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Fauna of soil nematodes (Nematoda) in coal post-mining sites in Illinois, USA

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Abstract. The soil nematode fauna at 54 coal post-mining sites and six natural sites in southern Illinois was studied in November 2009. The first set of samples was collected in ca. 30-year-old plantations of pine, sweet gum and white oak at post-mining sites either reclaimed by spreading topsoil or left untreated before planting trees. The second set of samples was collected in ca. 70-year-old plantations of pine and white oak and poplar dominated natural successions. The third set of samples was collected in remnants of a natural prairie and natural forests, and served as reference sites. In total 107 genera and 171species and morpho-species were identified at these sites. The mean numbers of species + morpho-species and genera recorded at 30-year-old forest sites were 29.9 and 24.3, at 70-year-old forest sites 39.4 and 31.9 and in natural forests (older than 100 years) 57.3 and 45.3, respectively. The positive association of nematode richness with site age is statistically significant. Cluster analyses indicates that the reclamation of post-mining sites by spreading topsoil had a noticeable effect on the generic composition of nematode faunas although the generic richness itself did not differ from that at sites not reclaimed. Nematode faunas at sites that were spread with topsoil were similar to that of natural prairie and developed to some extent in their own way, i.e. in a somewhat different direction than natural forest faunas. Non-topsoil sites had nematode faunas more similar to that in older natural successions and tree plantations, which were similar to natural nematode forest faunas, which are marked by a high richness of species and genera.

Key words. Soil zoology, ecology, Nematoda, species and generic richness, faunal similarity, tree plantation, landscape restoration, coal post-mining site, Illinois, USA.

INTRODUCTION

Coal is an essential raw material for many kinds of industry. Open-cast mining however, destroys large areas, which have previously been used for agriculture, silviculture or left wild. After coal-mining ceases there are large areas covered with spoil, which is commonly reclaimed by revitalizing and planting with trees or allowing them to undergo natural succession. Restoration measures result in the re-development of soil but the dynamics of this process are still poorly understood (Frouz et al. 2001, 2008). Therefore, The Institute of Soil Biology and Southern Illinois University, Carbondale, launched a joint project “Soil biota in areas affected by coal mining in USA and Europe: role in bioindication and soil formation (2008–2012)”. This study involved surveying soil nematode richness at coal post-mining sites in Illinois and comparing it with that at similar sites in the Czech Republic and Central Europe.

MATERIAL AND METHODS

Illinois lies entirely in the Interior Plains physiographic region that spreads across the Lauretania, which is a large continental craton that forms the ancient geographical core of central North America. Much of the surface bedrock is of Pennsylvanian age (younger sub-period of the Carboniferous period) and includes regular sequences of limestone, shale and black coal layers. This area is mainly covered with thick clay (illite) soils. Illinois has a continental climate with wide fluctuations in temperature and an average yearly precipitation varying from about 890 to 1,200 mm. Most of Illinois has a humid

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continental climate. The southernmost part, from about Carbondale southwards, where this study was carried out, borders on an area with a humid subtropical climate. This area was covered with a mixture of prairie and forest, with much of the area converted to farming. The southern third of the state was abundantly forested with oak, hickory and maple. The coal mining in Illinois started in the middle of the 19th century and significantly changed a great part of the landscape.

To study soil biota in areas affected by coal mining samples were collected during 2–7 November 2009 from the following Southern Illinois University mined land reclamation research sites: (i) Pyramid State Park (mined 1932–1954), (ii) Sahara (mined ca. 1940) and (iii) Sahara (mined ca. 1980) – Ashby Kolar research plots.

Pyramid State Park, 38° 00' N, 89° 25' W, 139–180 m a. s. l. PMS(1–3): three sites (1–3) of poplar (*Populus* spp., *Platanus occidentalis* L., *Alnus* sp.) natural successions ca. 70-year-old; PMP(1–3): three sites (1–3) of pine (*Pinus taeda* L.) ca. 70-year-old plantations; PMQ(1–3): three sites (1–3) of white oak (*Quercus alba* L.) ca. 70-year-old plantations.

Sahara, 37° 42–43' N, 88° 38–39' W, 116–141 m a. s. l. SAS(1–3): three sites (1–3) of poplar (*Populus* spp., *P. occidentalis*, *Alnus* sp.) dominated natural successions ca. 70-year-old; SAP(1–3): three sites (1–3) of pine (*P. taeda*) ca. 70-year-old plantations; SAQ(1–3): three sites (1–3) of white oak (*Q. alba*) ca. 70-year-old plantations.

Sahara – Ashby Kolar research plots with topsoil (a part of the post-mining plain reclaimed by heaping and spreading local topsoil and then planted with trees), 37° 44' N, 88° 37' W, 107–133 m a. s. l. TP(1–3) and (4–6): two triplets of sites of pine (*P. taeda*) plantations ca. 30-year-old; TL(1–3) and (4–6): two triplets of sites of sweet gum (*Liquidambar styraciflua* L.) plantations ca. 30-year-old; TQ(1–3) and (4–6): two triplets of sites of white oak (*Q. alba*) plantations ca. 30-year-old.

Sahara – Ashby Kolar research plots with no topsoil (a part of the post-mining area, on which trees were planted into untreated spoil), 37° 43' N, 88° 36–37' W, 126–131 m a. s. l. NTP(1–3) and (4–6): two triplets of sites of pine (*P. taeda*) plantations ca. 30-year-old; NTL(1–3) and (4–6): two triplets of sites of sweet gum (*L. styraciflua*) plantations ca. 30-year-old; NTQ(1–3) and (4–6): two triplets of sites of white oak (*Q. alba*) plantations ca. 30-year-old.

The control (reference) sites, which were not affected by coal mining, were as follows: (a) **Remnants of a natural prairie** in an old cemetery – Cemet(1–3): three sites (1–3); (b) **Natural forests** – N-for (1–3): three sites (1–3)

At each site (PMS1 etc.) three soil samples were taken from an area of 4 m in diameter, using a cylindrical soil corer of cross-sectional area 10 cm^2, inserted down to a depth of 10 cm. Soil from the three samples from each plot was carefully mixed and weighed. Parts of the bulked soil were distributed among the scientists to study various groups of organisms. Nematodes were isolated from 13.5 g of bulked soil (altogether 60 samples representing 60 sites) using modified Baermann funnels, in which the soil was exposed to a temperature of to 25ºC for 24 hours. Animals were killed and preserved in a 3.5% solution of formaldehyde. Then they were transferred via the ethanol-glycerol procedure into glycerol and mounted in glycerol on slides. Nematodes were determined to genus level and to species or morpho-species within a genus because for some groups more individuals (often only juveniles were found at some of the sites surveyed) would be needed for determining the species using the available literature. There is also no comprehensive series of books on nematodes in North America comparable to those on the European fauna (Andrássy 2005, 2007, 2009), which seriously complicates determination. Nevertheless, genus richness is a sufficient estimator of the overall nematode richness (Háněl & Čerevková 2010). A total of 17,829 nematodes were identified. Statistical analyses were done using Statistica (StatSoft 2001).

RESULTS AND DISCUSSION

In total 107 genera were found at all the sites (Table 1) of which 91 were at post-mining sites and 82 at natural sites. The number of genera in 13.5 g of fresh soil at individual sites varied from 16 (in NTQ2) to 55 (in N-for3). Altogether 171 species and morpho-species, called hereafter (morpho) species, were identified at all the sites, of which 148 were at post-mining and 110 were at natural sites. Generic and species richness was therefore similar to those in post-mining tree plantations on colliery spoil near Sokolov in the Czech Republic (Háněl 2009).

The mean numbers of (morpho) species and genera recorded at 30-year-old forest sites were 29.9 and 24.3, in 70-year-old forest sites 39.4 and 31.9, and in natural forests (older than 100 years) 57.3 and 45.3, respectively. The positive effects of site age on the number of (morpho) species (one-way ANOVA of *ln*-transformed data, $F_{(2,54)}=23.85$, $p<0.01$; Levene's test $F_{(2,54)}=0.05$, $p=0.96$) and number of genera were statistically significant (one-way ANOVA of *ln*-transformed data, $F_{(2,54)}=25.52$, $p<0.01$; Levene's test $F_{(2,54)}=0.02$, $p=0.98$). One-way ANOVA of untransformed numbers gave similar results except for the heterogeneity of variances of (morpho) species.

Table 1. Check-list of nematode genera with numbers of positive samples (occurrences) in triplets of nearest sites in the coal post-mining landscapes Sahara and Pyramid in Illinois, NP = remnants of natural prairie, NF = natural forests, F[%] = total frequency of genus occurrence across the whole area studied. The numbers of (morpho) species, which could be distinguished within the genera in the whole material, are in parentheses; Ce = Cemet and Nf = N-for in Figs 1–3

site	Sahara – Ashby Kolar research plots												NP	Sahara			Pyramid SP			NF	
mined	ca. 1980													ca. 1940			1932–1954				
	topsoil sites						no-topsoil sites														
years since vegetation established	30	30	30	30	30	30	30	30	30	30	30	30	>100	70	70	70	70	70	70	>100	
orders and genera at sites	TP 1–3	TP 4–6	TL 1–3	TL 4–6	TQ 1–3	TQ 4–6	NTP 1–3	NTP 4–6	NTL 1–3	NTL 4–6	NTQ 1–3	NTQ 4–6	Ce 1–3	SAS 1–3	SAP 1–3	SAQ 1–3	PMS 1–3	PMP 1–3	PMQ 1–3	Nf 1–3	F[%]
Monohysterida																					
Cylindrotheristus Wieser, 1956 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1.7
Eumonhystera Andrássy, 1981 (3)	2	2	1	1	2	2	1	1	–	2	–	1	3	2	2	2	1	1	2	1	48.3
Geomonhystera Andrássy, 1981 (1)	1	3	2	3	2	–	2	3	3	2	2	1	–	2	3	2	2	2	1	3	65.0
Monhystrella Cobb, 1918 (1)	–	2	1	2	1	2	3	3	3	3	1	3	1	3	3	3	3	2	1	3	71.7
Araeolaimida																					
Cylindrolaimus de Man, 1880 (2)	–	1	–	–	–	–	2	–	1	1	–	2	1	1	–	3	3	–	3	3	35.0
Bastiania de Man, 1876 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Odontolaimus de Man, 1880 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	1	6.7
Rhabdolaimus de Man, 1880 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	6.7
Anaplectus De Coninck et Schuurmans Stekhoven, 1933 (1)	2	–	–	–	–	–	2	1	–	2	3	3	3	2	2	2	1	3	1	3	50.0
Plectus Bastian, 1865 (11)	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	98.3
Chiloplectus Andrássy, 1984 (1)	–	–	–	1	–	–	–	–	1	–	–	–	–	–	1	–	–	–	1	–	6.7
Ceratoplectus Andrássy, 1984 (1)	–	–	–	1	1	1	1	1	2	1	–	–	2	3	1	3	2	–	1	1	35.0
Tylocephalus Crossman, 1933 (2)	1	–	–	2	–	–	–	–	1	–	–	–	2	–	–	2	2	–	–	–	16.7
Ereptonema Anderson, 1966 (1)	–	–	–	–	–	–	1	–	1	–	–	–	–	2	1	–	1	–	1	1	13.3
Wilsonema Cobb, 1913 (2)	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	3	6.7
Metateratocephalus Eroshenko, 1973 (2)	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	–	–	2	10.0
Chromadorida																					
Prodesmodora Micoletsky, 1923 (1)	1	1	–	–	1	1	2	3	1	1	–	1	–	1	1	3	2	1	2	3	41.7
Achromadora Cobb, 1913 (3)	3	3	2	3	3	1	2	3	3	3	1	3	3	3	1	3	3	2	3	3	85.0
Rhabditida																					
Teratocephalus de Man, 1876 (6)	1	1	–	–	–	–	–	–	–	–	–	–	–	2	2	2	3	3	–	2	26.7
Cephalobus Bastian, 1865 (1)	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	1	5.0
Heterocephalobus Brzeski, 1960 (1)	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2	–	–	1	1	8.3
Eucephalobus Steiner, 1936 (2)	3	3	3	3	1	3	3	1	2	3	2	3	3	2	3	3	3	2	2	2	83.3
Bunobus De Ley, Siddiqi et Boström, 1993 (1)	1	–	–	1	1	–	–	–	–	–	–	–	–	–	1	1	–	–	–	1	10.0
Pseudacrobeles Steiner, 1938 (1)	2	–	2	1	1	–	–	–	–	–	–	–	–	–	2	1	1	–	–	–	16.7

Table 1. (continued)

site	Sahara – Ashby Kolar research plots												NP	Sahara			Pyramid SP			NF	
mined	ca. 1980													ca. 1940			1932–1954				
	topsoil sites						no-topsoil sites														
years since vegetation established	30	30	30	30	30	30	30	30	30	30	30	30	>100	70	70	70	70	70	70	>100	
orders and genera at sites	TP 1–3	TP 4–6	TL 1–3	TL 4–6	TQ 1–3	TQ 4–6	NTP 1–3	NTP 4–6	NTL 1–3	NTL 4–6	NTQ 1–3	NTQ 4–6	Ce 1–3	SAS 1–3	SAP 1–3	SAQ 1–3	PMS 1–3	PMP 1–3	PMQ 1–3	Nf 1–3	F[%]
Teratolobus Andrássy, 1968 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1.7
Deficephalobus De Ley et Coomans, 1990 (1)	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	1	1	–	–	–	6.7
Acrobeloides Cobb, 1924 (1)	2	2	1	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	90.0
Acrobelophis Andrássy, 1984 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	6.7
Cervidellus Thorne, 1937 (1)	–	–	–	–	–	–	–	2	2	1	–	1	–	1	–	–	1	1	–	1	16.7
Acrobeles Linstow, 1877 (1)	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	3.3
Seleborca Andrássy, 1985 (1)	–	1	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	1	6.7
Panagrolaimus Fuchs, 1930 (1)	–	–	1	1	–	1	1	1	–	–	3	1	1	1	1	1	–	1	–	–	23.3
Rhabditis Dujardin, 1845 (2)	3	3	3	2	3	3	3	3	2	2	3	3	3	3	3	3	2	3	3	3	93.3
Protorhabditis Osche, 1952 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	–	5.0
Bursilla Andrássy, 1976 (1)	–	1	1	–	2	–	1	–	2	2	1	1	2	–	–	–	–	1	–	1	25.0
Steinernema Travassos, 1927 juvs. (1)	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	3	8.3
Pristionchus Kreis, 1932 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	3.3
Aphelenchida																					
Aphelenchus Bastian, 1865 (1)	–	–	–	–	–	1	–	–	–	1	1	1	3	1	–	–	–	2	–	–	16.7
Paraphelenchus Micoletzky, 1922 (1)	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1.7
Aphelenchoides Fischer, 1894 (6)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	100.0
Tylenchida																					
Coslenchus Siddiqi, 1978 (1)	–	2	2	3	2	2	–	–	–	–	2	–	2	1	–	–	–	–	–	–	26.7
Filenchus Andrássy, 1954 (6)	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3	3	96.7
Basiria Siddiqi, 1959 (2)	3	3	3	3	3	3	1	3	1	2	2	2	3	2	–	3	3	3	3	3	81.7
Boleodorus Thorne, 1941 (1)	2	3	3	3	3	3	1	–	3	2	3	3	–	3	3	–	3	3	1	–	70.0
Neopsilenchus Thorne et Malek, 1968 (1)	3	3	3	3	3	3	1	3	1	2	–	–	3	–	–	–	–	–	–	–	46.7
Malenchus Andrássy, 1968 (3)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	1	–	–	3	2	15.0
Miculenchus Andrássy, 1959 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	3.3
Cephalenchus Goodey, 1972 (2)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	1	3	11.7
Ecphyadophora de Man, 1921 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Ditylenchus Filipjev, 1936 s.l. (1?)	2	1	3	1	3	1	3	3	3	1	1	2	3	1	3	3	1	2	1	3	68.3
Psilenchus de Man, 1921 (1)	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	6.7
Bitylenchus Filipjev, 1934 (1)	1	3	3	2	–	1	–	–	–	–	3	–	1	–	–	–	–	–	–	–	23.3
Tylenchorhynchus Cobb, 1913 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	5.0
Pratylenchus Filipjev, 1936 (1)	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	3.3

Hoplotylus s'Jacob, 1960 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Helicotylenchus Steiner, 1945 (2)	–	–	–	2	–	–	2	–	2	3	–	3	–	3	3	–	3	3	1	1	43.3
Hoplolaimus Daday, 1905 (1)	1	3	2	1	2	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	18.3
Heterodera Schmidt, 1871 (1)	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	5.0
Paratylenchus Micoletzky, 1922 (1)	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7
Gracilacus Raski, 1962 (1)	–	–	–	–	–	1	–	–	1	–	–	–	1	–	–	3	–	–	–	3	15.0
Trophotylenchulus Raski, 1957 (1)	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1	2	10.0
Criconemoides Taylor, 1936 (1)	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1.7
Mesocriconema Andrássy, 1965 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	5.0
Xenocriconemella De Grisse et Loof, 1965 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	3	8.3
Criconema Hofmänner et Menzel, 1914 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	3.3
Ogma Southern, 1914 (1)	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1.7
Hemicycliophora de Man, 1921 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
unidentified juveniles of a species (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Enoplida																					
Prismatolaimus de Man, 1880 (1)	3	3	3	3	3	2	3	3	2	3	3	3	3	2	3	3	3	2	3	3	93.3
Tripyla Bastian, 1865 (1)	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1.7
Tripylina Brzeski, 1963 (1)	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	1	–	1	–	6.7
Tobrilia Andrássy, 1967 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1.7
Alaimida																					
Alaimus de Man, 1880 (8?)	3	1	–	2	1	1	1	–	2	1	–	2	–	3	2	3	3	2	2	3	53.3
Caviputa Siddiqi, 1993 juvs. (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Paramphidelus Andrássy, 1977 (2)	1	–	–	–	2	–	–	–	1	–	–	1	3	3	–	3	–	1	3	2	33.3
Diphtherophorida																					
Diphtherophora de Man, 1880 (1)	1	–	2	1	2	1	–	–	–	–	–	–	–	2	–	–	3	1	–	1	23.3
Tylolaimophorus de Man, 1880 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Mononchida																					
Clarkus Jairajpuri, 1970 (3)	2	3	2	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	93.3
Mononchus Bastian, 1865 (1)	1	–	1	1	–	–	–	–	–	–	–	–	1	1	–	1	–	–	–	–	10.0
Prionchulus Cobb, 1916 (1)	–	–	–	–	–	–	1	–	–	2	–	2	–	2	1	1	–	–	1	–	16.7
Mylonchulus Cobb, 1916 (2)	1	–	–	1	–	1	2	1	3	3	1	2	–	3	3	2	3	3	1	3	55.0
Miconchus Andrássy, 1958 (1)	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7
Dorylaimida																					
Prodorylaimus Andrássy, 1959 (1)	–	–	–	–	–	–	–	–	–	–	–	–	3	1	–	3	–	–	–	2	15.0
Mesodorylaimus Andrássy, 1959 (1)	–	1	–	–	–	–	–	–	–	–	–	1	–	–	1	2	1	–	–	2	13.3
Drepanodorylaimus Jairajpuri, 1966 (2)	3	3	2	2	3	2	1	2	2	2	2	3	–	3	2	–	1	1	2	1	61.7
Discolaimus Cobb, 1913 (1)	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7
Allodorylaimus Andrássy, 1986 (1)	–	–	–	–	–	–	–	–	–	–	–	–	3	1	–	–	–	–	2	2	13.3
Crassolabium Yeates, 1967 (2?)	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	1	1	1	1	13.3

Table 1. (continued)

site	Sahara – Ashby Kolar research plots												NP	Sahara			Pyramid SP			NF	
mined	ca. 1980													ca. 1940			1932–1954				
	topsoil sites						no-topsoil sites														
years since vegetation established	30	30	30	30	30	30	30	30	30	30	30	30	>100	70	70	70	70	70	70	>100	
orders and genera at sites	TP 1–3	TP 4–6	TL 1–3	TL 4–6	TQ 1–3	TQ 4–6	NTP 1–3	NTP 4–6	NTL 1–3	NTL 4–6	NTQ 1–3	NTQ 4–6	Ce 1–3	SAS 1–3	SAP 1–3	SAQ 1–3	PMS 1–3	PMP 1–3	PMQ 1–3	Nf 1–3	F[%]
Epidorylaimus Andrássy, 1986 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Eudorylaimus Andrássy, 1959 (5?)	3	2	2	3	3	2	3	2	1	2	2	3	3	3	3	3	1	2	3	3	81.7
Microdorylaimus Andrássy, 1986 (2)	1	1	–	2	1	2	1	–	2	2	–	2	1	2	3	2	3	3	1	3	53.3
Aporcelaimidae juveniles * (2?)	–	2	1	1	2	–	1	–	–	–	–	–	–	–	–	2	–	1	–	1	18.3
Aporcelaimellus Heyns, 1965 (1?)	1	2	3	3	2	2	2	1	3	2	2	1	3	2	–	1	3	1	3	3	66.7
Longidorella Thorne, 1939 (1)	–	–	–	–	–	–	–	–	–	1	–	–	–	3	–	–	1	–	1	–	10.0
Heterodorus Altherr, 1952 (1)	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	6.7
Pungentella Andrássy, 2009 (1)	–	–	1	–	–	–	–	–	–	–	–	–	2	1	1	3	3	3	3	–	28.3
Pungentus Thorne et Swanger, 1936 (1)	1	3	2	2	3	2	–	–	–	–	–	1	1	3	–	1	2	–	–	3	40.0
Longidorus Micoletzky, 1922 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	5.0
Xiphinema Cobb, 1913 (2)	1	–	1	1	1	–	1	–	2	3	–	3	–	3	1	2	3	3	–	1	43.3
Axonchium Cobb, 1920 (1)	–	–	1	1	2	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	10.0
Oxydirus Thorne, 1939 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	3	–	–	–	–	6.7
Dorylaimellus Cobb, 1913 (3)	1	1	2	1	2	–	1	1	1	1	1	2	3	–	–	1	3	2	1	–	40.0
Leptonchus Cobb, 1920 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Funaria Van der Linde, 1938 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Basirotyleptus Jairajpuri, 1964 (1)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.7
Tylencholaimus de Man, 1876 (3)	3	3	1	2	3	3	2	3	2	2	2	3	1	1	3	3	2	3	3	3	80.0
Tylencholaimellus Cobb in Cobb, 1915 (1)	2	3	3	2	3	2	1	–	2	–	1	–	3	1	–	3	3	2	–	–	51.7
Σ genera	40	35	37	43	39	33	37	26	40	37	27	39	42	51	39	49	55	40	45	68	107
Σ (morpho)species	51	48	49	53	53	44	53	31	48	49	34	58	52	65	52	64	69	53	61	89	171

* juveniles (J1, J2, J3) of *Aporcelaimus* Thorne et Swanger, 1936, *Metaporcelaimus* Lordello, 1965, *Sectonema* Thorne, 1930 are often difficult to distinguish.

The nematode richness in the natural forests studied was evidently high. For example, Johnson et al. (1972) recorded a total of 175 species (a part of those could not be determined precisely) at 18 forests sites in Indiana over a 2-year period and the average for all sites was 43 species per sample.

The mean number of (morpho) species was slightly but significantly greater in topsoil (32.0) than in non-topsoil (27.7) at sites in 30-year-old forest plantations, but the mean number of genera did not differ significantly (25.4 and 23.1, respectively); *t*-test on both untransformed and *ln*-transformed data, Man-Whitney U test. The mean number of (morpho) species in 70-year-old forests at Pyramid was 38.2 and at Sahara 40.7. The respective values for genera were 31.3 and 32.4 and these numbers are not significantly different.

Therefore, there was a tendency for a greater nematode richness in older forest plantations on post-mining sites and the greatest nematode richness was recorded in climax forests. A similar situation exists in Europe (Háněl 2001, 2008) but there are exceptions. For example, soil under

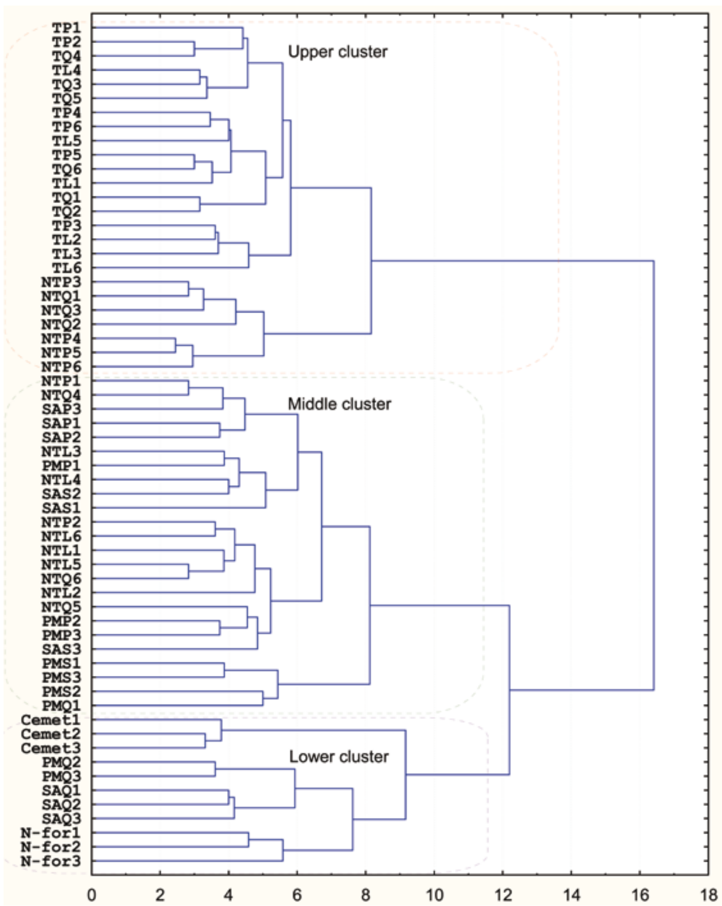

Fig. 1. Dendrogram based on cluster analysis of the presence/absence of nematode genera at 60 sites. Ward's method and Euclidean distances.

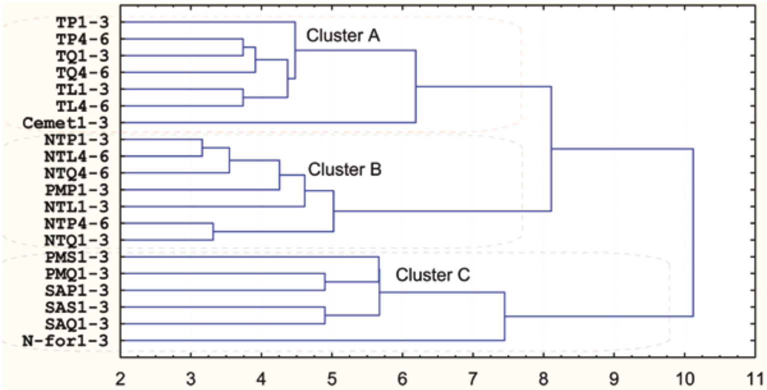

Fig. 2. Dendrogram based on cluster analysis of the presence/absence of nematode genera in triplets of nearest sites, with the same tree species or remnants of natural prairie. Ward's method and Euclidean distances.

alder (*Alnus glutinosa* (L.) Gaertn.) can harbour more species and genera and support more diverse nematode communities than soil under other trees (Háněl 2002, 2003, Hohberg 2003). Between the individual age classes of afforested sites in Illinois there were only slight differences in nematode richness.

Among all the (morpho) species recorded in Illinois 25 had a frequency of occurrence of F≥50%. These were: *Geomonhystera villosa* (Bütschli, 1873), *Monhystrella* sp., *Achromadora tenax* (de Man, 1876), *Anaplectus granulosus* (Bastian, 1865), *Plectus rhizophilus* de Man, 1880, *Plectus geophilus* de Man, 1880, *Plectus acuminatus* Bastian, 1865, *Acrobeloides nanus* (de Man, 1880), *Eucephalobus oxyuroides* (de Man, 1876), *Rhabditis* juvs. (probably mostly *R. terricola* Dujardin, 1845), *Aphelenchoides lagenoferrus* Baranovskaya, 1963 / *conimucronatus* Bessarabova, 1966 group, *Aphelenchoides parasubtenuis* Shavrov, 1967 / *curiolis* Gritsenko, 1971 group, *Basiria* sp., *Filenchus vulgaris* (Brzeski, 1963) group, *Filenchus misellus* (Andrássy, 1958) group, *Filenchus discrepans* (Andrássy, 1954) group, *Boleodorus thylactus* Thorne, 1941, *Ditylenchus* sp., *Prismatolaimus intermedius* (Bütschli, 1873) group, *Clarkus papillatus* (Bastian, 1865), *Mylonchulus brachyuris* (Bütschli, 1873), *Aporcelaimellus obtusicaudatus* (Bastian, 1865) s. l. (mostly juveniles), *Microdorylaimus* cf. *rapsus* (Heyns, 1963), *Tylencholaimellus striatus* Thorne, 1939 and *Tylencholaimus* cf. *micronanus* Yeates, 1979. Out of the 25 (morpho) species 16 (64.0%) also have a frequency of occurrence greater than 50% in a post-mining landscape studied in West Bohemia by Háněl (2009).

Seven (morpho) species occurred at a frequency of occurrence between F≥40% and F<50.0%: *Eumonhystera vulgaris* (de Man, 1880), *Prodesmodora* cf. *loksai* Andrássy, 1989, *Achromadora* cf. *pseudomicoletzkyi* Van der Linde, 1938, *Aphelenchoides macronucleatus* Baranovskaya, 1963 / *saprophilus* Franklin, 1957 group, *Neopsilenchus magnidens* (Thorne, 1949), *Drepanodorylaimus* sp., and *Xiphinema americanum* Cobb, 1913 group.

Two of them (*E. vulgaris*, *A. macronucletus/saprophilus*) have a F≥50% in West Bohemia. As concerns genera, represented by these (morpho) species, only *Drepanodorylaimus* and *Xiphinema* are absent in West Bohemia. Thus, similar dominant groups of soil nematodes will probably occur in coal post-mining landscapes in temperate climates of the Northern Hemisphere. Nevertheless, individual regions can have their specific (endemic) genera and species that can be dominant.

The dendrogram based on cluster analysis of genus presence/absence data for individual sites showed three main clusters (Fig. 1). The upper cluster contained all topsoil sites in Sahara Ashby Kolar research plots and some non-topsoil sites. The rest of the non-topsoil sites are in the middle cluster together with the majority of older sites (ca 70-year), except for white oak sites, which are in the lower cluster with reference prairie and natural forest sites.

The dendrogram based on cluster analysis of genus presence/absence data for triplets of nearest sites, with the same tree species or prairie, also have three main clusters (Fig. 2). The cluster A contains all topsoil sites in Sahara Ashby Kolar research plots and natural prairie. The cluster B consists of all non-topsoil sites and one old pine plantation triplet in Pyramid State Park. The cluster C encompasses all other older tree plantations and poplar natural successions on post-mining land and natural forests.

The dendrogram based on cluster analysis of genus occurrences (0, 1, 2, and 3) in triplets of nearest sites have two main clusters (Fig. 3). The cluster X consists of all topsoil sites in Sahara Ashby Kolar research plots and some non-topsoil sites and natural prairie. Cluster Y is composed of the rest of non-topsoil sites and of all the old forest successions and plantations together with natural forests.

The results of cluster analyses indicate that the reclamation of post-mining sites by spreading topsoil had a noticeable effect on the generic composition of nematode faunas although the generic richness itself did not differ from that at un-reclaimed sites. Nematode faunas at topsoil sites were similar to those recorded in natural prairie and developed to some extent in their own way, i.e. in a somewhat different direction than natural forest faunas. Non-topsoil sites had nematode faunas more similar to that in older natural successions and tree plantations, which were similar to natural nematode forest faunas, which are marked by a high species and generic richness. Differences in nematode faunas of coniferous and deciduous forest sites were less marked than in the afforested post-mining landscape in the Czech Republic (Háněl 2008).

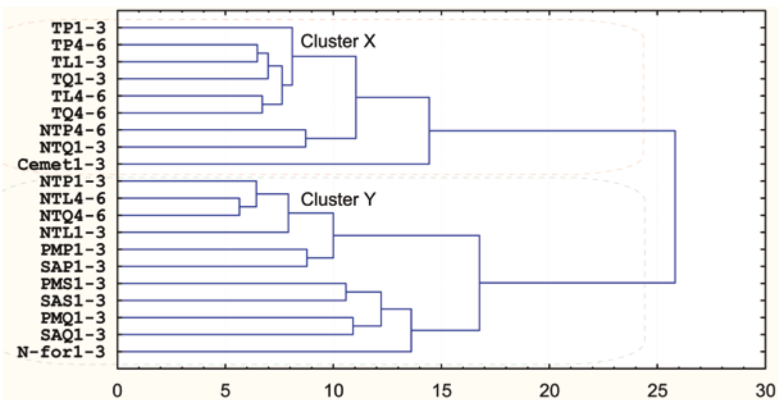

Fig. 2. Dendrogram based on cluster analysis of the occurrences (0, 1, 2, and 3) of nematode genera in triplets of nearest sites, with the same tree species or remnants of natural prairie. Ward's method and Euclidean distances.

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