Polesie. The purpose of the present study was to investigate the diversity and structure of the nematode communities from epiphytic mosses from different localities in the Left-bank Polesie (Ukraine).

MATERIAL AND METHODS

This study was performed in 2009–2014. Moss samples *Orthotrichum* spp. were collected from the following sites in the Left-bank Polesie of the Ukraine: the recreational green plantations of the city Chernihiv (N51°31'10.1», E31°17'58.8»; N51°29'50.1», E31°19'51.0»;

N51°32'31.0», E31°15'33.8»), forest ecosystems in the Mezin National Nature Park (N51°40'40», E32°52'07»; N51°39'21», E33°04'44»; N51°46'18», E33°04'13»; N51° 39'01», E33°05'15»; N51°41'34», E32°51'00») and in the natural reserves of the Horodnya district, Chernihiv region (N51°33'29», E31°39'16»; N51°33'13», E 31°39'16»). The study forests were the mesophilic broadleaved onrs of the *Carpino–Fagetea sylvaticae* Jakucs ex Passarge 1968 class: *Carpinion betuli* Issler 1931 and *Querco roboris–Tilion cordatae* Solomeshch et Laivinš ex Bulokhov et Solomeshch in Bulokhov et Semenishchenkov 2015. The vegetation syntaxa were identified according to Mucina *et al.* (2016) and Matuszkiewicz (2019). Moss samples were collected from the trunks of the trees aspen (*Popula tremula* L.) at a height of 100–120 cm. In total, 50 samples were processed.

Nematodes were extracted by the modified Baermann's method from the sample of 5 g. Exposition time was 48 h. Extracted nematodes were fixed in the TAF (2% triethanolamine, 7% formaldehyde solution, 91% water) and mounted on the temporary hydroglyceric slides (Kiryanova and Krall, 1969). A hundred of nematode specimens were randomly selected and identified, while the rest were calculated. In the samples with less than 100 nematodes, all the specimens were identified. Nematodes were examined under the light microscope Delta Optical Genetic Pro and identified to the species level based on literature (Goodey, 1963; Kiryanova and Krall, 1969; Nesterov, 1979). Taxonomy of the nematodes follows that in "Freshwater nematodes: ecology and taxonomy" (Abebe *et al*., 2006). Nematode abundance was expressed as specimens per 100 g of dry substrate.

We calculated a proportion of each species in the community (individual domination, D) as the ratio (in %) of the individuals of a species to the total number of nematodes. Five groups of dominance were established: eudominant (Ed) 10.1% and more, dominant (Dm) 5.1–10.0%, subdominant (Sd) 2.1–5%, recedent (R) 1.1–2.0% and subrecedent (Sr) <1.1% (Tischler, 1949; Solovyeva, 1986). We calculated a frequency of occurrence (F) as the ratio (in %) of a number of samples, in which the species was found to a total number of samples. Four classes of occurrence were used: accident (Ad) occurred in 1–25% of samples, accessory (As) in 26–49%, constant (C) in 50–74% and euconstant (Ec) in 75–100% (Solovyeva, 1986). Statistical analyses were performed with EXCEL 10.0.

RESULTS AND DISCUSSION

Nematodes were found in all samples collected. They are therefore considered as common inhabitants of epiphytic mosses in the studied area. In total 47 species of nematodes occurred, which were distributed among 34 genera, 21 families and 8 orders (Table 1). The number of nematode species in 50 samples varied from 2 to 16 per sample while the total abundance varied across samples from 60 to 35,300 individuals per 100 g of moss. The average number of nematodes was 4077 ± 5990 per 100 g of moss.

An abundance of nematodes inhabiting the epiphytic mosses in our study was the same as those in the study by Lazarova *et al.* (2000). According to these authors, abundance of nematodes ranged 3830 ± 4973 individuals/100 g of moss on tree trunks in a durmast oak forest (Bulgaria). They also reported that 20 species an 14 genera have been recorded.

Table 1. Functional structure of the nematode communities from epiphytic mosses of the Left-bank Polesie.

No	Order/familiy/species	A	D	F
	Enoplida Filipjev, 1929			
	Alaimidae Micoletzky, 1922			
1	*Alaimus primitivus* de Man, 1880	4.1±26.8	Sr	Ad
	Rhabdolaimidae Chitwood 1951 (Gerlach et Riemann 1974)			
2	*Rhabdolaimus terrestris* de Man, 1880	14.0±31.6	Sr	Ad
	Triplonchida Cobb, 1920			
	Prismatolaimidae Micoletzky, 1922			
3	*Prismatolaimus intermedius* Bütschli, 1873	18.8±151.5	Sr	Ad
4	*Prismatolaimus dolichurus* de Man. 1880	0.4±6.7	Sr	Ad
	Tripylidae de Man, 1876			
5	*Tripyla sp.*	1.9±33.9	Sr	Ad
6	*Paratripyla sp*	92.5±228.5	Sd	Ad
	Dorylaimida Pearse, 1942			
	Dorylaimidae De Man, 1876			
7	*Mesodorylaimus bastiani* Bütschli, 1873	408.8±1275.5	Ed	C
	Qudsianematidae (Jairajpuri, 1965) Siddiqi, 1969			
8	*Eudorylaimus carteri* (Bastian, 1865) Andrassy, 1959	6.7±37.5	Sr	Ad
9	*Eudorylaimus circulifera* Loof 1961	45.1±174.3	R	As
10	*Eudorylaimus pratensis* (de Man. 1880) Andrassy, 1959	2.4±30.6	Sr	Ad
11	*Ecumenicus monohystera* (de Man, 1880) Thorne, 1974	63.3±133.9	R	Ad
	Tylencholaimidae Filipjev, 1934			

12	*Tylencholaimus teres* Thorne, 1939	131.3±2128.8	Sd	Ad
	Aporcelaimidae Heyns, 1965			
13	*Aporcelaimellus paracentrocercus* (de Coninck, 1935) Baqri and Coomans, 1973	210.6±333.9	Dm	Ad
	Mononchida Jairajpuri, 1969			
	Mononchidae Chitwood, 1937			
14	*Clarcus papillatus* (Bastian, 1865) Jairajpuri, 1970	5.4±7.3	Sr	Ad
15	*Prionchulus muscorum* (Dujardin, 1845) Wu & Hoeppli, 1929	207.5±526.9	Dm	As
	Monhysterida De Coninck et Sch. Stekhoven, 1933			
	Monhysteridae De Man, 1876			
16	*Eumonhystera vulgaris* de Man, 1880	28.3±283.1	Sr	Ad
17	*Geomonhystera villosa* Bütschli, 1873	732.0±544.5	Ed	C
	Plectida Malakhov, 1982			
	Plectidae Örley, 1880			
18	*Anaplectus granulosus* (Bastian, 1865) De Coninck et Sch. Stekhoven, 1933	40.5±403.4	Sr	Ad
19	*Plectus assimilis* Bütschli, 1873	16.3±121.5	Sr	Ad
20	*Plectus cirratus* Bastian, 1865	757.7±5334.6	Ed	Ad
21	*Plectus geophilus* de Man, 1880	0.4±6.7	Sr	Ad
22	*Plectus parietinus* Bastian, 1865	620.0±1507.9	Ed	C
23	*Plectus parvus* (Bastian, 1865) Paramonov, 1964	64.7±302.6	R	Ad
24	*Plectus rhizophilus* (de Man, 1880) Paramonov, 1964	34.0±21.9	Sr	Ad
25	*Tylocephalus auriculatus* (Bütschli, 1873) Anderson, 1966	127.7±336.6	Sd	As
	Rhabditida Chitwood, 1933			
	Teratocephalidae Andrassy, 1958			
26	*Teratocephalus terrestris* Bütschli, 1873	2.3±17.2	Sr	Ad
	Cephalobidae Filipjev, 1934			
27	*Cephalobus persegnis* Bastian, 1865	19.6±18.3	Sr	Ad
28	*Eucephalobus mucronatus* (Kozlowska et Roguska-Wasilewska, 1963) Andrassy, 1967	1.1±15.6	Sr	Ad
29	*Eucephalobus. oxyuroides* (de Man, 1880) Steiner, 1936	6.4±34.2	Sr	Ad
30	*Acrobeloides bűtschlii* (de Man, 1884) Steiner et Buhrer, 1933	0.4±7.7	Sr	Ad
31	*Chiloplacus symmetricus* (Thorne, 1925) Thorne, 1937	1.5±16.7	Sr	Ad
	Panagrolaimidae Thorne, 1937			
32	*Panagrolaimus rigidus* (Schneider, 1866) Thorne, 1937	78.4±237.4	R	As
33	*Panagrobelus topayi* Andrassy, 1960	8.0±11.4	Sr	Ad
34	*Macrolaimus taurus* Thorne, 1937	5.4±35.9	Sr	Ad
	Rhabditidae Örley, 1880			
35	*Rhabditis filiformis* Bütschli, 1873	1.2±21.9	Sr	Ad
36	*Rhabditis* spp.	2.6±26.6	Sr	Ad
	Mesorhabditidae Andrassy, 1976			
37	*Mesorhabditis monhystera* (Bütschli, 1873) Dougherty, 1955	25.4±121.3	Sr	Ad
	Tylenchida Thorne, 1949			
	Tylenchidae Oerley, 1880			
38	*Aglenchus agricola* (de Man, 1921) Andrassy, 195	27.7±21.6	Sr	Ad
39	*Tylenchus davainei* Bastian, 1865	10.9±186.5	Sr	Ad
40	*Tylenchus* spp.	67.5±49.2	R	Ad
	Aphelenchidae (Fuchs, 1937) Steiner, 1949			
41	*Aphelenchus avenae* Bastian, 1965	1.0±12.3	Sr	Ad
	Paraphelenchidae Goodey, 1961			
42	*Paraphelenchus pseudoparietinus* (Micoletzky, 1922) Micoletzky, 1925	0.4±7.7	Sr	Ad
	Aphelenchoididae Skarbilovich, 1947			
43	*Aphelenchoides composticola* Franklin, 1957	114.6±520.6	Sd	As
44	*Aphelenchoides pusillus* (Thorne,1929) Filipjev, 1934	0.3±5.8	Sr	Ad
45	*Aphelenchoides* spp.	16.3±24.7	Sr	Ad
46	*Laimaphelenchus penardi* (Steiner, 1914) Filipjev et Sch. Stek., 1941	43.2±166.7	R	As
	Anguinidae Nicoll, 1935			
47	*Ditylenchus myceliophagus* Goodey, 1958	8.4±97.6	Sr	Ad
	Total	**4077±5990**		

A – abundance (mean ± SD). D – proportion in the community, %: eudominant (Ed), dominant (Dm), subdominant (Sd), recedent (R) and subrecedent (Sr). F – frequency of occurrence, %: accident (Ad), accessory (As), constant (C) and euconstant (Ec).

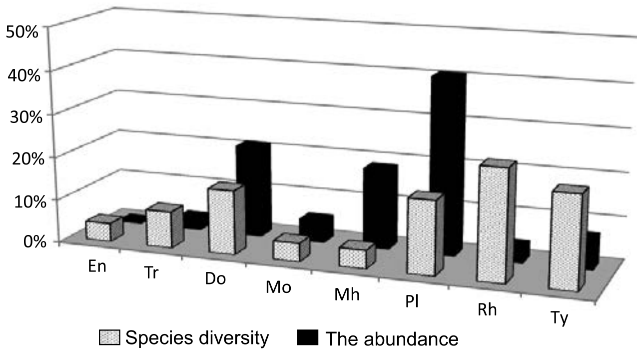

Fig. 1. Taxonomic diversity of nematode communities in epiphytic mosses of the Left-bank Polesie: En – Enoplida, Tr – Triplonchida, Do – Dorylaimida, Mo – Mononchida, Mh – Monhysterida, Pl – Plectida, Rh – Rhabditida, Ty – Tylenchida.

The order Rhabditida was the richest in species number and it was represented by 12 species or 25.5% of the species composition (Fig. 1). Less diverse were Tylenchida, Plectida and Dorylaimida (10, 8, 7 species, respectively). Triplonchida was represented by four species. The orders Enoplida, Mononchida and Monhysterida consisted of two species each.

In terms of a number of individuals, Plectida was the most abundant (proportion in the community 40.75%), followed by Dorylaimida (21.30%), Monhysterida (18.65%), Tylenchida (7.12%) and Mononchida (5.22%). However, in the quantitative representation Rhabditida comprised 3.74% only.

Most families (10) were represented by a single species (Fig. 2), five families (Prismatolaimidae, Tripylidae, Mononchidae, Monhysteridae and Rhabditidae) by two, two families (Panagrolaimidae and Tylenchidae) by three and two families (Qudsianematidae, Aphelenchoididae) by four. The richest families were Cephalobidae (5 species) and Plectidae (8 species).

Plectids were both the most diverse and the most numerous (Fig. 2). By the number of specimens in the nematodes community of epiphytic mosses, the family Monhysterida was the second most abundant (18.65%). The Dorylaimidae appeared to be the third (10.03%) and the Mononchidae (5.22%) and Aporcelaimidae (5.17%) were the fourth ones. The proportion of other six families was >1%: Panagrolaimidae (2.25%), Tripylidae (2.32%), Tylenchidae (2.61%), Qudsianematidae (2.88%), Tylencholaimidae (3.22%) and Aphelenchoididae (4.28%). Representation of other ten families was insignificant.

The identified nematode species occurred in epiphytic mosses with different frequency and in different amounts. Grouping of nematode species into ecological groups based on their proportion in the community (dominance) and the frequency of occurrence are presented (Table 1).

The analysis of nematode species occurrence in the samples revealed that 37 species, or 78.72% of all species collected, were accidental species (Fig. 3). Only 10 species (21.28% of the species composition) occurred in more than 25% of the samples, thus becoming the basic part of the faunal nematode complex of epiphytic mosses. The number of these species in nematode communities of epiphytic mosses was almost 60% of the total number of nematodes.

Seven species (14.89% of the collected fauna) were classified as accessory species. They are *T. auriculatus*;

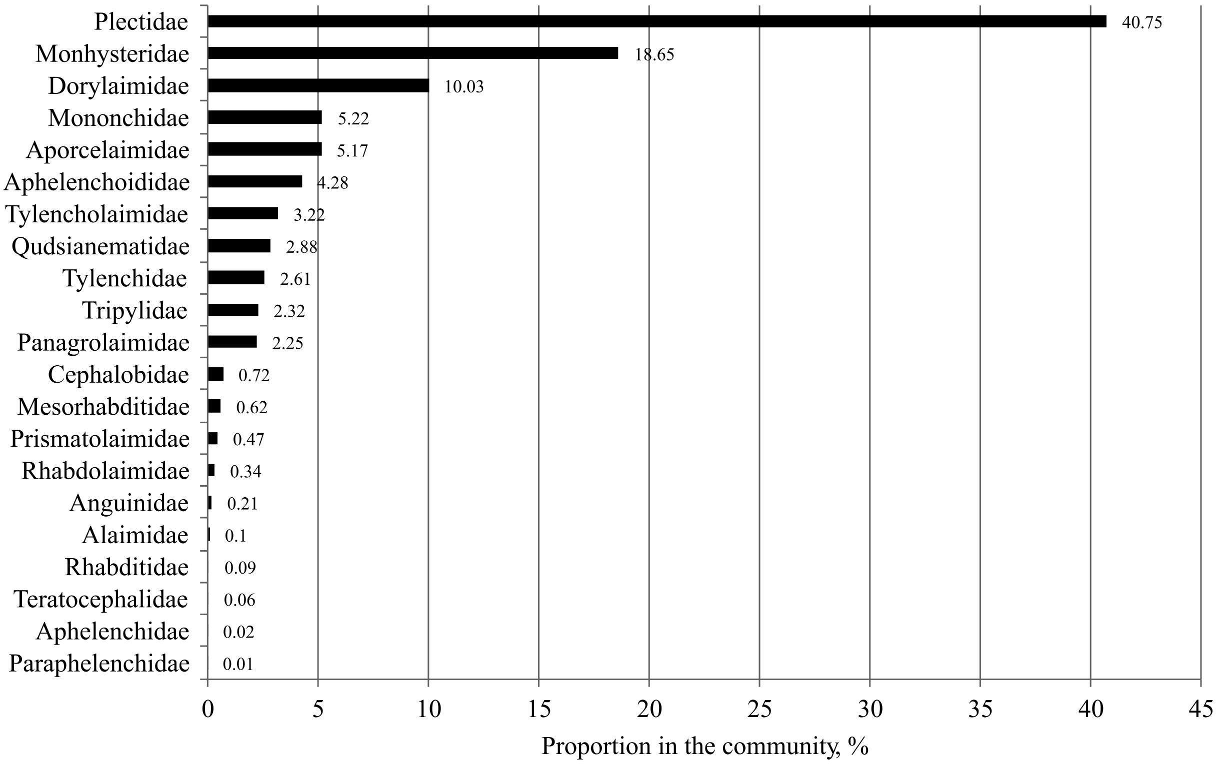

Fig. 2. Average abundance (%) and diversity of nematode families in epiphytic mosses of the Left-bank Polesie.

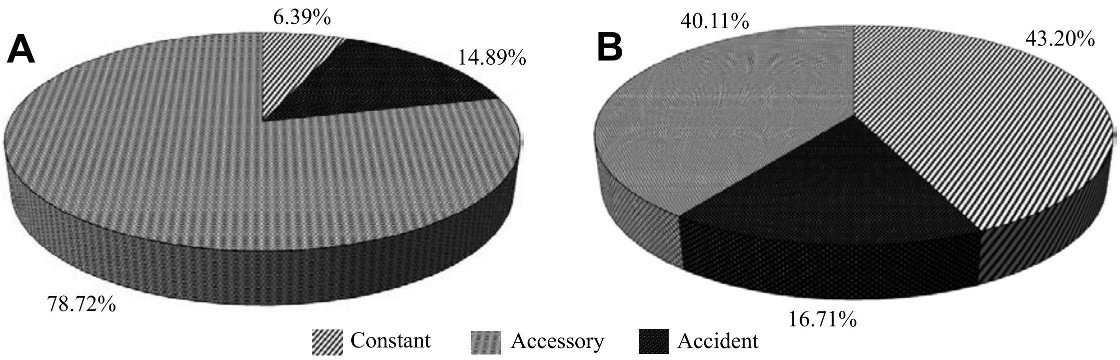

Fig. 3. Structure of nematode fauna of epiphytic mosses in the Left-bank Polesie according to the frequency of occurrence criterion: A – species diversity, %; B – the abundance, %.

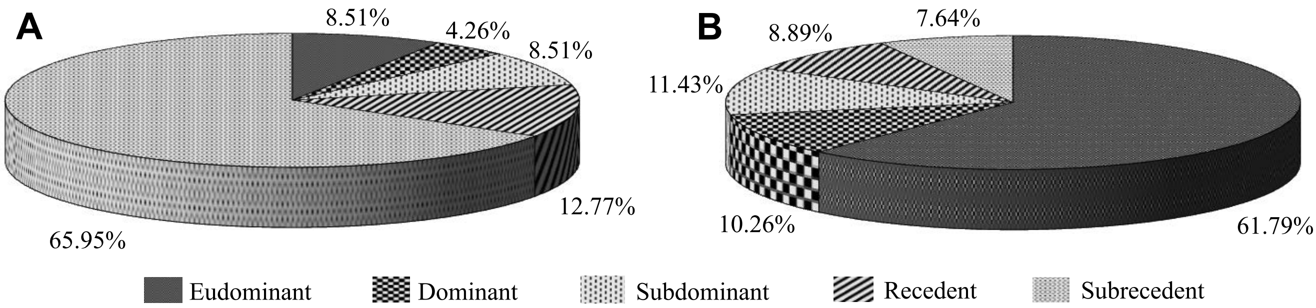

Fig. 4. Structure of nematode fauna of epiphytic mosses in the Left-bank Polesie according to the dominance criterion: A – species diversity, %; B –abundance, %.

*A. composticol*a; *E. circulifera; P. rigidus*; *P. muscorum*; *P. parvus*; *L. penardi*. Their contribution was 16.71% of the total number. *P. parietinus; M. bastiani* and *G. villosa* were the most common species from the epiphytic mosses; they were found in 70.21, 57.45 and 53.19% of the samples, respectively. These three species are included in the group of constant and accounted for about 43% of all specimens. In more than 75% of the samples the species were absent.

The species found in our samples have been recorded from mosses in different regions (Zullini and Peretti, 1986; Gadea, 1988; Georgievska, 1990; Steiner, 1994a; Lazarova et al., 2000). *Plectus* spp., *G. villosa*, *T. auriculatus*, *P. rigidus* and *P. muscorum* were frequently found in mosses, but were not specific.

Based on the corresponding proportions in the nematode communities, we assigned four species (8.51% of the found species) to the eudominant ones (Fig. 4). They were *M. bastiani*, *G. villosa*, *P. parietinus* and *P. cirratus*. The abundance of eudominant species in nematode communities is significant and amounted to 61.79%.

A. paracentrocercus and *P. muscorum* appeared to be in the dominant group and their contribution was 10.26% in total abundance. Steiner (1994b) indicates that the species *P. muscorum* typically occurred at rural sites.

Four species (8.51%) were subdominant (proportion combined together 11.43%). Six species (12.77%) were identified as recedent. Thirty-one species (65.95% of the found species) constituted the subrecedent. The abundance of subrecedent species in nematode communities was low (7.64%). Therefore *M. bastiani*, *G. villosa*, *P. parietinus*, *P. cirratus*, *P. muscorum* and *A. paracentrocercus* were the most abundant in communities of epiphytic moss-inhabiting nematodes.

In our study, *M. bastiani*, *G. Villosa and P. parietinus* occurred in more than 50% of samples and were the most numerous species (proportion 10.03–18.59%). This corresponds with the results of Georgievska (1990), where *G.villosa* was the dominant species, and those of Zullini and Peretti (1986) where *Plectus* spp. prevailed. In general outlines all of the found species are common forms.

CONCLUSIONS

The present study indicates that nematodes are common inhabitants of epiphytic mosses in the studied area. 47 species of nematodes found in the epiphytic mosses represent 34 genera, 21 families and 8 orders. Rhabditida, Tylenchida, Dorylaimida and Plectida species are more rich. The species of these four orders comprised 78.7%. Rhabditida constituted the most representative group: 12 species or 25.5% of the whole species composition.

Representatives of three order Plectida, Dorylaimida and Monhysterida were the most numerous within the considered community (proportion in the communities were 40.75%, 21.30%, 18.65%, respectively).

A frequency of occurrence was quite low for most nematode species with less than 25% of the samples (37 or 78.72% of species composition). They were found in 2.13–19.15% of samples and were accidental species. The majority of the identified species were subrecedent (31 or 65.95% of species composition), their proportion in the communities was 0.01–0.99% of the total number of nematodes.

Our study proved that the communities of nematodes inhabiting epiphytic mosses of the Left-bank Polesie are characterized by a dominance of a small number of species. *P. parietinus*, *M. bastiani* and *G. villosa* were the most common species from the epiphytic mosses; they were found in 70.21, 57.45 and 53.19% of the samples, respectively. At the same time, *M. bastiani*, *G. villosa*, *P. parietinus* and *P. cirratus* were the most numerous (proportion in the community 10.03, 17.96, 15.21 and 18.59%, respectively). Thus, three species: *P. parietinus*, *M. bastiani* and *G. villosa* composed the core of nematode communities from epiphytic mosses in the Left-bank Polesie.

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