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The mollusc fauna changes along a moisture gradient across the lower Morava River floodplain (SW Slovakia)

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Abstract: During hydrologically "normal" year 2004 we studied changes in structure of the molluscan assemblages at the transect across the lower Morava (March) alluvium. In total 733 living individuals of land molluscs (including fresh shells) and 397 shells of freshwater species were obtained from samples. A total number 19 terrestrial species (including slugs) and 12 freshwater species was found alive and as fresh shells. The highest overall density and number of species (11) were found at the river bank and the lowest density at dry meadow. The species number of other sites – terrain depression, moister grassland and elevated terrace ranged from 4 to 10. Highest species diversity (λ) had the molluscan assemblages of the terrace platform, river bank and terrain depression, respectively. The molluscan assemblage at the terrace had most equitable structure.
Key words: flooded meadows, floodplain, Morava river, moisture gradient, Mollusca.

Introduction

The Slovak part of the lower Morava River floodplain comprises 1913 hectares of grasslands. They mostly belong to subcontinental vegetation of the alliance *Cnidion venosi* Bal.-Tul. These communities differ from other moist meadow communities both phytosociologically and ecologically. *Cnidion venosi* grasslands are situated in warm and relatively dry regions on subhalophilous soils and contain species tolerating both long-term inundation and low soil water availability in the topsoil (Šeffer, J. & Stanová, V. 1999). Since the structure of molluscan assemblages is poorly known, we decided to conduct some detailed quantitative coenological studies of flooded grasslands at model study area. The objectives of this study were twofold – to acquire quantitative data and evaluate the structure of molluscan assemblages along the moisture gradient of the river floodplain.

For the model study area we selected seasonally flooded meadows of the lower Morava (March) not far away from Slovak capital Bratislava (see below for details). As to the flooded grasslands of Morava alluvium, the first more detailed faunistical report concerning the locality Hofierske Lúky gave Kučeravý, A. (1995). Čejka, T. (2000) studied molluscan fauna of flooded grasslands near the town of Stupava and assemblages of fen grasslands at National Nature Reserve Abrod, Borská nížina lowland (Čejka, T. 2003). Based on the analysis of collembolan assemblages *(Colembolla),* Rusek, J. (1984) compared variety of ecological aspects of three different types of inundated grasslands at Lanžhot (South Moravia). Majzlan, O. (1993) studied structure of weevil assemblages *(Coleoptera, Curculionidae)* on the lower Morava River floodplain. Majzlan, O. & Rychlík, I. (2000) described beetle assemblages of the same site as dealing this study. Zulka, K. (1994, 1994a) studied population dynamics of carabid beetles *(Carabidae)* in the Austrian part of the Morava alluvium.

Description of the study area

The study site is situated at the lower stretch of the river Morava, 9 km upstream from its confluence with the Danube, at the left river bank near the colony Devínske Jazero (coordinates: 48°15'00''N,16°58'18''E). Here the Morava floodplain is typically 1 km wide. For a flood pulse adaptations study of the molluscan fauna molluscs were studied at four plots of the 700 m long transect perpendicular to the river, corresponding to the moisture gradient in dependency of groundwater and flood regime. The plots are represented by (A) the river bank (fluvial levee, sensu Brierley *et al.,* 1997), (B) terrain depression, (C) gently sloping bank and (D) the terrace platform (see Fig. 1). Altitude ranges from 139 to 175 m a.s.l. Alluvial vegetation consist largely of meadows, mowed once or twice a year usually at the end of May. In contrast to other grasslands of Southern Slovakia which are grazed after first mowing, Moravian meadows are never grazed. Trees are present as a narrow strip of the willow *(Salix alba)* forest along the bank as well as few scattered individuals at the meadow complex. The site belongs to mapping square 7767d of the Databank of Fauna of Slovakia (DFS).

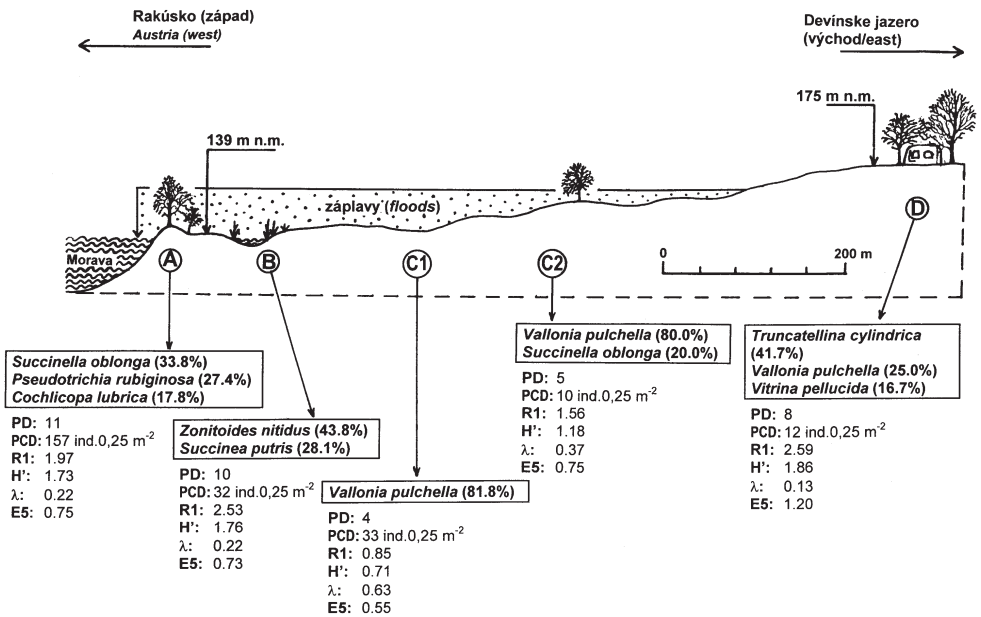

Fig. 1.: The profile across the Morava River floodplain with study plots and structural attributes of particular molluscan assemblages. PD – number of species, PCD – overall density, R1 – Margalef's index, H' – Shannon-Wiener diversity index, *Lambda* – Simpson's diversity index, E5 – Hill's ratio.

Methods

At each site of the transect four quadrats 25×25 cm of topsoil 3 cm thick homogenized to one sample were taken four times a year. Samples were processed by standard procedure following Evans, J. G. (1972). Molluscs were identified to species level following Kerney, M.P. *et al.* (1983), Glöer, P. & Meier-Brook, C. (2003). Nomenclature follows Turner, H. *et*

al. (1998). We used a following dominance scale (unlike Tischler, W. 1949): dominant species (more than 15% of the total density of the assemblage), subdominant (6–15%), recedent (1–6%) and subrecedent (less than 1%). Dominance was calculated from the total number of living individuals (not including slugs) and fresh shells, which corresponds to majority of recent malacocoenological studies (e.g. Millar, A. J. & Waite, S. 1999). A relative abundance of the species (searching on site during 30 min.) is signified by five degrees: 1 – single or rare species, 2 – scarce species, 3 – medium-abundant species, 4 – abundant species, 5 – very abundant species. To express the species richness (alpha-diversity) we used the *Margalef's index* (in Ludwig, J.A. & Reynolds, J.F. 1988), where Di = S-1/log N and Simpson's diversity index (λ) = $\Sigma(n_i/N)^2$, where ni – density (abundance) of i-species; N – total densities. Structural equitability of assemblages was expressed by *Hill's ratio* (E5 sensu Ludwig, J. A. & Reynolds, J. F. 1988). The most equitable assemblages approach to value 1. Nomenclature of plant communities follows Balátová-Tuláčková, E. (1966).

Results

a) Results from the whole area

Density and species richness

This quantitative study was undertaken in hydrologically "normal" year 2004. During the research we obtained from samples 733 living individuals, fresh shells of land molluscs and 397 shells of freshwater species. A total of 19 terrestrial species (including slugs which could not be sampled from the quadrats and, therefore, are not included in the analyses) and 12 freshwater species was found alive and as fresh shells. The maximum overall density was recorded in the study plot A (river bank), following with plots B (terrain depression), C1 (moister parts of the meadow) and D (terrace); lowest density was in the plot C2 (drier part of the meadow) (see tab. 1). Highest number of species (11) was in the plot A, the species number in other plots were: B–10, C1–4, C2–6, D–9. Highest species diversity (l) was found in plot D (terrace), A (river bank) and B (terrain depression), respectively. The most equitable structure of an assemblage was in the site D (terrace).

b) Results from the individual study plots

A. River bank

The study plot is characterized by riparian vegetation of the association *Salici–Populetum* (willow–poplar forest) at the fluvial levee landform (see Fig. 1). In the herb layer *Urtica dioica* and *Aster lanceolatus* agg. dominated, codominants were *Symphytum officinale* and *Equisetum telmateia.* The substrate is gley fluvisoil.

Terrestrial malacocoenosis was dominated by three species – hygrophilous snail *Succinella oblonga* (33.8%), *Pseudotrichia rubiginosa* (27.4%) and euryecious *Cochlicopa lubrica* (17.8%). Local assemblage was characterized by the highest average overall density (157 ind. 0.25 m^{-2}). By visual search, we found two hygrophilous species, *Oxyloma elegans* (scarce at the site) and *Deroceras laeve* (medium-abundant population).

Total number of the species recorded (including species found by visual search): 11.

B. Terrain depression

Study plot was situated on the gentle slope of terrain depression (= former main channel of the river) in the plant association *Gratiolo-Caricetum praecocis-suzae.* The site used to be flooded two or more times a year. During a vegetation season and hydrologically "normal" years, the depression is usually filled with stagnant water. The soil type is fluvisol (presence of organic remains).

The dominant plants were typical wetland species: *Leucojum aestivum, Iris pseudacorus, Carex vulpina, Rorippa amphibia, Glyceria maxima, Lythrum salicaria, Rumex crispus* and *Poa trivialis.*

Molluscan assemblage was characterized by low average overall density (32 ind. 0,25 m^{-2}) and dominance of two polyhygrophilous species *Zonitoides nitidus* (43.8%) and *Succinea putris* (28.1%). Another species *Deroceras laeve* (medium-abundant), *Arianta arbustorum* (medium-abundant) and *Vallonia pulchella* (scarce) were recorded by visual search at the site. Total number of species: 10.

With regard to habitat character we also found several freshwater species. *Planorbis planorbis* (60.5%) prevailed, *Planorbarius corneus* (12.8%) and *Anisus spirorbis* (9.3%) were on the subdominant level. Other species (see tab. 1) belong to typical species of temporary waters (see Table 1).

C. Flooded meadow

It belongs to subcontinental alliance of *Cnidion venosi*, ass. *Cnidio-Violetum pumilae*. Characteristic plants are *Clematis integrifolia*, *Viola pumila*, *Alopecurus pratensis*, *Carex praecox*, *Poa pratensis*, *Plantago lanceolata*, *Cnidium dubium*, *Sanguisorba officinalis*, *Galium verum*, *Lysimachia nummularia*, *Filipendula ulmaria, Lychnis flos-cuculi*, *Inula salicina* etc. In the spring, temporary waters become colonized by tadpole shrimps (*Lepidurus apus*).

Within the meadow complex we recognized two different parts:

C1. *Depressed moist part* – with differential plant taxon *Clematis integrifolia*.

Here only three land snail species occurred regularly – dominant *Vallonia pulchella* (81,8%), subdominant *Cochlicopa lubrica* (12.1%) and *Succinella oblonga* (6.1%). The average overall density was nearly identical as in study plot B – only 33 ind.0.25 m^{-2}. Slug *Deroceras laeve* was confirmed by visual search (the species was medium-abundant).

C2. *Slightly elevated drier part of the meadow* – differential plant taxon was *Alopecurus pratensis*. In this habitat we found only 2 species characterized by very low density – *Vallonia pulchella* (80.0%) and *Succinella oblonga* (20.0%). The average overall density was lowest of all assemblages (10 ind. 0.25 m^{-2}). The hygrophilous slug *Deroceras laeve* (scarce), *Vallonia costata* (scarce) and *Arion subfuscus* (rare) were recorded by visual search.

D. Terrace

Study site is situated around of the 2nd World War ferroconcrete bunker at the edge of the terrace. Local vegetation is largely determined by non-indigenous and ruderal species (*Robinia pseudoacacia, Aristolochia clematitis*, *Chelidonium majus*, *Chenopodium rubrum*, *Artemisia vulgaris*, *Capsella bursa-pastoris*, *Geranium pyrenaicum* etc.).

Table 1. Distribution of molluscs along the transect across the floodplain of the lower Morava River at the site of Devínske jazero, SW Slovakia (land molluscs are arranged according their hygropreferences). Dom – dominance, for A–D see Results.

Terrestrial molluscs	**A**	Dom	**B**	Dom	**C1**	Dom	**C2**	Dom	**D**	Dom
Oxyloma elegans (Risso, 1826)	+	–	1	3,1	–	–	–	–	–	–
Carychium minimum O. F. Müller, 1774	4	2,5	1	3,1	–	–	–	–	–	–
Succinea putris (Linnaeus, 1758)	6	3,8	9	**28,1**	–	–	–	–	–	–
Pseudotrichia rubiginosa (A. Schmidt, 1853)	43	**27,4**	2	6,3	–	–	–	–	–	–
Zonitoides nitidus (O. F. Müller, 1774)	5	3,2	14	**43,8**	–	–	–	–	–	–
Deroceras laeve (O. F. Müller, 1774)	+	–	+	–	+	–	+	–	–	–
Vitrea crystallina (O. F. Müller, 1774)	14	8,9	–	–	–	–	–	–	–	–
Succinella oblonga (Draparnaud, 1801)	53	**33,8**	2	6,3	2	6,1	2	**20,0**	–	–
Cochlicopa lubrica (O. F. Müller, 1774)	28	**17,8**	3	9,4	4	12,1	–	–	–	–
Arianta arbustorum (Linnaeus, 1758)	1	0,6	+	–	–	–	–	–	–	–
Vallonia pulchella (O. F. Müller, 1774)	3	1,9	+	–	27	**81,8**	8	**80,0**	3	**25,0**
Vallonia costata (O. F. Müller, 1774)	–	–	–	–	–	–	+	–	+	–
Arion subfuscus (Draparnaud, 1805)	–	–	–	–	–	–	+	–	–	–
Truncatellina cylindrica (Férussac, 1807)	–	–	–	–	–	–	–	–	5	**41,7**
Cochlicopa lubricella (Porro, 1858)	–	–	–	–	–	–	–	–	+	–
Cepaea vindobonensis (Férussac, 1821)	–	–	–	–	–	–	–	–	1	8,3
Xerolenta obvia (Menke, 1828)	–	–	–	–	–	–	–	–	+	–
Helix pomatia Linnaeus, 1758	–	–	–	–	–	–	–	–	1	8,3
Vitrina pellucida (O. F. Müller, 1774)	–	–	–	–	–	–	–	–	2	**16,7**
Total density	**157**	100,0	**32**	100,0	**33**	100,0	**10**	100,0	**12**	100,0
Number of species	11	–	10	–	4	–	5	–	8	–
Freshwater molluscs										
Bithynia leachii (Sheppard, 1828)	–	–	3	1,7	1	–	–	–	–	–
Galba truncatula (O. F. Müller, 1774)	2	–	3	1,7	–	–	–	–	–	–
Anisus vortex (Linnaeus, 1758)	–	–	2	1,2	–	–	–	–	–	–
Planorbarius corneus (Linnaeus, 1758)	–	–	22	12,8	–	–	–	–	–	–
Planorbis planorbis (Linnaeus, 1758)	–	–	104	**60,5**	–	–	–	–	–	–
Anisus spirorbis (Linnaeus, 1758)	–	–	16	9,3	–	–	–	–	–	–
Viviparus contectus (Millet, 1813)	–	–	9	5,2	–	–	–	–	–	–
Bithynia tentaculata (Linnaeus, 1758)	–	–	2	1,2	–	–	–	–	–	–
Lymnaea stagnalis (Linnaeus, 1758)	–	–	1	0,6	–	–	–	–	–	–
Valvata cristata O. F. Müller, 1774	–	–	2	1,2	–	–	–	–	–	–
Valvata macrostoma Mörch, 1864	–	–	6	3,5	–	–	–	–	–	–
Stagnicola cf. *turricula* (Held, 1836)	–	–	2	1,2	–	–	–	–	–	–
Total density	2	–	**172**	**100,0**	1	–	–	–	–	–
No. of species	1	–	12	–	1	–	–	–	–	–

The land snail assemblage is characterized by low overall density (12 ind. 0.25 m^{-2}). In the assemblage of the 8 species *Truncatellina cylindrica* (41.7%), *Vallonia pulchella* (25.0%) and *Vitrina pellucida* (16.7%) were dominated. The species *Vallonia costata*, *Cochlicopa lubricella*, *Xerolenta obvia* were found by visual search (all species could be assessed as rare).

Discussion

Species richness, density

In total, we found 19 terrestrial and 12 freshwater species in five study plots. Comparing our research in nearby situated flooded meadows at Stupava town (Čejka, T. 2000), where we found 12 species (plus 22 freshwater species) the species richness is higher due to the presence of several forest hygrophilous species (*Arianta arbustorum*, *Vitrea crystallina*, *Arion subfuscus*). Kučeravý, A. (1995) mentions 16 terrestrial and 31 freshwater species from Hofierske Lúky grasslands. Besides the same taxa as found by this study, he listed additionally *Alinda biplicata*, *Cepaea hortensis*, *Euconulus praticola*, *Punctum pygmaeum* and *Granaria frumentum*; the latter evidently being washed out from the original embankment or other xerothermic habitats. Kučeravý did not mention typical species of flooded grassland as *Deroceras laeve*, *Arion subfuscus*, neither semisilvicolous snails *Vallonia costata* or *Oxyloma elegans*.

Frank, C. (1987) conducted ecofaunistic survey of Austrian part of the Morava alluvium. Unlike our surveys she also mentions slugs *Arion distinctus* Mabille, 1868 and *Arion fasciatus* (Nilsson, 1823). The investigations of Frank confirmed also low density of the snail *Vertigo pygmaea*: during the 1981–1984 survey she found no living individual, same goes for the species *Carychium tridentatum*, *Cochlicopa nitens*, *Columella edentula*, *Pupilla muscorum*, *Merdigera obscura*, *Chondrula tridens*, *Cecilioides acicula* and *Euomphalia strigella*.

Comparison with Middle-Danube remnant flooded meadows (locality Sporná sihoť near the village of Kľúčovec) shows that they are faunistically almost indentical, the only snail to differ was *Monacha cartusiana* (Čejka, T. unpubl.). Nevertheless, Danube grasslands malacocoenoses are quantitatively nearly sevenfold richer comparing to those of lower Morava. The total average density is 342 ind.0.25 m^{-2}, at which *Vallonia pulchella* and *Cochlicopa lubrica* predominated. In this study, comparable general density is very low (48.8 ind.m^{-2}), similar to flooded meadows at Stupava (56.3 ind.m^{-2}). Presumably the major causative factors of the low density are long-time stagnation of the water and low content of soil carbonates, typical for major part of Morava alluvium at its Slovak stretch. The distribution of the total density in our study plots coincides with study of Majzlan, O. & Rychlík, I. (2000) along the same transect. They also found the density of carabid beetles to be highest at the river bank (site A), following with plots at the terrain depression and the meadow (B, C), with the lowest density on the fluvial terrace (D).

Distribution of the individual species along the moisture gradient

The moisture gradient along the established transect is not continual. Although the area is seemingly of plain pattern, in fact it is abrupted by terrain depressions of different depth and a few metres high enclaves of sandy-gravel bars. Anthropogenic relief disturbations are also

present (Račko, J. & Bedrna, Z. 1994). The study plot A is situated on the moderately elevated levee of the former river bed, so that it lies correspondingly higher compared to plots B–C2. In comparison to the plot B the snail assemblage is therefore more „drier" with dominant hygrophilous species *Succinella oblonga* and *Pseudotrichia rubiginosa*. With regard to a vegetation cover and larger quantity of the litter, some woodland hygrophilous species concentrate there (*Vitrea crystallina*, *Arianta arbustorum*). Highest number of polyhygrophilous species is present at the terrain depression (plot B, dom. *Zonitoides nitidus*, *Succinea putris*). Due to the long-term stagnation of water some stagnicolous and temporary paludicolous species found favourable conditions there (dom. *Planorbis planorbis*, *Anisus vortex*). The grassland, especially the plot C1 are most exposed to the destructive influence of flooding. Therefore they have both low number of species and density (dom. *Vallonia pulchella*). On the elevated part C2 also *Succinella oblonga*, *Arion subfuscus* and *Deroceras laeve* occur. The snail assemblages of the terrace substantially differs from the others (dom. *Truncatellina cylindrica*, *Vallonia pulchella* and euryecious species *Vitrina pellucida*). Xerothermic species *Cepaea vinobonensis, Xerolenta obvia* and *Helix pomatia* are present here, although with lower abundance. Unlike our evidence, Majzlan, O. & Rychlík, I. (2000) at the same transect recorded highest species number at the terrain depression (plot B) and lowest at the river bank (plot A).

Summary

We studied structural changes of molluscan assemblages across flooded meadows of the lower Morava, SW Slovakia. During hydrologically "normal" year 2004 molluscs were sampled by quadrat method: four quadrats 25×25 cm of topsoil 3 cm thick homogenized to one sample were taken four times yearly from each study plot. Four sites were established at the transect across the left bank, representing the moisture gradient: study plot (A) the river bank – a narrow strip of the floodplain forest ass. *Salici-Populetum*, (B) flooded terrain depression, overgrown by vegetation of ass. *Gratiolo-Caricetum praecocis-suzae*, (C) flooded meadow, (D) terrace. In total 733 living individuals, fresh shells of land molluscs and 397 shells of freshwater species were obtained from samples during the research. A total of 19 terrestrial species (including slugs which were not able to be sampled from the quadrats and, therefore, are not included in the analyses) and 12 freshwater species were found alive and as fresh shells. The highest overall density was recorded at the river bank, terrain depression, moister meadow and terrace platform, respectively. Lowest density was ascertained at dry meadow. Site at the river bank also had a maximum number of species (11), the species number of other plots ranged from 4(C1) to 10(B). Highest species diversity (Simpson's index) had terrace habitat, river bank and B nearby terrain depression. The most equitable structure of the assemblage was in the site D (terrace).

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