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INLAND DELTA PLANT COMMUNITY STRUCTURE AND SOIL MICROSCOPIC FUNGI ON KOPAC ISLAND (SLOVAKIA) AFTER DAMMING OF DANUBE RIVER

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Abstract. Old gravel-sandy sediments of the head of the inland delta of the Danube River represent a specific soil and plant ecosystem. There, on Kopac Island, seven areas were studied and the phytocoenoses and soil microscopic fungi communities compared. The areas differ in elevation, level of groundwater, depth of gravel-sandy material, texture of the soil profile, and vegetation communities. Moisture as the primary ecological factor apparently very strongly affected the soil and plant communities but not the microscopic fungi community structure.

Key words: *Asparago-Crataegetum danubiale*, microscopic fungi, mycocoenosis, alluvial soils, groundwater

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INTRODUCTION

The study area, Kopac Island, is at the left bank of the Danube River, southeast of Bratislava (Fig. 1). The core of Kopac Island is formed by a gravel constituent created by sediment transport processes during the glacial era, or during the Alleröd when gravel accumulation along the Danube River finished. During the Preboreal period, river accumulation declined in intensity. Later the activity of the river was characterized by accumulation of finer sediments (Fulajtar 1995), followed by a period of lack of precipitation, when average flow decreased and the sediments remained above the river level. Consequently, the gravel core was settled by mixed oak forest. The next succession was limited by Danube floods (Krippel 1963).

Kopac Island represents a wide range of forest stands, such as willow-poplar, ash-poplar, oak-elm and the rare plant association *Asparago-Crataegetum danubiale*. This locality with its great diversity of animals and plants is protected under the Ramsar Convention of 1993.

Due to damming of the Danube River in 1992 and the history described above, part of the soil is under zonal conditions of development; part of the soils were influenced by intrazonal processes, and part by the water table (Mičuda 2005). The

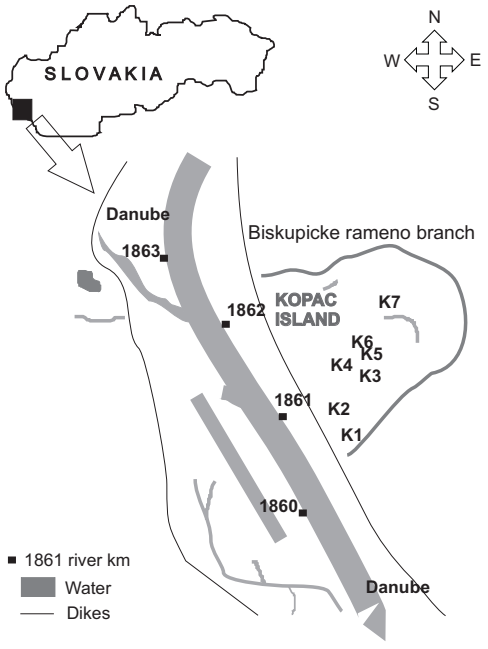

Fig. 1. Study areas K1–K7.

area is interesting for its diversity of soil texture, elevation, groundwater level, depth of the humus horizon, and depth of the gravel-sandy layer, which in some places reaches the surface, interrupting the ascent of groundwater by capillary action (rare plant association).

The aim of this study was to determine the indicator fungal species in relation to plant community structure and selected soil characteristics (elevation, groundwater level, depth of gravel core, soil texture) after damming of the Danube River.

Material and methods

Plant species were classified according to a checklist of non-vascular and vascular plants of Slovakia (Marhold & Hindák 1998) and the phytocoenological classification follows Mucina and Maglocký (1985). Soil types follow the FAO classification (1998). Soil was sampled during the vegetation period each month from March to October 2006, from 0–10 cm depth.

The soil samples were air-dried and passed through a 2 mm sieve. Soil pH (in H_2O and 1M KCl), % $CaCO_3$, organic carbon content (% C_{ox}), percentage of humus, C/N ratio, nitrogen content (% N_{tot}) and granulometric composition were determined by standard methods (Fiala 1999). The same soil samples were used for soil analysis and for isolation of microscopic fungi.

Soil microscopic fungi were isolated by the dilution plate method in three replicates, using 1 ml inoculum from the soil suspension. Czapek-Dox agar and Sabouraud maltose agar (Biomark) and Malt Extract Agar (HiMedia, Bombay) were used. The fungi cultures were incubated in the dark at 25°C for 14 days (Šimonovičová 1992a, b). Fungi were identified (genera and species level) with identification keys (Klich 2002; Domsch *et al*. 2007). In some cases the identification was confirmed with PCR targeted on a large subunit of ribosomal DNA (26S) and subsequent sequencing (Kurtzman & Robnett 1998). The fungal sequences were compared directly with those in GenBank by FASTA searches (http://www.ebi.ac.uk/fasta33/).

Results and discussion

The studied area (Fig. 1) shows great variability of soil and environmental characteristics (Mičuda 2003). Area K1, in the southern part of the study area, is characterized by poplar monoculture with a rich herb layer dominated by *Urtica dioica* and *Solidago gigantea*. The soil type is Calcaric Fluvisol.

Area K2 represents a profile at the lowest elevation, where the water table fluctuates between 1 and 0.5 m depth during the year. The depth of the gleic horizon ranges from 0.15 to 0.60 m. Vegetation consists of *Salici-Populetum*. The soil type is Fluvic Gleysol.

Area K3 is situated between floodplain forest (*Fraxino-Populetum*) and mixed shrub/forest (*Ulmo-Quercetum-Asparago-Crataegetum*). Gravel and sand is present at horizon C_2 at 0.45 m depth. The soil type is Calcaric Fluvisol.

Area K4 is located in a depression in an oxbow, with an intrazonal forest community of *Fraxino-Populetum* with *Populus alba* and a well developed shrub layer with *Swida sanguinea*. The depth of the gravel-sandy layer ranges in the C horizon from 0.20 to 0.65 m depth. The soil type is Calcaric Fluvisol.

Area K5 is situated at the beginning of the gravel core. The soil is rich in humus, and the vegetation consists of xerothermic oak-elm forest. A gravel-sandy layer occurs in the C horizon at 0.2–0.5 m depth. The soil type is Calcaric Fluvisol.

Area K6 is in the central part of study area where the gravel-sandy layer rises to the surface. The soil is shallow, covered with a sparse shrub layer without trees, with xerothermic plant species (*Asparago-Crataegetum danubiale*). The soil type is Calcaric Fluvisol.

Area K7 is located in sandy fluviatic parent material, with *Pinus nigra* dominating. The soil type is Calcaric Fluvisol.

The basic chemical characteristics of the studied soils are listed in Table 1. The pH ranged from 7.47 in gleysols (K2) to 7.76 in fluvisols (K7); this was related to the sandy character of the soil. The soils were calcareous, with $CaCO_3$ content from 11.5% to 24.0%. Organic carbon content in topsoil ranged from 0.94% to 4.10%. The highest organic carbon content was in soil affected by a shallow water table (K2). Total nitrogen content trended similarly to organic carbon content. The soil texture was classified as silty loam for soils situated in depressions (K2), and as sandy loam soil for those

Table 1. Basic chemical characteristics of soil samples from Kopac Island (K1–K7 as in Fig. 1).

Area	pH H_2O	pH KCl	$CaCO_3$ [%]	C_{ox} [%]	N_{tot} [%]	C/N	Humus [%]
K1	7.78	7.47	24.0	3.00	0.52	5.8	5.17
K2	7.47	7.10	20.0	4.10	0.55	7.4	7.07
K3	7.54	7.17	18.0	3.80	0.51	7.4	6.55
K4	7.59	7.21	14.0	3.55	0.47	7.5	6.12
K5	7.79	7.31	19.0	2.35	0.37	6.3	4.05
K6	7.72	7.35	12.0	1.60	0.31	5.2	2.76
K7	7.76	7.44	15.0	0.94	0.20	4.7	1.62

on the gravel core of Kopac Island (K5, K6). The water regime, groundwater level, and occurrence of floods play an important role in the evolution of soil in the area, related to relief, soil profile structure and climatic conditions (Fulajtár 1995). At localities with a more developed humus layer and favorable substrate (loam-sand), the soils develop into on soils with a mollic A horizon, which together with elm-oak vegetation provides good conditions for rapid humification (Mičuda 2005). In places with non-gravelly soils, where the water table reaches the cover layer, the groundwater supplies the soil with 50–100 mm water per annum by capillary action to the transpiration zone (Fulajtár 1995). Moisture percentage (Table 2) correspond to the groundwater level at the sites.

Only 37 species of soil microscopic fungi were identified: Zygomycota 24.3%, mitosporic fungi 67.6%, Ascomycota 5.4% and Basidiomycota 2.7%. Zygomycota were represented by *Absidia cylindrospora* var. *cylindrospora, A. glauca* var. *glauca, A. spinosa* var. *spinosa, Cunninghamella* sp., *Mortierella* sp., *M. polycephala, Mucor hiemalis* f. *hiemalis, Mycocladus corymbifer* and *Rhizopus arrhizus* (Table 3). The species were isolated mainly from samples K1–K4, which contained sufficient organic matter (Table 1). Mitosporic fungi species were most abundant (67.6%). Species of the genera *Penicillium* and *Trichoderma* are among the ones most frequently isolated. Other isolates belonged to the genera *Aspergillus, Cladosporium, Clonostachys, Humicola* and *Metarhizium*. *Isaria fumosorosea* (K1, K2, K4) is a new species for Slovakia (Šimonovičová 2007). Ascomycota were represented by *Neosartorya fischeri* and *Chaetomium* sp. Isolates of *Chaetomium* were very abundant in soils from K1 to K5, and occurred very often in decomposable cellulose of these soil samples (Juršíková *et al*. 2006). *Neosartorya fischeri* was isolated only once. Soil mycobiota from K2 was the most variable in comparison to the other. *Aspergillus fischerianus, Mortierella polycephala, Penicillium corylophilum* and *Trametes hirsuta* were isolated only from K2 soil samples (Table 3).

Microbial communities (bacteria, microscopic fungi, actinomycetes) play a large role in

Table 2. Moisture (%) of soil samples from Kopac Island (K1–K7 as in Fig. 1).

Area	Month of sampling							
	III	IV	V	VI	VII	VIII	IX	X
K1	26.5±0.5	8.3±0.2	7.2±0.5	19.1±1.4	25.2±1.9	5.1±0.3	9.6±0.7	27.7±0.8
K2	51.9±0.2	14.7±4.6	21.9±0.7	43.9±0.5	61.9±0.5	19.3±0.3	20.7±1.4	62.8±0.5
K3	20.6±1.5	10.6±2.1	4.4±0.1	15.2±1.1	17.8±0.9	2.9±0.3	6.2±0.1	12.8±0.3
K4	25.9±0.6	7.8±0.1	7.2±0.4	19.8±0.4	22.7±0.1	2.4±0.1	9.7±0.4	16.5±0.3
K5	18.4±0.7	7.5±1.1	4.4±0.6	7.1±0.6	15.4±0.1	2.4±0.1	6.5±0.1	17.8±0.4
K6	16.3±0.3	7.6±1.0	1.1±0.1	3.7±0.7	12.5±0.2	6.6±0.2	6.7±0.6	14.8±0.9
K7	16.4±1.6	5.3±0.1	2.2±0.1	4.2±0.7	9.5±0.2	0.9±0.1	2.1±0.2	6.8±0.2

Table 3. Microscopic fungi isolated from soil samples of Kopac Island (K1–K7 as in Fig. 1).

Fungi species / genera	Study area						
	K1	K2	K3	K4	K5	K6	K7
Absidia cylindrospora Hagem. var. *cylindrospora*	.	.	.	+	.	.	.
A. glauca Hagem. var. *glauca*	.	.	+	.	.	.	+
A. spinosa Lendn. var. *spinosa*	.	+	.	.	.	+	+
Acremonium berkeleyanum (P. Karst) W. Gams	.	.	.	.	.	+	.
A. murorum (Corda) W. Gams	+	.	.	.	+	.	.
A. strictum (Negroni) W. Gams	.	.	.	.	.	.	.
Aspergillus sp.	.	.	.	.	.	+	.
A. fischerianus Samson & W. Gams	.	+	.	.	.	.	.
A. flavus Link	.	.	.	.	.	+	.
A. glaucus Link	.	.	.	.	.	+	.
Aureobasidium pullulans (de Bary) G. Arnaud	.	.	.	.	.	+	.
Chaetomium sp.	+	+	+	+	+	.	.
Cladosporium sp.	+	.	+	.	.	.	.
Clonostachys rosea (Link: Fr.) Schroers, Samuels & Seifert f. *rosea*	.	.	.	.	.	+	.
Cunninghamella elegans Lendn.	.	.	+	.	.	.	.
Doratomyces stemonitis (Pers.: Fr.) F. J. Morton	.	.	+	.	.	.	.
Humicola sp.	+	.	.	.	.	.	.
Isaria fumosorosea Wize	+	+	.	+	.	.	.
Metarhizium anisopliae (Metschn.) Sorokin var. *anisopliae* (99.460% – AF280634)	.	.	+	+	.	+	.
Mortierella sp.	.	.	+	.	.	.	.
M. polycephala Coem. (93.7% – AF113464)	.	+	.	.	.	.	.
Mucor hiemalis Wehmer f. *hiemalis*	.	.	+	.	+	.	.
Mycocladus corymbifer (Cohn) Váňová	.	.	.	+	.	.	.
Neosartorya fischeri (Wehmer) Malloch & Cain	.	.	.	+	.	.	.
Paecilomyces sp.	+	+	+	.	.	.	+
P. lilacinus (Thom) Samson (99.08% – AF339534)	+	.	.	.	+	.	+
Penicillium sp.	+	+	+	+	+	+	+
P. canescens Sopp (99.2% – AF033493)	.	+	.	+	.	.	+
P. corylophilum Direckx (99.2% – AF034456)	.	+	.	.	.	.	.
Rhizopus oryzae Went & Prinsen Geerlings	+	+	+	+	.	.	.
Stachybotrys chartarum (Ehrenb.: Fr.) S. Hughes	.	+	.	.	+	.	.
Trametes hirsuta (Wulf. *ex* Fr.) Lloyd (96.817% – AY855910)	.	+	.	.	.	.	.
Trichoderma sp.	.	+	.	+	+	.	+
T. koningii Oudem.	.	+	+	+	.	.	.
T. viride Pers. *ex* Gray	+	+	.	+	.	.	.
Verticillium sp.	.	.	.	.	.	.	+
Mycelia sterilia	+	+	+	+	.	.	+
Total	11	16	13	13	7	9	9

soil development, as confirmed by the significant positive correlation between the persistence of soil water repellency and microbial biomass (Juršíková *et al*. 2006; Šimkovic *et al*. 2006). Dilly *et al.* (2005) and Reinklebe and Langer (2006) also observed the importance of microbial communities activity, in floodplain soils exposed to flooding in submerged Gleysol and Eutric Fluvisols at the Elbe River in North Germany 30 years after damming. However, our study showed very little or

no relationship between plant community structure and the identified taxa of soil microscopic fungi. Our findings correspond to those of Bettucci *et al*. (2002), Ehrenfeld *et al*. (2005) and Kubartová *et al*. (2007). Houston *et al.* (1998), Šimonovičová (1992a, b) and Šimonovičová and Gódyová (2004) also noted little or no relationship between vegetation and identified soil microscopic fungi. In all those papers, environmental conditions such as physicochemical characteristics, organic matter, effect of flooding and flowing water were found to be more important than the plant species covering the area.

The differences between all the study areas were influenced mainly by the groundwater level and its fluctuation during the vegetation period. A very good example is plot K2, which is situated at the lowest elevation and where the water table fluctuates annually between 1 and 0.5 m below the soil surface. The positive influence of moisture combined with adequate organic matter permits the diverse fungal community to proliferate. The study confirms the primary influence of ecological factors such as amount of water (groundwater, flooding or flowing water) and accessible organic matter, and the secondary influence of plant community structure.

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