DOI 10.2478/s11687-007-0016-6

HELMINTHOLOGIA, 44, 3: 112 – 117, 2007

Soil nematodes inhabiting an original dry meadow and an abandoned vineyard in the National Park Seewinkel, Eastern Austria

P. ZOLDA[1], L. HÁNĚL[2]

[1]Department of Conservation Biology, Vegetation- and Landscape Ecology Althanstrasse 14, A- 1090 Vienna, Austria, E-mail: *pamela.zolda@univie.ac.at*; [2]Institute of Soil Biology, Academy of Sciences of the Czech Republic, Na Sádkách 7, CZ-370 05 České Budějovice, Czech Republic, E-mail: *hanel@upb.cas.cz*

Summary

Nematode communities of cultivated vineyards showed characteristics typical for cultivated ecosystems, e.g. predominance of plant parasitic nematodes followed by bacterivores. The abandoned vineyard showed a reverse trophic structure: bacterivorous nematodes with short life cycles (*cp* 2) predominated and the population of plant parasites was small. The nematode trophic structure of the dry meadow was similar to the abandoned vineyard. Nevertheless, Principal Component Analysis (PCA) showed that differrences in nematode communities were still detectable at the generic level, with some genera occurring solely in one or the other site (e.g. *Xiphinema*). Thus, soil nematodes indicated a recovery of primary production and decomposition processes in the formerly cultivated vineyard soil, because plant parasites consuming plant tissues decreased, and organic matter breakdown was slower, as in low-input grasslands. Communities of soil nematodes were also compared with intensively cultivated vineyards previously surveyed in Eastern Austria.

Key words: diversity; grassland restoration; Nematoda; community indices; viticulture

Introduction

The landscape of eastern Austria is characterized by unique dry grassland ecosystems of the Puzsta type. This territory was relatively little affected by land cultivation except for viniculture from 1945 until 1989. Since 1989 a lot of vineyards have been abandoned, as they became a part of National Park Seewinkel. Fauna of soil nematodes in intensively cultivated vineyards was studied by Hoschitz (2004) and Hoschitz and Reisenzein (2004). Nevertheless, nothing has hitherto been known about nematodes in original meadow soil used for planting vine grape nor about changes in nematode populations succeeding vineyard abandonment. Nematodes in European grasslands were investigated within the frame of the DEGRRE project (Ekschmitt *et al.*, 1999, 2001) but not those in Austria. The nearest grasslands similar to those in eastern Austria were studied for nematodes by Nagy (1998) in Hungary. Therefore, the aim of this study was to investigate nematodes inhabiting the original vegetation type of the National Park (dry meadow) and evaluate the recovery of nematode populations from viniculture practices 15 years after vineyard abandonment.

Material and Methods

Site characteristics, sampling

The study sites are located on the Podersdorfer Seedamm (47°46.34` N, 16° 45.98` E; elevation 121m a.sl) in the National Park Seewinkel, Austria. The mean annual temperature is 10°C, the mean annual precipitation 600 mm (Bundesanstalt für Bodenkartierung, 1986).

Meadow (M): size: 0.5 ha, *Potentillo arenariae-Festucetum pseudovinae*, *Equisetetum ramosissimi*, *Brometum tectorum*, vegetation coverage: 70 %; moderate grazing by cattle; soil characteristics: middle sand, pH 7.6, water content 3.42 %, organic carbon 2.50 %, total N 9 mg/l, phosphate 2 mg/l.

Abandoned vineyard (V): size: 0.5 ha, used as a vineyard from 1945 until 1989, trunks of vines were left in the soil, moderate grazing by cattle; *Artemisietea vulgaris, Convolvulo-Agropyrion repentis* with occurrence of *Cynoglossum hungaricum* and *Euphorbia cyparissias,* vegetation coverage: 61 %, soil characteristics: middle sand, pH 7.5, water content 3.37 %, organic carbon 5.56 %, total N 8 mg/l, phosphate 7 mg/l.

Nematodes were sampled from mineral soil on five dates: 14 May 2003 (1), 20 June 2003 (2), 25 July 2003 (3), 1 September 2003 (4), 8 July 2004 (5) in eight replicates (core diameter 10.7cm, 10cm deep) at each site. Samples were stored in polyethylene bags at 4°C, and 25g of each

core were used for nematode extraction with Baermann funnels (24 h). All nematodes were fixed in hot formaldehyde, mounted and identified to genus level on glycerine slides.

Statistics

Statistical analyses were performed with the package SPSS 13, ordination with PC Ord 4.0. Nematodes were assigned to six main trophic groups (bacterial feeders, fungal feeders, root fungal feeders, plant parasites, omnivores and predators) according to Yeates *et al.* (1993). The following nematode community indices were calculated: Nematode channel ratio (NCR) (NCR= B/(B+F)), where B and F are the relative contributions of bacterial feeding and fungal feeding nematodes to total nematode abundance (Yeates, 2003). Additionally, the index of trophic diversity, T, (Heip *et al.*, 1988), where $T= 1/ \Sigma (p_i)^2$, in which p_i is the proportion of trophic group i in the nematode community, was computed.

Nematode families were allocated along the coloniser (*c*)-persister (*p*) scale according to Bongers (1990). The maturity index, MI, (without plant feeding families) the plant parasite index, PPI, (only plant feeding families) (Bongers, 1990; Bongers & Bongers, 1998) and the sum of the maturity index, ΣMI, (all families) (Yeates, 1994) were calculated as measures of functional diversity. Based on the "weighted faunal analysis concept" (Ferris *et al.*, 2001), nematodes except plant feeders were assigned to functional guilds, which are characterised by their life histories and feeding habits: three indices - the structure index (SI), enrichment index (EI), and the channel index (CI) - were calculated to express predominating mineralization pathways of nutrients during decomposition, which is either fungal or bacterial dominated. Low values suggest a bacterial decomposer community; high values a fungal dominated decomposition.

Results

A total of 67 nematode genera were found in the study plots, 56 in the meadow and 62 in the abandoned vineyard (Table 1). Most genera belonged to the order of Dorylaimida (16), followed by Tylenchida (15) and Rhabditida (13). The genus *Acrobeles* was most abundant, showing

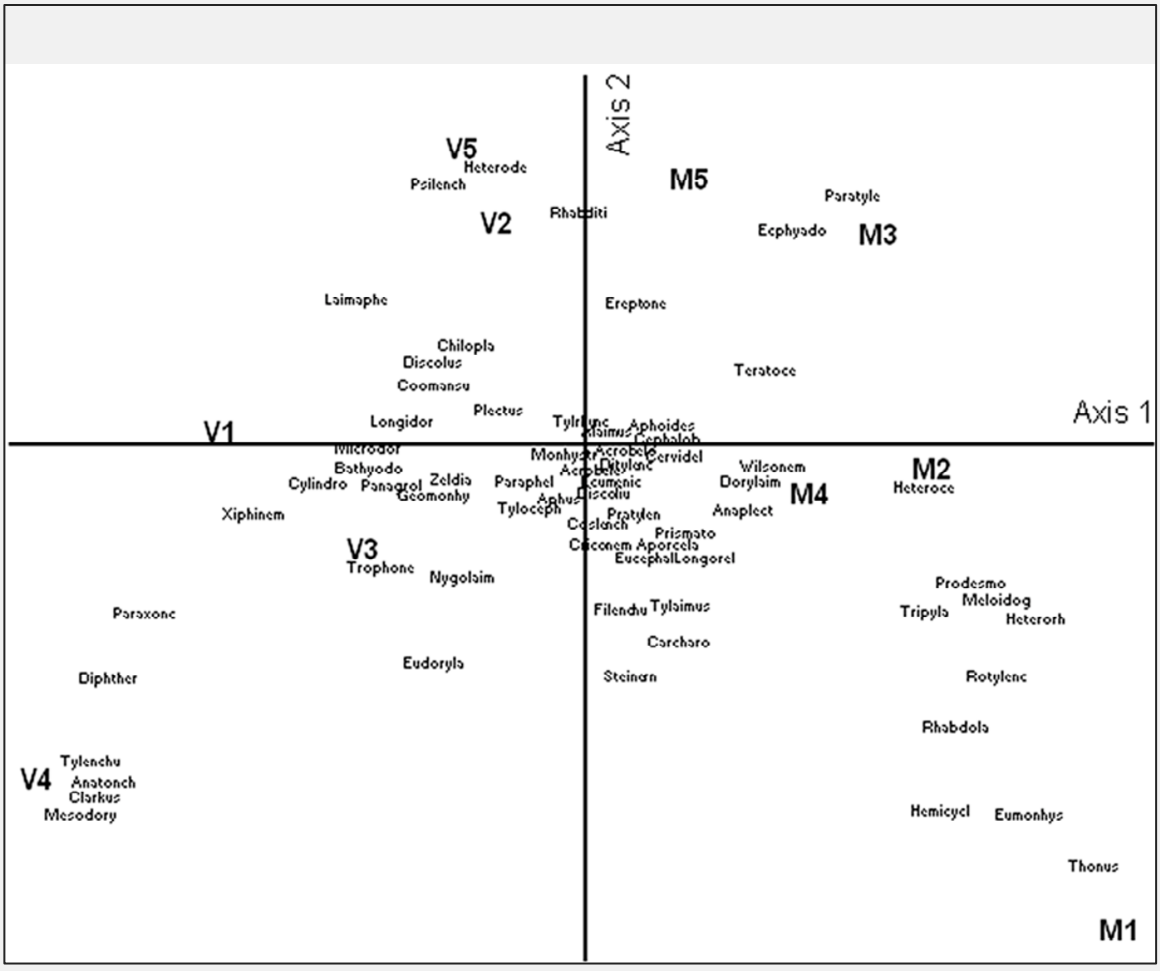

Fig. 1. Ordination (PCA, correlation matrix) of nematodes, data log (y + 1) genera abundance. Eigenvalues of the first 4 axes: 15.54, 13.45, 9.93, 7.10, cumulative percentage of variance: 68.69. M = meadow; V = abandoned vineyard; numbers 1 – 5 code sampling dates; for abbreviations of genera see table 1

Table 1. Abundance (A) x 10^3 ind. m^{-2}, dominance (D) and frequency of occurrence (F) of nematode genera. Orders (RH Rhabditida, MO Monhysterida, PL Plectida, TP Triplonchida, MN Mononchida, DE Desmodorida, TY Tylenchida, AP Aphelenchida, EN Enoplida, DO Dorylaimida), *cp*- classes (Bongers, 1990) and abbreviations for PCA are given

Genus	Abbrev.	*cp*-class	Order	Meadow			Vineyard		
				A	D (%)	F(%)	A	D (%)	F(%)
Bacterivores				**296.3**	**54.8**	**100**	**434.1**	**65.9**	**100**
Acrobeles	Acrobele	2	RH	105.9	19.57	92.5	224.9	34.14	100
Acrobeloides	Acrobelo	2	RH	48.9	9.04	90	39.2	5.95	82.5
Alaimus	Alaimus	4	EN	0.4	0.08	5	0.3	0.05	5
Anaplectus	Anaplect	2	PL	3.1	0.58	15	3.2	0.49	5
Bathyodontus	Bathyodo	4	MN	0.3	0.05	2.5	5.5	0.83	35
Cephalobus	Cephalob	2	RH	1.6	0.30	12.5	2.0	0.31	15
Cervidellus	Cervidel	2	RH	50.3	9.29	75	17.4	2.64	70
Chiloplacus	Chilopla	2	RH	0.1	0.03	2.5	1.2	0.18	7.5
Cylindrolaimus	Cylindro	3	PL	0.1	0.03	2.5	5.6	0.85	30
Ereptonema	Ereptone	2	PL	5.2	0.96	32.5	4.1	0.62	25
Eucephalobus	Eucephal	2	RH	4.8	0.88	30	3.6	0.54	32.5
Eumonhystera	Eumonhys	2	MO	2.7	0.49	5	0.3	0.05	5
Geomonhystera	Geomonhy	2	MO	6.1	1.13	45	46.7	7.09	62.5
Heterocephalobus	Heteroce	2	RH	3.3	0.60	25	0.2	0.03	2.5
Monhystrella	Monhystr	2	MO	2.4	0.44	25	6.3	0.96	37.5
Panagrolaimus	Panagrol	1	RH	2.5	0.47	20	18.4	2.80	55
Plectus	Plectus	2	PL	7.3	1.35	47.5	15.3	2.33	72.5
Prismatolaimus	Prismato	3	TP	3.7	0.69	30	3.8	0.57	25
Prodesmodora	Prodesmo	3	DE	0.7	0.14	12.5			
Rhabdolaimus	Rhabdola	3	PL	4.5	0.82	10	0.3	0.05	2.5
Rhabditis	Rhabditi	1	RH	0.3	0.05	5	0.7	0.10	5
Teratocephalus	Teratoce	3	RH	12.3	2.28	30	4.6	0.70	20
Tylocephalus	Tyloceph	2	PL	4.8	0.88	27.5	9.7	1.48	35
Wilsonema	Wilsonem	2	PL	22.7	4.21	65	8.0	1.22	42.5
Zeldia	Zeldia	2	RH	2.2	0.41	12.5	12.6	1.92	47.5
Fungivores				**89.1**	**16.5**	**95**	**63.8**	**9.7**	**82.5**
Aphelenchoides	Aphoides	2	AP	22.0	4.07	65	12.3	1.86	57.5
Aphelenchus	Aphus	2	AP	10.9	2.01	57.5	13.1	1.99	52.5
Diphtherophora	Diphther	3	TP				1.2	0.18	7.5
Ditylenchus	Ditylenc	2	TY	18.6	3.44	55	17.2	2.61	52.5
Dorylaimellus	Dorylaim	5	DO	27.2	5.03	67.5	10.7	1.63	17.5
Laimaphelenchus	Laimaphe	2	AP				0.3	0.05	5
Paraphelenchus	Paraphel	2	AP	2.5	0.47	15	3.8	0.57	25
Tylencholaimus	Tylaimus	4	DO	7.9	1.46	32.5	5.1	0.78	25
Root-fungal feeders				**23.5**	**4.3**	**55**	**31.4**	**4.8**	**55.0**
Coslenchus	Coslench	2	TY	11.3	2.09	37.5	22.8	3.47	40
Ecphyadophora	Ecphyado	2	TY	1.2	0.22	5	0.2	0.03	2.5
Filenchus	Filenchu	2	TY	11.0	2.03	27.5	7.8	1.19	37.5
Psilenchus	Psilench	2	TY				0.2	0.03	2.5
Tylenchus	Tylenchu	2	TY				0.3	0.05	2.5
Plant parasites				**77.6**	**14.3**	**72.5**	**62.9**	**9.6**	**90.0**
Criconemoides	Criconem	3	TY	0.6	0.11	5	1.2	0.18	7.5

Hemicycliophora	Hemicycl	3	TY	4.0	0.74	2.5	0.7	0.10	10
Heterodera	Heterode	3	TY				1.7	0.26	7.5
Longidorella	Longorel	4	DO	1.8	0.33	15	0.7	0.10	7.5
Longidorus	Longidor	5	DO	0.1	0.03	2.5	2.0	0.31	17.5
Meloidogyne	Meloidog	3	TY	0.6	0.11	7.5			
Paratylenchus	Paratyle	2	TY	21.6	3.99	7.5	0.7	0.10	7.5
Pratylenchus	Pratylen	3	TY	1.5	0.27	20	1.7	0.26	17.5
Rotylenchus	Rotylenc	3	TY	20.2	3.74	15			
Trophonema	Trophone	2	TY				0.2	0.03	2.5
Tylenchorhynchus	Tylrhync	3	TY	27.2	5.03	55	38.9	5.90	72.5
Xiphinema	Xiphinem	5	DO				15.2	2.30	42.5
Omnivores				**22.0**	**4.1**	**70**	**30.4**	**4.6**	**75.0**
Aporcelaimellus	Aporcela	5	DO	5.7	1.04	42.5	5.5	0.83	22.5
Ecumenicus	Ecumenic	5	DO	13.4	2.47	52.5	18.8	2.85	60
Eudorylaimus	Eudoryla	4	DO	0.6	0.11	7.5	1.4	0.21	12.5
Mesodorylaimus	Mesodory	5	DO				0.2	0.03	2.5
Microdorylaimus	Microdor	4	DO	1.2	0.22	5	4.3	0.65	17.5
Paraxonchium	Paraxonc	5	DO				0.3	0.05	5
Thonus	Thonus	4	DO	1.2	0.22	7.5			
Predators				**15.2**	**2.8**	**50**	**27.6**	**4.2**	**70**
Anatonchus	Anatonch	4	MN				0.2	0.03	2.5
Carcharolaimus	Carcharo	5	DO	1.2	0.22	10	1.4	0.21	12.5
Clarkus	Clarkus	4	MN				0.2	0.03	2.5
Coomansus	Coomansu	4	MN	0.3	0.05	5	1.2	0.18	12.5
Discolaimium	Discoliu	5	DO	4.5	0.82	30	7.0	1.06	42.5
Discolaimus	Discolus	5	DO	0.3	0.05	2.5	1.4	0.21	10
Nygolaimus	Nygolaim	5	DO	3.9	0.71	22.5	15.9	2.41	32.5
Tripylina	Tripyla	3	TP	5.1	0.93	15	0.5	0.08	2.5
Insect parasites				**2.8**	**0.5**		**2.0**	**0.3**	
Heterorhabditis	Heterorh		RH	0.7	0.14	20			
Steinernema	Steinern		RH	2.1	0.38	10	2.0	0.31	10
Larva indet.				14.4	2.7		6.6	1.0	
Total abundance				540.9			658.7		
Total number of genera				56			62		

higher population densities as well as an overall dominance in the abandoned vineyard. The second most abundant nematode was *Acrobeloides*, with a somewhat higher abundance and dominance in the meadow. *Cervidellus* populations were larger in the meadow; *Geomonhystera* was more abundant in the abandoned vineyard. Total nematode abundance was similar in both sites without any statistical difference (Table 2).

Overall, bacterivorous nematodes had the greatest abundance in both sites, followed by plant parasites and fungal feeders. The difference between sites in the abundance of fungivorous nematodes (lower in the abandoned vineyard) was statistically significant (Table 2). Indices of the nematode community did not differentiate the sites at a statistical level, except for the NCR (Table 2).

Abundance of nematodes in the meadow varied from 421 x 10^3 to 900 x 10^3 ind./m², in the abandoned vineyard from 365 x 10^3 to 1215 x 10^3 ind./m² and bacterial feeders dominated in both sites at all sampling dates. A significant difference between sites occurred only on the fourth sampling date ($p = 0.005$, U-test). Seasonal changes in the meadow site showed no significant differences, but in the vineyard there was a significant difference between date 4 and 5 ($p = 0.001$, U-test). A positive significant correlation bet-

Table 2. Community indices and trophic group percentage (mean, standard deviation, coefficient of variation (%), range of values, n = 5) of nematodes the dry meadow and abandoned vineyard; significant differences (U-test) marked by asterisks ($p < 0.05$); H`gen.= Shannon index of diversity; MI = maturity index; PPI = plant parasite index; ΣMI = sum of the maturity index; CI = channel index; SI = structure index; EI = enrichment index; TI = trophic diversity index; NCR = nematode channel ratio

Characteristics	Meadow				Vineyard			
	mean	sd	cv	range	mean	sd	cv	range
Abundance x 10^3 ind./m^2	542.79	201.64	37	421.56 – 900.67	667.35	344.88	52	365.68 – 1215.11
Number of genera	14.43	1.93	13	12.88 – 17.25	15.85	3.41	22	10.25 – 19
H`gen.	2.08	0.13	6	1.97 – 2.17	2.05	0.31	15	1.55 – 2.41
Equitability	0.81	0.03	4	0.77 – 0.84	0.77	0.06	8	0.70 – 0.85
MI	2.38	0.13	6	2.23 – 2.57	2.31	0.12	5	2.19 – 2.44
PPI	2.96	0.57	19	1.99 – 3.37	2.75	0.40	14	2.14 – 3.25
ΣMI	2.53	0.16	6	2.36 – 2.70	2.45	0.16	6	2.25 – 2.65
CI	86.53	13.77	16	63.06 – 95	56.36	27.67	49	26.03 – 92.86
SI	43.56	10.00	23	36.74 – 61.22	42.24	10.40	25	27.85 – 53.45
EI	13.22	7.74	59	7.58 – 26.39	17.36	10.47	60	3.21 – 29.37
TI	2.65	0.38	14	2.15 – 3.15	2.14	0.45	21	1.51 – 2.61
Bacterivores	56.24	7.33	13	45.64 – 65.02	66.84	9.37	14	58.74 – 80.68
Fungivores	17.86	5.63	32	11.59 – 24.13	8.82*	3.50	40	5.21 – 13.61
Root fungal feeders	4.51	3.15	70	1.74 – 9.46	4.72	3.32	70	1.31 – 8.30
Plant parasites	14.76	4.66	32	9.09 – 21.95	11.10	6.55	59	4.47 – 18.66
Omnivores	4.09	1.49	36	2.41 – 6.08	4.47	1.86	42	1.75 – 6.19
Predators	2.55	1.90	74	0.36 – 5.14	4.03	2.39	59	1.59 – 7.57
NCR	0.76	0.08	11	0.65 – 8.84	0.88*	0.05	5	0.87 – 0.93

ween seasonal changes of soil water content and total nematode abundance was found in the meadow ($R^2 = 0.87$), but not in the abandoned vineyard.

The faunal composition of study sites was similar except for the presence of *Xiphinema* in the vineyard and *Rotylenchus* in the meadow (Table 1). Nonetheless, ordination of genus abundance data (Figure 1) clearly separated the sites, reflecting different proportions of genera in the two communities.

Discussion

Intensively cultivated vineyards in the area studied by Hoschitz (2004) were dominantly inhabited by plant parasitic nematodes (46 %, mainly *Helicotylenchus*, *Longidorus* and *Xiphinema*) and bacterivorous nematodes (31 %, mainly *Protorhabditis* followed by *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Chiloplacus*). The abandoned vineyard in this study was mainly inhabited by bacterivorous Cephalobidae (*Acrobeles* most important), plant parasitic Hoplolaimidae were not found and the proportion of Longidoridae was much lower.

Dry meadows in Hungary (Nagy, 1998) and Austria (Zolda, 2006) showed a predominance of bacterivorous nematodes (mainly Cephalobidae, Prismatolaimidae and Plectidae) followed by plant parasites and fungal feeders in lower population densities. A similar composition of trophic groups was found in the meadow in the present study (Table 1). Therefore, the trophic structure in the abandoned vineyard changed considerably when compared with cultivated vineyard and became close to the situation in original meadow sites characterising the National Park Seewinkel landscape.

Nevertheless, some differences in community structure still persisted as shown by ordination, which placed meadow and vineyard samples on opposite sides of the first axis. The meadow had greater abundance of *Cervidellus*, *Wilsonema*, *Dorylaimellus*, *Paratylenchus*, *Rotylenchus* (absent in vineyard), whereas in the abandoned vineyard *Acrobeles*, *Geomonhystera*, *Panagrolaimus* and *Xiphinema* (absent in meadow) were more abundant. Thus, during the 15 years of spontaneous succession, the nematode fauna in the abandoned vineyard developed in a manner very similar to that in the climax meadow nearby, but still retained some vineyard characteristic genera. This is especially true for the genus *Xiphinema*, which is a parasite of vines (Lišková & Brown, 2003), but was found neither in dry continental grasslands in Hungary studied by Nagy (1998) nor in our site in Austria.

Differences in the structure of nematode communities also indicate changes in soil processes: in the cultivated vineyard soil nematodes played a great role in feeding on life plant tissues (Hoschitz, 2004) and high proportions of bacterial feeding Rhabditidae indicated fast decomposition processes (Freckman & Ettema, 1993). In this study a slower, fungal dominated decomposition pathway was indicated by a higher proportion of fungal- feeding nematodes (Bardgett & Cook, 1998) in the meadow. In the abandoned vineyard, decomposition processes may have slowed down during the 15 year abandonment, which was indicated by

the dominance of Cephalobidae (Yeates, 2003; Wasilewska, 1998). Nevertheless, the higher Nematode Channel Ratio and lower Channel Index values may still indicate faster nutrient cycling in the abandoned vineyard than in the dry meadow (Table 2). This is also supported by the higher proportion of the family Panagrolaimidae (early colonisers) in the abandoned vineyard.

Insignificant differences of diversity and maturity indices between the two sites studied here and values of MI and PPI similar to that in the cultivated vineyard studied by Hoschitz (2004) suggest that intensive cultivation did not affect nematode diversity as a whole. Nonetheless, similar values of the indices followed from different genera combinations reflecting optima for nematode reproduction in different sites. For example the genus *Xiphinema* (c – p value 5) can sustain very well in the introduced vineyards offering sufficient food supply, but probably not in grasslands of the area studied. On the other hand, the genus *Rotylenchus* (c – p value 3) can find sufficient food resources to reproduce in original dry grassland sites of the National Park Seewinkel. Generally, the study carried out here showed that intensive vineyard cultivation has lead to changes in nematode fauna of the original grasslands. After a 15 year period of abandonment the nematode populations were able to recover from anthropogenous stress although some differences in composition of nematode assemblages still persisted.

Acknowledgements

The study was carried out as a part of the projects NP-26 of the National Park Seewinkel and IRP ISB AS CR AV0Z60660521 and received support from the Austrian Exchange Service and the Ministry of Education, Youth and Sports of the Czech Republic (Project No. 2004-13).

References

BARDGETT, R. D., COOK, R. (1998): Functional aspects of soil animal diversity in agricultural grasslands. *Appl. Soil Ecol*., 10: 263 – 276

BONGERS, T. (1990): The maturity index: an ecological measure of environmental disturbance based on nematode species composition. *Oecologia*, 83: 14 – 19

BONGERS, T., BONGERS, M. (1998): Functional diversity of nematodes. *Appl. Soil Ecol*., 10: 239 – 251

BUNDESANSTALT FÜR BODENKARTIERUNG (1986): Erläuterungen zur Bodenkarte 1:25.000- Kartierungsbereich Neusiedl/See-Süd, Burgenland, KB 139, Wien

EKSCHMITT, K., BAKONYI, G., BONGERS, M., BONGERS, T., BOSTRÖM, S., DOGAN, H., HARRISON, A., KALLIMANIS, A., NAGY, P., O`DONNEL, A. G., SOHLENIUS, B., STAMOU, G. P., WOLTERS, V. (1999): Effects of the nematofauna on microbial energy and matter transformation rates in European grassland soils. *Plant Soil*, 212: 45 – 61

EKSCHMITT, K., BAKONYI, G., BONGERS, M., BONGERS, T., BOSTRÖM, S., DOGAN, H., HARRISON, A., NAGY, P., O`DONNEL, A. G., PAPATHEODOROU, E.M., SOHLENIUS, B., STAMOU, G. P., WOLTERS, V. (2001): Nematode community structure as indicator of soil functioning in European grassland soils. *Eur. J. Soil Biol*., 37: 263 – 268

FERRIS, H., BONGERS, T., DE GOEDE, R. (2001): A framework for soil web diagnostics: extension of the nematode faunal analysis concept. *Appl. Soil Ecol*., 18: 13 – 29

FRECKMAN, D. W., ETTEMA, C. (1993): Assessing nematode communities in agroecosystems of varying human intervention. *Agric. Ecosyst. Environ*., 45: 239 – 261

HEIP, C., HERMAN, P. M. J., SOETAERT, K. (1988): Data processing evaluation and analysis. In HIGGINS, R.P. and THIEL, H. (Eds.): *Introduction to the study of meiofauna*, Smithsonian Institution Press, Washington, D.C.

HOSCHITZ, M. (2004): Community and trophic structure of soil nematodes associated with *Vitis* spp. in Austria. Verh. *Zool. Bot. Ges. Österr*., 141: 97 – 107

HOSCHITZ, M., REISENZEIN, H. (2004): Vergleichende Untersuchungen der bodenbewohnenden Nematodenfauna von mit der Wurzelreblaus (*Vitis vitifoiliae* Fitch) befallenen Weinreben (*Vitis* spp.). *Vitis*, 43: 131 – 138

LIŠKOVÁ, M., BROWN D. J. F. (2003): Longidoridae (Nematoda: Dorylaimida) in the Slovak Republic. *Helminthologia*, 40: 165 – 172

NAGY, P. (1998): The nematode fauna of dry continental steppe grassland at Lake Donger, Hungary. In DE GOEDE, R.G.M., BONGERS, T. (Eds.): *Nematode Communities of Northern Temperate Grassland Ecosystems*. Focus Verlag, Giessen

WASILEWSKA, L. (1998): Changes in the proportions of groups of bacterivorous soil nematodes with different life strategies in relation to environmental conditions. *Appl. Soil Ecol*., 9: 215 – 220

YEATES, G.W. (1994): Modification and qualification of the nematode maturity index. *Pedobiologia*, 38: 97 – 101

YEATES, G. W. (2003): Nematodes as soil indicators: functional and biodiversity aspects. *Biol. Fert. Soils*, 37: 199 – 210

YEATES, G. W., BONGERS, T., DE GOEDE, R. G. M., FRECKMAN, D. W., GEORGIEVA, S. S. (1993): Feeding habits in soil nematode families and genera- An outline for soil ecologists. *J. Nematol*., 25: 315 – 331

ZOLDA, P. (2006): Nematode communities of grazed and ungrazed semi-natural steppe grasslands in Eastern Austria. *Pedobiologia*, 50: 11 – 22

RECEIVED FEBRUARY 19, 2007

ACCEPTED JUNE 12, 2007