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Species and genera of soil nematodes in forest ecosystems of the Vihorlat Protected Landscape Area, Slovakia

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Summary

Fauna of soil nematodes was studied in three main forest types of the Vihorlat Mountains, *Querceto-Fageto-Aceretum* at Remetské Hámre (RH), *Fagetum* at Morské oko (MO), and *Fageto-Aceretum* at Sninský kameň (SK). Each forest type was represented by five sites. In total 198 species and 98 genera of soil nematodes were distinguished. Most species belonged to rare taxa with the frequency of occurrence lower than 50 %. The number of species and genera decreased from RH (167 species and 86 genera) through MO (115 and 68) to SK (87 and 51). Species and generic richness was significantly positively correlated with soil pH(H_2O), negatively with altitude, soil moisture and C_{ox}. Greater part of nematode species and genera belonged to microbivores and to the taxa with higher cp values of 3 – 5. We can conclude that rich nematode fauna indicated undisturbed forest soil condition, nevertheless, the richness decreased with increasing altitude.

Keywords: Forest; soil nematodes; species richness; trophic diversity; maturity

Introduction

Nematodes are the most abundant multicellular animals (Bongers & Ferris, 1999) and very likely the second most diverse phylum with about 27 000 recently described species (estimated number up to 1 000 000) after arthropods (Huggot *et al.*, 2001). Due to their diverse communities they significantly influence ecosystem processes, particularly in soil (Vinciguerra, 1979; Wasilewska, 1979; Bongers & Bongers, 1998), and they are a useful indicator of soil condition in forest ecosystems (Yeates, 2007).
The fauna of soil nematodes in forest ecosystems of Slovakia was relatively well studied (Šály, 1983; Lišková *et al.*, 2008; Čerevková & Renčo, 2009), but the eastern woodland of the Vihorlat mountains has not been paid attention till now. This territory is characterised by deciduous forests arranged in altitudinal gradient, moreover, these forests are still devoid of marked anthropogeneous disturbance. We selected three main forest types that characterise the Vihorlat woodland to study soil nematode communities as they vary with natural environment under low or negligible human intervention. This paper gives the first part of the study aimed at evaluation of species and generic richness in the Vihorlat woodland.

Material and Methods

Vihorlat Mountains is a volcanic (mostly andesite) mountain range in eastern Slovakia that belongs to the Inner Eastern Carpathians. The middle part of the mountains was established the Vihorlat Protected Landscape Area (4 500 ha) in 1973. The area in mainly covered by natural deciduous forests with valuable beech ecosystems at the peak Vihorlat (1076 m a.s.l.) protected by UNESCO since 2007. Nematodes were studied in the vicinity of three localities described below. Values of soil parameters as gravimetric soil moisture, pH (H_2O), and C_{ox} are given in arithmetical mean ± SE (range of values), n = 10.
Remetské Hámre: RH, 48° 50' N, 22° 10' E, 403 m a.s.l., mean annual air temperature 5 – 7 º C, annual precipitation approximately 700 – 800 mm. The vegetation is characterised by *Querceto-Fageto-Aceretum* forest type with shrub-rich mostly with *Corylopsis, Ligustrum* and *Frangula alnus* on cambisol. Soil moisture = 31.84 ± 2.99 (15.21 – 46.74) %, pH (H_2O) = 7.69 ± 0.25 (6.54 – 9.10),

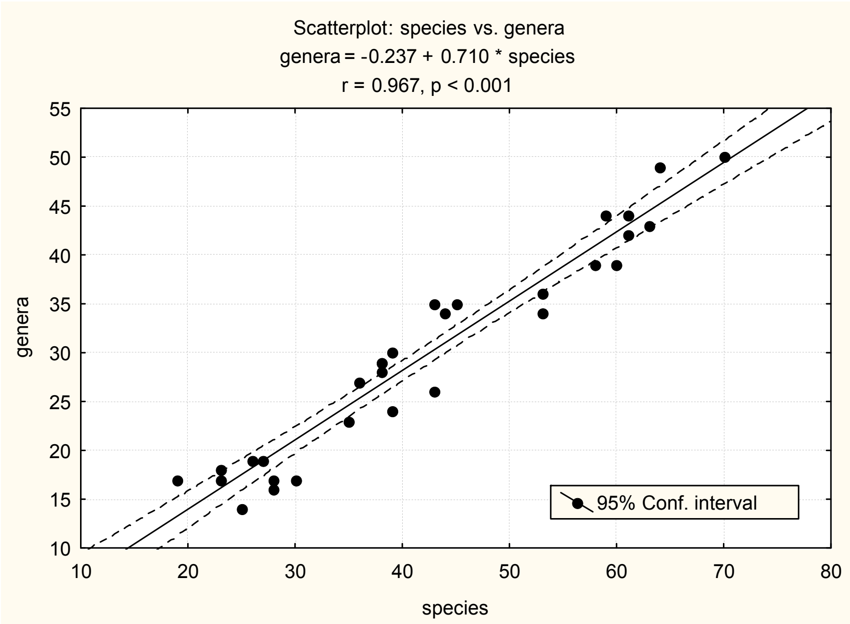

Fig. 1. Scatterplot with linear regression line fitted to the species versus genus numbers and 95% confidence intervals for that line.

C_{ox} = 8.81 ± 0.70 (5.95 – 12.50) %.

Morské oko: National Nature Reserve: MO, 48° 54' N, 22° 13' E, 618 m a.s.l., mean annual air temperature 4 – 5 ° C, precipitation 800 – 1100 mm. Vegetation is generally characterised by woody composition, where beech (*Fagetum*) has absolute superiority with poor or almost without herb cover undergrowth on clay-loamy cambisol. Soil moisture = 33.00 ± 2.30 (15.06 – 40.09) %, pH (H_2O) = 6.94 ± 0.10 (6.45 – 7.60), C_{ox} = 11.09 ± 0.96 (4.63 – 15.27) %.

Sninský kameň: SK, 48° 56' N, 22° 12' E, 1 005 m a.s.l., mean annual air temperature 4 – 5 ° C, precipitation 800 - 1100 mm. Forest vegetation is characterised by *Fageto-Aceretum* forest type on sandy-loamy cambisol. Herbaceous undergrowth is forming considerable layer characterised by the *Cicerbita alpina*. Due to harsh climate plants have limited growth. Soil moisture = 44.40 ± 1.17 (38.35 – 51.76) %, pH (H_2O) = 6.18 ± 0.13 (5.66 – 7.06), C_{ox} = 18.21 ± 0.84 (13.50 – 22.13) %.

At each locality representing a forest type five plots each of 50 x 50 m were established. Soil samples were collected on

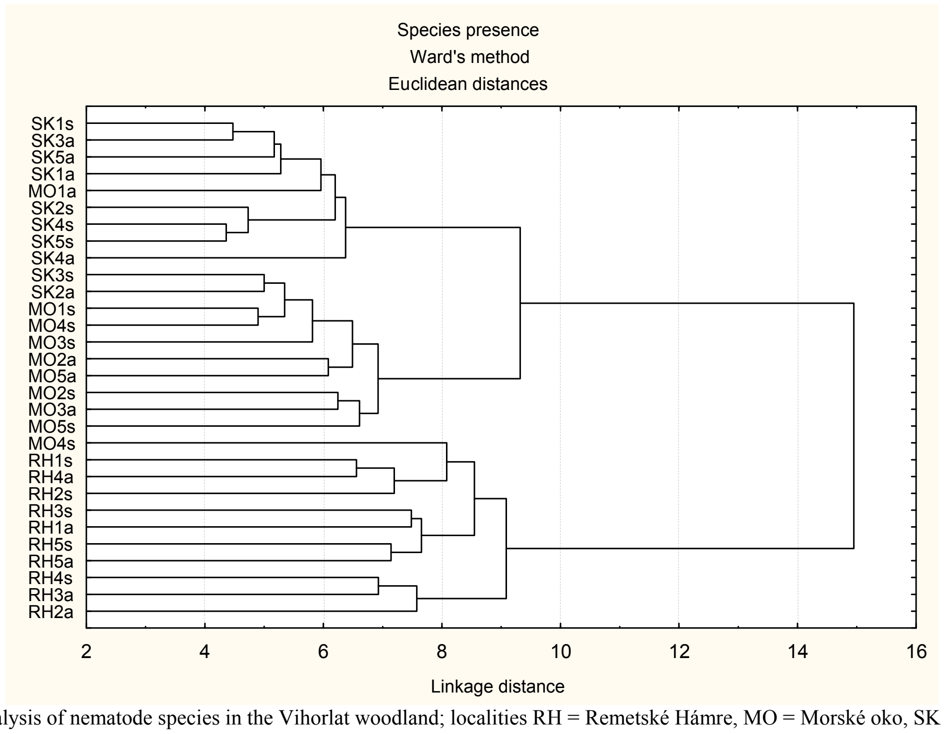

Fig. 2. Cluster analysis of nematode species in the Vihorlat woodland; localities RH = Remetské Hámre, MO = Morské oko, SK = Sninský kameň; 1, 2, 3, 4, and 5 = sites at individual localities; s = spring sampling date, a = autumn sampling date; the distance metric Euclidean distance on species presence and joining rule Ward's method.

Table 1. Variation in nematode species and genus numbers in three forest types of the Vihorlat Mountains: *Querceto-Fageto-Aceretum* at Remetské Hámre (RH), *Fagetum* at Morské oko (MO), and *Fageto-Aceretum* Sninský kameň (SK). Different letters indicate significant differences as suggested by Fisher post-hoc tests ($p < 0.05$) in one-way ANOVA.

	Species								
	mean	n	SD	SE	minimum	maximum	25% quantile	median	75% quantile
RH	58.40[a]	10	7.40	2.34	43.00	70.00	53.00	59.50	63.00
MO	38.40[b]	10	11.08	3.50	19.00	61.00	35.00	38.00	44.00
SK	30.10[c]	10	6.94	2.19	23.00	43.00	25.00	28.00	36.00
All woodland	42.30	30	14.69	2.68	19.00	70.00	28.00	39.00	58.00
	Genera								
	mean	n	SD	SE	minimum	maximum	25%quantile	median	75%quantile
RH	41.30[a]	10	5.62	1.78	34.00	50.00	36.00	41.00	44.00
MO	28.60[b]	10	7.53	2.38	17.00	42.00	23.00	29.00	34.00
SK	19.50[c]	10	4.50	1.42	14.00	27.00	17.00	17.50	24.00
All woodland	29.80	30	10.79	1.97	14.00	50.00	19.00	29.00	39.00

2 April and 2 October 2008. At each site (plot) five soil subsamples covering an area of 100 cm^2 down to the depth of 10 cm were taken using a hand spade. The soil was hand-mixed and nematodes were isolated from two 50 g portions of bulked soil using the Baermann funnel method. One nematode isolate was evaluated quantitatively to genus level. The second one was subjected to detailed study of species occurrence as many rare species in the first isolate were found only juvenile or were absent. Nematodes were fixed in FAA, mounted on permanent glycerol slides and determined to species level using light microscope Leica Leitz DMRB equipped with interference contrast. Statistical analyses were performed using the software package STATISTICA (StatSoft, 2001).

Nematodes were classified according to Andrássy (2005, 2007, 2009) and these books together with author's earlier works were used for the determination of nematodes. Tylenchida were mostly determined according to Brzeski (1998), some Dorylaimida according to Loof (1999) and further according to original descriptions and redescriptions in various papers. Species were allocated to trophic groups mainly using data on food preferences in genera as outlined by Yeates *et al*. (1993) and newer data, e.g. Okada & Kadota (2003). Cp values of species and genera were derived from cp values for families as given by Bongers & Bongers (1998) using Bongers' (1988) allocations to families. Trophic diversity T (Freckman & Ettema, 1993) and Sum Maturity Index ∑MI (Yeates, 1994) were calcu-

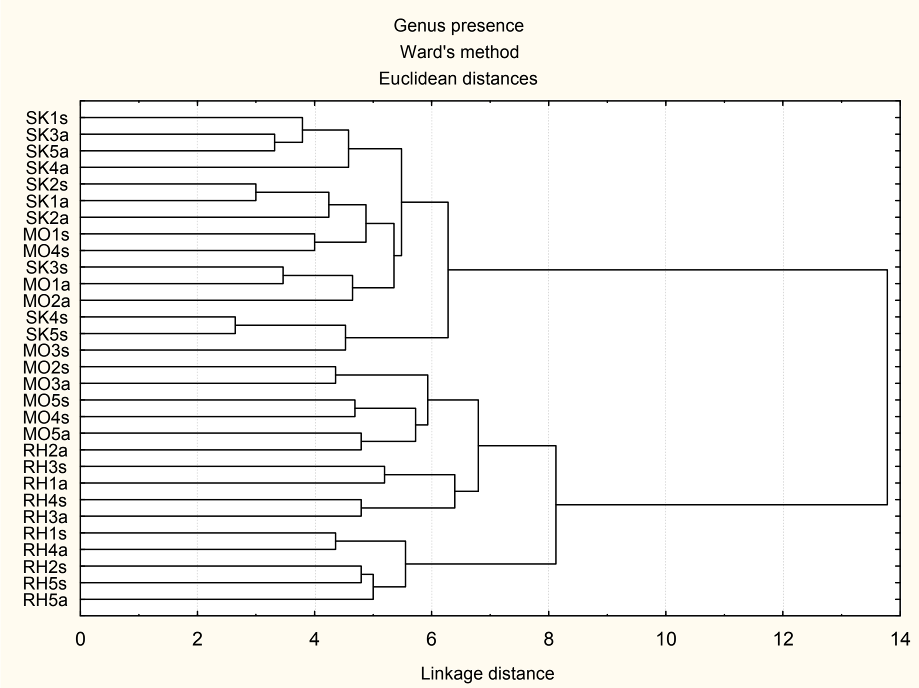

Fig. 3. Cluster analysis of nematode genera in the Vihorlat woodland; localities RH = Remetské Hámre, MO = Morské oko, SK = Sninský kameň; 1, 2, 3, 4, and 5 = sites at individual localities; s = spring sampling date, a = autumn sampling date; the distance metric Euclidean distance on genus presence and joining rule Ward's method.

lated either from the number of nematoda taxa in trophic groups or in cp groups, respectively; i.e. supposing that all species (genera) were present in a community and had the same abundance.

Kruskal-Wallis ANOVA and multiple comparisons of mean ranks for all groups supported significantly greater number of species ($H_{(2, N=30)} = 18.019$, $p < 0.001$) and genera ($H_{(2, N=30)} = 21.048$, $p < 0.001$) in RH than in SK, the effect of season was insignificant.

Table 2. Numbers of nematode species and genera in trophic groups and their percentage proportions to the total fauna with trophic diversity T index at individual localities and in all woodland.

	Species							
	RH		MO		SK		All woodland	
	No.	%	No.	%	No.	%	No.	%
Bacterivores	60	35.9	42	36.5	28	32.2	67	33.8
Fungivores	27	16.2	14	12.2	16	18.4	32	16.2
Root-fungal feeders	22	13.2	11	9.6	15	17.2	26	13.1
Plant parasites	19	11.4	19	16.5	9	10.3	28	14.1
Omnivores	22	13.2	20	17.4	12	13.8	27	13.6
Predators	16	9.6	8	7.0	6	6.9	17	8.6
Insect parasites	1	0.6	1	0.9	1	1.1	1	0.5
Sum	167	100.0	115	100.0	87	100.0	198	100.0
T	4.72		4.55		4.96		4.91	
	Genera							
	RH		MO		SK		All woodland	
	No.	%	No.	%	No.	%	No.	%
Bacterivores	32	37.2	26	38.2	19	37.3	37	37.8
Fungivores	9	10.5	6	8.8	7	13.7	9	9.2
Root-fungal feeders	8	9.3	74	5.9	6	11.8	9	9.2
Plant parasites	13	15.1	11	16.2	7	13.7	16	16.3
Omnivores	11	12.8	12	17.6	7	13.7	13	13.3
Predators	12	14.0	8	11.8	4	7.8	13	13.3
Insect parasites	1	1.2	1	1.5	1	2.0	1	1.0
Sum	86	100.0	68	100.0	51	100.0	98	100.0
T	4.61		4.37		4.64		4.52	

Results

In total 198 species and 98 genera of soil nematodes were distinguished (Appendix 1). Some nematodes could not be determined to species because of the absence of adults or if the adult specimens were present those could not be identified with the available species descriptions for certain. Of the 198 species only 26 (13.13 %) had the frequency of occurrence in the woodland (F) greater than 49.99 %, of the 98 genera such were 19 (19.39 %). The numbers of species and genera were significantly positively correlated (Fig. 1., Pearson r = 0.967, $p < 0.001$; Spearman R = 0.948, $p < 0.001$) and there also were significant positive correlations within individual forest types.

Most nematode species and genera were found in *Querceto-Fageto-Aceretum* at Remetské Hámre (RH). Two-way ANOVA (homogeneity of variances assumption was not violated) showed that species ($F_{(2, 24)} = 26.959$, $p < 0.001$) and genera ($F_{(2, 24)} = 31.289$, $p < 0.001$) numbers in RH were significantly greater than in MO and SK. MO had significantly more species and genera than SK (Table 1). The effect of season (spring and autumn sampling) upon the numbers of species and genera was insignificant.

The cluster analysis on species occurrence (Fig. 2) produced two main clusters, the upper one having two sub-clusters consisting of SK and MO samples (except for MO1a, SK3s and SK2a). The lower cluster consisted of RH samples plus MO4s. The cluster analysis on genus occurrence (Fig. 3) produced two main clusters, the upper one consisting of SK and MO samples and the lower one consisting of MO and RH samples.

The number of species over the Vihorlat woodland sites and sampling dates (n = 30) was significantly positively correlated with pH(H_2O) (r = 0.529, p = 0.003), negatively correlated with soil moisture (r = -0.558, p = 0.001), C_{ox} (r = -0.612, $p < 0.001$), and with altitude (r = -0.758, $p < 0.001$). The number of genera was significantly positively correlated with pH(H_2O) (r = 0.580, p = 0.001), negatively correlated with soil moisture (r = -0.625, $p < 0.001$), C_{ox} (r = -0.697, $p < 0.001$), and with altitude (r = -0.815, $p < 0.001$), Fig. 4. Spearman R gave very similar values. Soil pH(H_2O) was negatively correlated with increasing altitude (r = - 0.759, $p < 0.001$, n = 30) whereas soil moisture and C_{ox} were positively correlated with the altitude (r = 0.614, r = 0.840, $p < 0.001$, n = 30, respectively). The altitudinal gradient studied manifested in accumulation of soil organic

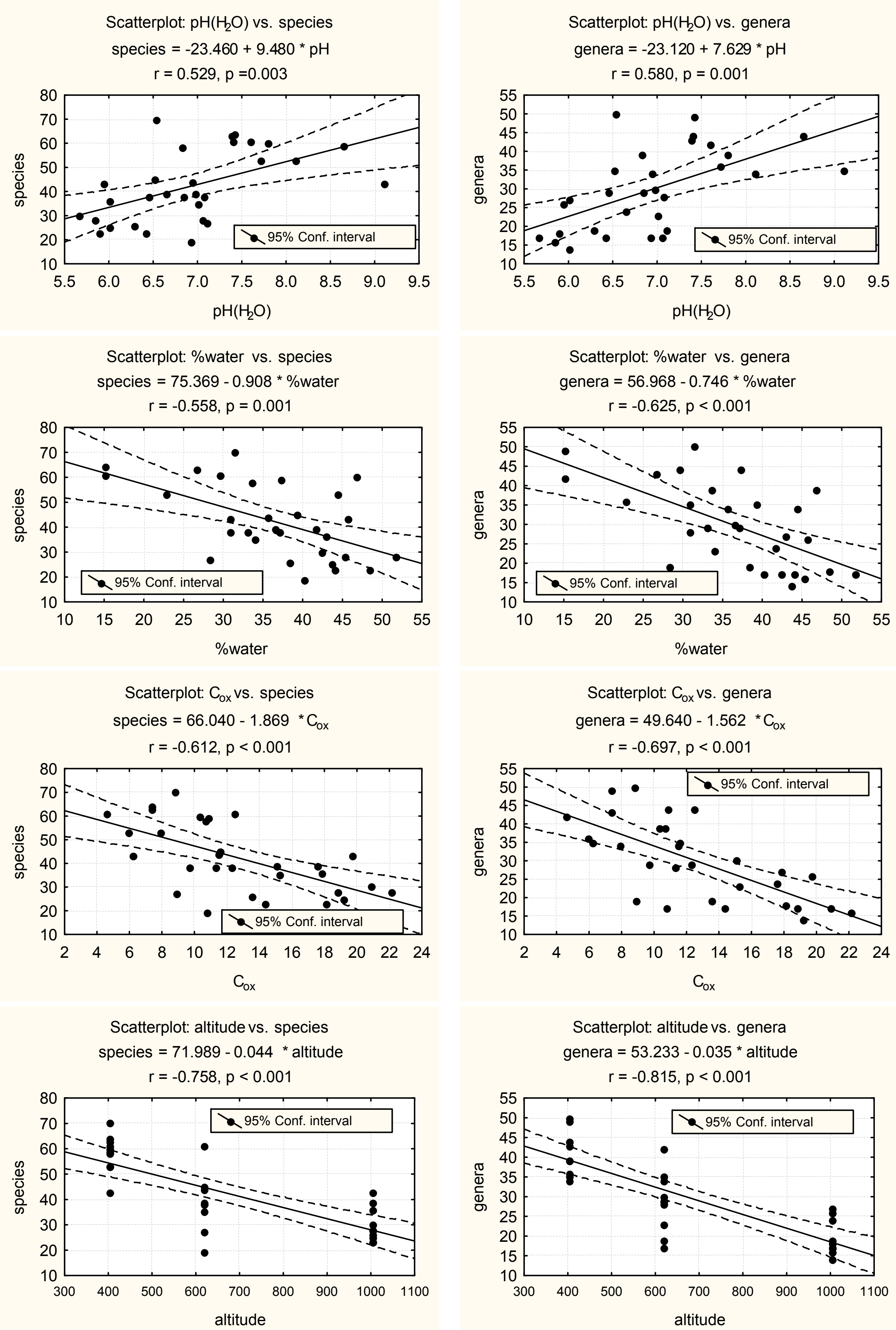

Fig. 4. Scatterplots with linear regression lines fitted to the species and genus numbers versus environmental variables (soil pH(H_2O), gravimetric soil moisture as % water in wet soil, C_{ox} % in dry soil, and altitude in m a.s.l.) and 95% confidence intervals for that line.

Table 3. Numbers of nematode species and genera in cp groups and their percentage proportions to the total fauna with Sum Maturity Index ∑MI at individual localities and in all woodland.

	RH		MO		SK		All woodland	
Species								
	No.	%	No.	%	No.	%	No.	%
cp 1	6	3.6	4	3.5	5	5.7	7	3.5
cp 2	73	43.7	46	40.0	46	52.9	87	43.9
cp 3	42	25.1	27	23.5	15	17.2	49	24.7
cp 4	38	22.8	28	24.3	16	18.4	43	21.7
cp 5	8	4.8	10	8.7	5	5.7	12	6.1
Sum	167	100.0	115	100.0	87	100.0	198	100.0
∑MI	2.81		2.95		2.66		2.83	
Genera								
	RH		MO		SK		All woodland	
	No.	%	No.	%	No.	%	No.	%
cp 1	6	7.0	4	5.9	5	9.8	7	7.1
cp 2	32	37.2	22	32.4	22	43.1	36	36.7
cp 3	24	27.9	18	26.5	10	19.6	26	26.5
cp 4	16	18.6	14	20.6	9	17.6	17	17.3
cp 5	8	9.3	10	14.7	5	9.8	12	12.2
Sum	86	100.0	68	100.0	51	100.0	98	100.0
∑MI	2.86		3.06		2.75		2.91	

matter and lowered pH(H_2O) under wetter and cooler climate and combination of these factors negatively affected nematode richness.

Microbivorous species and genera prevailed in nematode fauna of the Vihorlat woodland. The number of species and genera in all trophic groups was always lower at SK than at RH. Consistent decrease from RH through MO to SK was found in the number of bacterivorous species and genera, predaceous species and genera, omnivorous species, and plant parasitic genera. Such trend was not observed in the values of the T index (Table 2).

More nematode species and genera belonged to the groups with higher cp scaling (together for 3, 4 and 5) than to the groups with lower cp scaling (together for 1 and 2). The number of species and genera in all cp groups was always lower at SK than at RH. Consistent decrease from RH through MO to SK in the number of species and genera was observed for cp groups 3 and 4. The values of ∑MI index for both species and genera were lower at SK than at RH, greatest values were at MO (Table 3).

Discussion

The nematode fauna in the Vihorlat Mountains had a great species and generic richness as in similar woodland landscapes of Central Europe. For example, Šály (1985) found 182 species of soil nematodes in the Slovak Paradise, Andrássy (1996) 122 species in the Bükk Mountains, and Háněl (1996a) 138 species in the Křivoklátsko woodland. Very high species and generic richness were found in *Querceto-Fageto-Aceretum* woodland at RH when compared with other European deciduous ecosystems (e.g. Alphei, 1998; Büttner, 1989; Popovici, 1989) very likely due to favourable climate and rich plant community.

Nematode species and genera were significantly positively correlated as in our study on meadow ecosystems (Háněl & Čerevková, 2006) and in tree plantations on colliery spoils (Háněl, 2009). Therefore, genus richness is a sufficient estimator of overall nematode richness although species can better distinguish different types of ecosystems (Figs. 1 and 2). Majority of nematode species belonged to rare or very rare animals (Appendix 1), which suggested a great variety of microhabitats and low degree of disturbance to the Vihorlat woodland.

We found decline in species and generic richness with increasing altitude. Similar trend was observed in spruce forests of the Beskydy mountains (Háněl, 1996b). Also Ruess *et al.* (2001) found greater nematode richness at the low altitude heath than at the high altitude fellfield in arctic soils. On the other hand nematode richness in Romanian grasslands studied by Popovici and Ciobanu (2000) did not appear to be affected by altitude, with an exception for Vladeasa Mts. where nematode richness tended to decline with increasing altitude. Reverse trends can also occur as a low nematode richness in spruce plantations in lowlands (Háněl, 1992) compared to a higher richness in semi-natural spruce forests in mountains (Háněl, 2004).

Nematode taxomic richness was found to exhibit consistent correlations with mass and activity parameters of both nematofauna and microflora in the European mineral grassland soils (Ekschmitt *et al.*, 2001) and the authors considered high nematode richness a good indicator of the decomposition function. More diverse nematode assemblages contribute to more resilient ecosystem services

(Yeates, 2007). Thus, our data suggested faster nutrient cycling in lower altitudes of the Vihorlat woodland than in higher. Recovery from disturbance to forest ecosystem at SK could therefore be slower than at RH.

In contrast to the decrease in species and genus richness from RH through MO to SK trophic diversity (T) and maturity (∑MI) of nematode faunas showed little variation (Tables 2 and 3). Ettema (1998) suggested that considerable functional redundancy probably exists at least in bacterivore nematodes however soil nematode diversity is important for long-term stability of soil functioning. Climatically harsh high-altitude sites can be especially sensitive to the impact of perturbations on nematode faunas due to lower initial biodiversity (i.e. redundancy) at such sites (Ruess *et al.*, 2001). The results from the Vihorlat could indicate that species redundancy in nematode fauna occurred at RH compared to that at SK whereas potential functioning of soil nematode communities sustained unchanged and maintained at different levels of species richness.

Nevertheless, recently available cp scaling of nematode taxa should be taken with caution. For example, *Plectus* reproduces slowly than *Acrobeloides* and may be scaled higher on the cp scale relative to *Acrobeloides* (Postma-Blaauw *et al.*, 2005). Fiscus & Neher (2002) found different responses of some nematode genera to soil disturbances than could be expected with respect to their cp values. Allocation of nematode species to feeding groups is often uncertain (Yeates, 2003). Moreover, harsher climate at SK compared to RH could constrain nematode community (and other soil biota) from full functioning and change proportion between bacteria-based and fungal-based decomposition channels. Evaluation of abundance data on nematode genera, a topic of further study, can throw more light on actual functioning of nematode communities in the Vihorlat woodland.

Acknowledgements

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Appendix 1. Check-list of nematode species with the number of positives samples at the localities SK, MO and RH, total frequency of occurrence F[%] in all Vihorlat woodland. tg = allocation of species to trophic groups B (bacterivores), F (fungivores), RFF (root-fungal feeders), PP (plant parasites), P (predators), O (omnivores), and IP (insect parasites). cp = allocation of species to cp groups 1-5. N = species new to Slovakia

No.	Species in orders	tg	cp	**SK**	**MO**	**RH**	F[%]
	Monhysterida De Coninck & Schuurmans Stekhoven, 1933						
1	*Eumonhystera dispar* (Bastian, 1865)	B	2	0	0	1	3.33
2	*Eumonhystera longicaudatula* (Gerlach et Riemann, 1973)	B	2	0	4	5	30.00
3	*Eumonhystera vulgaris* (de Man, 1880)	B	2	0	1	7	26.67
4	*Eumonhystera* sp.	B	2	0	1	2	10.00
5	*Geomonhystera villosa* (Bütschli, 1873)	B	2	0	1	5	20.00
	Araeolaimida De Coninck & Schuurmans Stekhoven, 1933						
6 N	*Cylindrolaimus communis* de Man, 1880	B	3	0	2	4	20.00
7	*Domorganus* sp.	B	3	0	0	2	6.67
8 N	*Bastiania uncinata* Andrásssy, 1991	B	3	0	4	9	43.33
9 N	*Bastiania vesca* Eroshenko, 1977	B	3	0	0	2	6.67
10 N	*Odontolaimus chlorurus* de Man, 1880	B	3	0	6	2	26.67
11	*Rhabdolaimus terrestris* de Man, 1880	B	3	0	1	0	3.33
12	*Anaplectus granulosus* (Bastian, 1865)	B	2	2	5	10	56.67
13	*Plectus acuminatus* Bastian, 1865	B	2	9	8	9	86.67
14 N	*Plectus amorphotelus* Ebsary, 1985	B	2	6	5	0	36.67
15	*Plectus communis* Bütschli, 1873	B	2	2	2	2	20.00
16 N	*Plectus exinocaudatus* Truskova, 1976	B	2	0	1	1	6.67
17	*Plectus geophilus* de Man, 1880	B	2	3	1	6	33.33
18	*Plectus longicaudatus* Bütschli, 1873	B	2	8	6	9	76.67
19	*Plectus parietinus* Bastian, 1865	B	2	7	7	5	63.33
20	*Plectus parvus* Bastain, 1865	B	2	0	2	2	13.33
21	*Plectus rhizophilus* de Man, 1880	B	2	0	0	4	13.33
22	*Plectus* sp.	B	2	0	0	1	3.33
23 N	*Chiloplectus cancellatus* (Zullini, 1978)	B	2	3	2	0	16.67
24	*Ceratoplectus armatus* (Bütschli, 1873)	B	2	0	1	7	26.67
25	*Tylocephalus auriculatus* (Bütschli, 1873)	B	2	2	4	5	36.67

26 N	*Tylocephalus* cf. *laticollis* Zell, 1985 juv.	B	2	0	0	1	3.33
27 N	*Ereptonema arcticum* Loof, 1971	B	2	0	1	0	3.33
28	*Wilsonema otophorum* (de Man, 1880)	B	2	0	7	7	46.67
29	*Wilsonema schuurmansstekhoveni* (De Coninck, 1931)	B	2	6	1	1	26.67
30	*Metateratocephalus crassidens* (de Man, 1880)	B	3	4	2	5	36.67
31	*Metateratocephalus gracilicaudatus* Andrássy, 1985	B	3	2	4	4	33.33
	Chromadorida Chitwood, 1933						
32 N	*Prodesmodora* cf. *arctica* (Mulvey, 1969)	B	3	0	0	1	3.33
33 N	*Achromadora tenax* (de Man, 1876)	B	3	0	5	9	46.67
	Rhabditida Chitwood, 1933						
34 N	*Teratocephalus dadayi* Andrássy, 1968	B	3	0	0	2	6.67
35 N	*Teratocephalus lirellus* Anderson, 1969	B	3	8	7	8	76.67
36 N	*Teratocephalus paratenuis* Eroshenko, 1973	B	3	1	1	3	16.67
37	*Teratocephalus tenuis* Andrássy, 1956	B	3	0	0	1	3.33
38	*Teratocephalus terrestris* Bütschli, 1873	B	3	0	0	3	10.00
39	*Teratocephalus* sp.	B	3	0	0	3	10.00
40	*Cephalobus persegnis* Bastian, 1865	B	2	0	0	4	13.33
41	*Heterocephalobus elongatus* (de Man, 1880)	B	2	5	3	6	46.67
42 N	*Bunobus loofi* (Andrássy, 1968)	B	2	2	1	1	13.33
43	*Eucephalobus mucronatus* (Kozlowska et Roguska-Wasilewska, 1963)	B	2	0	0	1	3.33
44	*Eucephalobus oxyuroides* (de Man, 1876)	B	2	0	1	6	23.33
45	*Acrobeloides nanus* (de Man, 1880)	B	2	10	10	10	100.00
46	*Chiloplacus* sp.	B	2	1	0	4	16.67
47	*Acrobelophis minimus* (Thorne, 1925)	B	2	0	0	3	10.00
48	*Cervidellus vexilliger* (de Man, 1880)	B	2	5	7	7	63.33
49 N	*Deficephalobus* cf. *humophilus* Zell, 1987	B	2	2	0	0	6.67
50 N	*Drilocephalobus coomansi* Ali, Suryawanshi et Christy, 1973	B	2	0	0	1	3.33
51	*Panagrolaimus rigidus* (Schneider, 1866)	B	1	4	0	5	30.00
52	*Steinernema* dauer larvae	IP	1	4	5	5	46.67
53	*Rhabditis terricola* Dujardin, 1845	B	1	9	10	10	96.67
54	*Protorhabditis filiformis* (Bütschli, 1873)	B	1	0	0	1	3.33
55	*Bursilla monhystera* (Bütschli, 1873)	B	1	1	3	7	36.67
56	*Diplogasteritus* sp. juv.	B	1	1	0	0	3.33
57	*Pristionchus* cf. *lheritieri* (Maupas, 1919)	B	1	0	1	2	10.00
	Aphelenchida Siddiqi, 1980						
58	*Aphelenchus avenae* Bastian, 1865	F	2	1	0	3	13.33
59	*Paraphelenchus pseudoparietinus* Micoletzky, 1922	F	2	0	0	1	3.33
60 N	*Aphelenchoides conimucronatus* Bessarabova, 1966	F	2	1	0	1	6.67
61 N	*Aphelenchoides curiolis* Gritsenko, 1971	F	2	4	6	7	56.67
62 N	*Aphelenchoides* cf. *eradicitus* Eroshenko, 1968 [1)]	F	2	1	0	0	3.33
63 N	*Aphelenchoides lagenoferrus* Baranovskaya, 1963 [2)]	F	2	8	5	7	66.67
64 N	*Aphelenchoides macronucleatus* Baranovskaya, 1963	F	2	8	9	8	83.33
65 N	*Aphelenchoides parasubtenius* Shavrov, 1967	F	2	7	6	8	70.00
66 N	*Aphelenchoides rarus* Eroshenko, 1968	F	2	0	0	1	3.33
67	*Aphelenchoides* sp.	F	2	0	2	2	13.33
68 N	*Seinura variobulbosa* Haque, 1966	P	2	0	0	1	3.33
	Tylenchida Thorne, 1949						
69	*Aglenchus agricola* (de Man, 1884)	RFF	2	1	0	0	3.33
70	*Coslenchus* sp. 1 [3)]	RFF	2	1	1	1	10.00
71	*Coslenchus* sp. 2 [3)]	RFF	2	0	1	0	3.33
72 N	*Filenchus* cf. *aquilonius* (Wu, 1969) [4)]	RFF	2	1	0	3	13.33

73 N	*Filenchus baloghi* (Andrássy, 1958)	RFF	2	0	0	1	3.33
74 N	*Filenchus discrepans* (Andrássy, 1954)	RFF	2	5	5	6	53.33
75 N	*Filenchus facultativus* (Szczygiel, 1970)	RFF	2	8	4	6	60.00
76 N	*Filenchus longicaudatulus* Zell, 1988	RFF	2	8	4	8	66.67
77 N	*Filenchus misellus* Andrássy, 1958 s.l. [5)]	RFF	2	10	10	10	100.00
78	*Filenchus spicatus* (Brzeski, 1986) [6)]	RFF	2	7	6	10	76.67
79 N	*Filenchus vulgaris* (Brzeski, 1963)	RFF	2	2	1	1	13.33
80	*Filenchus* sp. 1	RFF	2	1	0	1	6.67
81	*Filenchus* sp. 2	RFF	2	0	0	2	6.67
82	*Filenchus* sp. 3	RFF	2	1	1	0	6.67
83	*Basiria gracilis* (Thorne, 1949)	RFF	2	0	0	1	3.33
84 N	*Basiria tumida* (Colbran, 1960)	RFF	2	0	0	2	6.67
85	*Basiria* sp.	RFF	2	0	0	1	3.33
86	*Boleodorus thylactus* Thorne, 1941	RFF	2	1	3	4	26.67
87	*Neopsilenchus magnidens* (Thorne, 1949)	RFF	2	0	0	1	3.33
88 N	*Malenchus acarayensis* Andrássy, 1968	RFF	2	0	0	3	10.00
89 N	*Malenchus andrassyi* Merny, 1971	RFF	2	0	0	1	3.33
90	*Malenchus bryophilus* (Steiner, 1914)	RFF	2	1	0	0	3.33
91 N	*Malenchus neosulcus* Geraert et Raski, 1986	RFF	2	4	2	1	23.33
92 N	*Cephalenchus hexalineatus* (Geraert, 1962)	RFF	2	1	0	7	26.67
93 N	*Cephalenchus leptus* Siddiqi, 1963	RFF	2	0	0	2	6.67
94	*Lelenchus leptosoma* (de Man, 1880)	RFF	2	0	0	2	6.67
95 N	*Ditylenchus acutus* (Khan, 1965) [7)]	F	2	0	0	1	3.33
96	*Ditylenchus elegans* Zell, 1988	F	2	0	0	1	3.33
97 N	*Ditylenchus equalis* Heyns, 1964	F	2	1	0	0	3.33
98 N	*Ditylenchus filenchulus* Brzeski, 1991	F	2	1	0	1	6.67
99 N	*Ditylenchus longimatricalis* (Kazachenko, 1975)	F	2	0	0	2	6.67
100 N	*Ditylenchus lutonenensis* (Siddiqi, 1980) [7)]	F	2	9	4	4	56.67
101 N	*Ditylenchus terricola* Brzeski, 1991	F	2	0	0	1	3.33
102	*Ditylenchus* sp. 1	F	2	1	0	0	3.33
103	*Ditylenchus* sp. 2	F	2	1	0	4	16.67
104 N	*Bitylenchus bryobius* (Sturhan, 1966) Jairajpuri, 1982 [8)]	PP	3	0	0	1	3.33
105	*Bitylenchus dubius* (Bütschli, 1873) Filipjev, 1934 [8)]	PP	3	4	4	6	46.67
106	*Nagelus* sp. juv.	PP	3	0	1	0	3.33
107	*Pratylenchus penetrans* (Cobb, 1917)	PP	3	1	0	1	6.67
108	*Pratylenchus pratensis* (de Man, 1880)	PP	3	1	3	0	13.33
109	*Pratylenchus thornei* Sher et Allen, 1953	PP	3	0	1	1	6.67
110	*Hoplotylus femina* s'Jacob, 1959	PP	3	0	0	1	3.33
111	*Helicotylenchus canadensis* Waseem, 1961	PP	3	0	2	0	6.67
112	*Helicotylenchus digonicus* Perry in Perry, Darling et Thorne, 1959	PP	3	1	2	4	23.33
113	*Helicotylenchus exallus* Sher, 1966	PP	3	0	2	0	6.67
114	*Helicotylenchus pseudorobustus* (Steiner, 1914)	PP	3	0	1	3	13.33
115	*Helicotylenchus varicaudatus* Yuen, 1964	PP	3	0	1	1	6.67
116	*Helicotylenchus vulgaris* Yuen, 1964	PP	3	0	0	1	3.33
117	*Rotylenchus robustus* (de Man, 1876) acc. Brzeski (1998)	PP	3	0	2	2	13.33
118	*Heterodera* juv.	PP	3	0	0	1	3.33
119	*Paratylenchus nanus* Cobb, 1923 group [9)]	PP	2	2	0	2	13.33
120	*Paratylenchus projectus* Jenkins, 1956	PP	2	0	1	0	3.33
121 N	*Paratylenchus similis* Khan, Prasad et Mathur, 1967	PP	2	0	2	0	6.67
122	*Paratylenchus straeleni* (de Coninck, 1931)	PP	2	7	9	8	80.00
123	*Paratylenchus* sp.	PP	2	0	1	0	3.33
124	*Xenocriconemella macrodora* (Taylor, 1936)	PP	3	5	3	3	36.67

125	*Criconema annuliferum* (de Man, 1921)	PP	3	0	0	3	10.00
126 N	*Deladenus aridus* Andrássy, 1957	F	2	2	0	3	16.67
127	tylenchid invasive juvs. sp. 1	F	2	0	4	3	23.33
128	tylenchid invasive juvs. sp. 2	PP	3	0	2	5	23.33
	Enoplida Filipjev, 1929						
129	*Prismatolaimus dolichurus* de Man, 1880	B	3	0	1	0	3.33
130 N	*Prismatolaimus matoni* Mulk et Coomans, 1979	B	3	2	6	7	50.00
131	*Prismatolaimus* sp. 1 (cf. *primitivus* Loof, 1971) [10)]	B	3	0	0	1	3.33
132	*Prismatolaimus* sp. 2 (cf. *stenolaimoides* Loof, 1971) [10)]	B	3	1	1	3	16.67
133 N	*Stenonchulus troglodytes* W. Schneider, 1940	P	3	0	0	3	10.00
134	*Tripyla affinis* de Man, 1880	P	3	1	0	1	6.67
135	*Tripyla filicaudata* de Man, 1880	P	3	1	0	4	16.67
136	*Tripyla setifera* Bütschli, 1873	P	3	0	3	3	20.00
137 N	*Trischistoma gracile* Andrássy, 1985	P	3	0	0	2	6.67
138	*Tobrilia* sp. (cf. *longicaudata* Andrássy, 1968) [10)]	P	3	0	0	1	3.33
	Alaimida Siddiqi, 1983						
139 N	*Alaimus meyli* Andrássy, 1961	B	4	0	2	4	20.00
140	*Alaimus parvus* Thorne, 1939]	B	4	1	1	4	20.00
141	*Alaimus primitivus* de Man, 1880 / *jaulasali* Siddiqi et Husain, 1967 [11)]	B	4	4	4	6	46.67
142	*Alaimus* sp.	B	4	0	0	1	3.33
143	*Paramphidelus dolichurus* (de Man, 1876)	B	4	0	0	4	13.33
144 N	*Paramphidelus pseudobulbosus* (Altherr, 1936) juv.	B	4	0	0	2	6.67
145 N	*Paramphidelus pusillus* (Thorne, 1936)	B	4	0	0	1	3.33
	Diphtherophorida Loof, 1991						
146	*Diphtherophora communis* de Man, 1880	F	3	0	0	3	10.00
147	*Diphtherophora* sp.	F	3	1	3	7	36.67
148	*Tylolaimophorus minor* (Thorne, 1939)	F	3	4	3	0	23.33
149	*Tylolaimophorus typicus* de Man, 1880	F	3	0	0	3	10.00
150	*Tylolaimophorus* sp.	F	3	0	0	1	3.33
151	*Trichodorus sparsus* Szczygiel, 1968	PP	4	4	2	2	26.67
	Mononchida Jairajpuri, 1969						
152	*Clarkus papillatus* (Bastian, 1965)	P	4	1	9	10	66.67
153	*Coomansus parvus* (de Man, 1880)	P	4	0	0	1	3.33
154	*Coomansus zschokkei* (Menzel, 1913)	P	4	0	6	3	30.00
155	*Prionchulus muscorum* (Dujardin, 1845) s.l. [12)]	P	4	3	0	2	16.67
156 N	*Prionchulus punctatus* Cobb, 1917	P	4	3	3	4	33.33
157	*Mylonchulus brachyuris* (Bütschli, 1873)	P	4	1	3	6	33.33
158	*Miconchus hopperi* Mulvey, 1962	P	4	0	0	1	3.33
159	*Anatonchus tridentatus* (de Man, 1876)	P	4	0	3	0	10.00
	Dorylaimida Pearse, 1942						
160	*Nygolaimus* sp. juv.	P	5	0	1	1	6.67
161	*Prodorylaimus* sp. juv.	O	5	0	4	3	23.33
162	*Mesodorylaimus bastiani* (Bütschli, 1873)	O	5	5	6	9	66.67
163 N	*Crassolabium circuliferum* (Loof, 1961)	O	4	1	1	1	10.00
164	*Crassolabium ettersbergense* (de Man, 1885)	O	4	0	0	1	3.33
165 N	*Crasolabium medianum* (Eroshenko, 1976)	O	4	0	5	1	20.00
166	*Crasolabium* sp. juv.	O	4	0	0	1	3.33
167 N	*Epidorylaimus lugdunensis* (de Man, 1880)	O	4	0	1	1	6.67
168 N	*Epidorylaimus* cf. *humilior* (Andrássy, 1959) [10)]	O	4	0	1	1	6.67
169	*Eudorylaimus bureshi* (Andrássy, 1958)	O	4	3	1	4	26.67

170	*Eudorylaimus carteri* (Bastian, 1865)	O	4	1	1	0	6.67
171 N	*Eudorylaimus discolaimiodeus* (Andrássy, 1958)	O	4	4	3	6	43.33
172 N	*Eudorylaimus familiaris* Winiszewska-Slipinska, 1987	O	4	1	0	0	3.33
173	*Eudorylaimus silvaticus* Brzeski, 1960	O	4	8	4	5	56.67
174	*Eudorylaimus similis* (de Man, 1876) s.l. [13)]	O	4	9	8	7	80.00
175	*Eudorylaimus* sp. 1	O	4	0	0	1	3.33
176	*Eudorylaimus* sp. 2	O	4	0	0	1	3.33
177	*Eudorylaimus* sp. 3	O	4	0	1	0	3.33
178 N	*Microdorylaimus longicollis* (Brzeski, 1964)	O	4	0	0	1	3.33
179	*Microdorylaimus parvus* (de Man, 1880)	O	4	0	1	1	6.67
180	*Ecumenicus monohystera* (de Man, 1880)	O	5	1	2	2	16.67
181	*Aporcelaimellus obtusicaudatus* (Bastian, 1865) s.l. [12)]	O	5	4	10	9	76.67
182	*Aporcelaimus* sp. juv.	O	5	0	1	0	3.33
183	*Metaporcelaimus labiatus* (de Man, 1880)	O	5	2	6	2	33.33
184	*Sectonema* sp. juv.	P	5	0	1	1	6.67
185	Nordiidae sp. (one female)	PP	4	0	0	2	6.67
186 N	*Longidorella* cf. *murithi* Altherr, 1950 [14)]	PP	4	0	2	5	23.33
187	*Pungentus engadinensis* (Altherr, 1950)	PP	4	0	1	1	6.67
188	*Pungentus silvestris* (de Man, 1912)	PP	4	1	4	6	36.67
189	*Longidorus* sp. juv.	PP	5	1	0	0	3.33
190	*Xiphinema* sp. juv.	PP	5	0	1	0	3.33
191	*Oxydirus oxycephalus* (de Man, 1885)	O	5	0	3	0	10.00
192	*Dorylaimellus* sp.	O	5	0	0	5	16.67
193 N	*Tylencholaimus constrictus* Vinciguerra, 1986	F	4	0	0	6	20.00
194	*Tylencholaimus minimus* de Man, 1876	F	4	0	2	0	6.67
195	*Tylencholaimus mirabilis* (Bütschli, 1873)	F	4	8	10	8	86.67
196 N	*Tylencholaimus minutus* Vinciguerra, 1986	F	4	0	1	1	6.67
197 N	*Tylencholaimus* sp. (cf. *paradoxus* Loof et Jairajpuri, 1968) [10)]	F	4	0	3	1	13.33
198	*Tylencholaimus stecki* Steiner, 1914	F	4	0	5	3	26.67
	Total number of species			87	115	167	198
	Total number of genera			51	68	86	98

Key: [1)] Zell (1990) synonymized *A. eradicitus* with *A. lagenoferrus* when gave redescription of the latter. [2)] Andrássy (2007), p. 34, synonymized *A. lagenoferrus* with *A. sacchari* Hooper, 1958 but gave no details. The genus *Aphelenchoides* needs thorough revision. [3)] Specimens in poor condition so the number of longitudinal cuticle incisures is uncertain. [4)] Brzeski (1997) synonymized *F. aquilonius* with *F. orbus* Andrássy, 1954, specimens from Vihorlat are closer to the original description of the former than to the latter. [5)] Brzeski (1997) synonymized 11 *Filenchus* species with *F. misellus*. It is hard to say whether morphological variability in those small *Filenchus* is intra-specific character or whether reflects a group of close related species (Háněl, 2000). [6)] Brzeski (1998) synonymized *F. spicatus* with *F. acris* (Brzeski, 1986), specimens from Vihorlat are closer to the original description of the former than to the latter. [7)] Andrássy (2007) accepts *Nothotylenchus acutus* Khan, 1965 and *Safianema lutonense* Siddiqi, 1980 whereas Brzeski (1998) places those species into the genus *Ditylenchus*. For the practical reasons of quantitative evaluation of the material the two species are in kept in the genus *Ditylenchus* because of variation in pharynx morphology in juvenile stages. [8)] Brzeski (1998) places those species in the genus *Tylenchorhynchus*. [9)] Resting juvenile stages were not found so species couldn't be determined with certainty. [10)] Insufficient material for precise determination. [11)] Material is partly damaged and may include both species. [12)] There may be a group of very similar and hardly distinguishable species. [13)] According to Loof (1999) *E. similis* and *E. schraederi* Altherr, 1974 are the same species. [14)] Key according to Andrássy (2009) leads to *L. murithi* but there are some differences from the description.

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