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THE MALACOFAUNA OF THE TISZA VALLEY: INHABITATION AND SUBSEQUENT IMPOVERISHMENT

K. Bába

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Abstract. Recent flood areas restricted between dikes can be considered as the last refugia for the Tisza Valley biota, and also serve as ecological corridors for fauna dispersal. Sylvicultural management and poplar plantation, as the most severe human interventions, change the composition of river valley fauna, alter the direction of fauna migration, and homogenize the flood plain fauna. These finally lead to the irreversible degradation of the Tisza Plain biota. Poplar cultivation modifies microclimate, that also influences agricultural food production outside the dikes. Forestry practices produce numerous newly cut roads, along which the noxious weed *Ambrosia artemisiifolia* rapidly invades flood areas. Furthermore, poplar plantations are unfavourable for recreation activities and tourism. The processes of the Tisza's regulation and the drainage of the Great Hungarian Plain seems to be completed with accomplishing the once abolished plan for the canalization of the Tisza.

Key words: ecological corridor, fauna transport, species groups, species migration.

K. Bába, Department of Biology, Juhász Gy. Teachers Training College, Szeged, Hungary

Introduction

The issues exposed in the title will be approached through summarizing the results of a regional study on malacofauna. In this way, a comprehensive treatment will be given to the problems of fauna establishment and impoverishment.

Material and Methods

This summary is based on the author's more than 35 years of study on snail assemblages. During this, the absolute method was used with quadrats of 10×10×25 and 100×25×25 cm. All major forest and grassland community types in the Tisza Valley and on the Great Hungarian Plain were covered (Andó and Bába 1952, Bába 1969, 1973, 1975, 1976, 1977, 1980a,b,c,d, 1983a,b, 1989, 1991a, 1992a,c,d, 1993, 1994c, 1995). This overview was compiled as a result of the author's assignment to prepare UTM distribution maps for 97 snail species occurring on the Hungarian part of the Great Plain (Bába 1991a). For this, he used his own and literature data, and covered the most part of the malacofauna, as altogether 104 snail species inhabit the entire Great Plain (Bába and Kondorossy 1994). Several related works were also used for this analysis, like those by Radó (1967) and Pécsi (1969) to estimate the degree of forestedness and the hydrological status of the area recently and also prior to the regulation of riverways. The climatic districts by Kakas (1960), the physical geographical classification of Somogyi (1961), and statements of Andó and Vágás (1972) on river densities in certain areas (Bába 1982b) were also considered in the assessment of fauna distributions (Bába 1979a, 1982a,b). An area-analytical zoogeographical scheme of the Hungarian malacofauna was also prepared (Bába 1982a, 1989, 1992c), which enabled the evaluation of fauna distributions. Altogether 22 recent and Pleistocene faunas from fluvial sediments were analyzed (Bába 1979b). Further studies — lasting for two or more years — were conducted on the fluctuation and seasonal dynamics of snail assemblages in natural and managed forest stands (Bába 1980b, 1994a), and on the influence of poplar plantation in river flood plains on the snail fauna (Bába 1994b). The effects of forest management and hydrology on woodlands were studied by zoogeographical (Bába 1980, 1992b) and ecological methods through applying species groups (Bába 1991b, 1992d, 1994a,b). Species groups used are as follows. Ecological groups: sciophilous (A) and photophilous (C) moisture demanding elements; swamp dwellers (B, the member Monacha species may also occur in muddy saline soils); species of open areas (D); riparian ubiquists (E). Habitat types: forest dweller (F); bush forest dweller (BE, indicates scrub formation); riparian species (RU); steppe dwellers (ST). Nutritional types: omnivore (O); herbivore (H); saprophagous (SZ).

The foregoing discussion can be divided into two main parts following the sequence of problems exposed in the title.

Inhabitation of the Tisza Valley

The malacofauna populated the Tisza Valley, and the Great Hungarian Plain as well, mostly by way of river transport. Several evidences support this theory. Thus, for example, the composition of the transported fauna changes in accordance with the species composition at river origins, as it was shown by studies on fluvial sediment snail assemblages (Bába 1979b). The Danube and Tisza rivers differ in the carried malacofauna. Rank orders of species in the fauna of Tisza deposits and in the snail assemblages establishing in willow thickets are similar. After grouping the Great Hungarian Plain collection sites according to physico-geographical subregions and then checking dissimilarities with χ^2 tests, clear differences appeared between the faunas of the Tisza Plain and the Dráva or Danube floodplains. This also confirms that the fauna of a given river valley is greatly influenced by the species composition at the river source.

Two groups can be distinguished among species occurring on the Great Hungarian Plain: a) ecological generalists of wide geographical distribution, and b) species restricted to former river beds or recent flood areas. From the latter group, forty eight species of subatlantic climatic character are listed in Table 1. These ecological specialists normally inhabit hilly areas in the Carpathian Basin, but occasionally occur on the Great Plain as well. Species were grouped according to the area-analytical zoogeographical classification, thus the directions of possible fauna transport events can be elucidated. These 48 species belong to 6 major and 17 subordinate fauna groups. They occur in inundation areas and former flood plains. The bottom chart displays the fauna groups carried by the Tisza and its tributaries, and the location of their probable entrance to the Great Hungarian Plain.

Table 1. Zoogeographical classification for 48 snail species of narrow ecological tolerance.

5.1. Illyrian
Aegopinella ressmanni (Westerlunnd 1883)
Aegopis verticillus (Ferrussac 1822)
Clausilia dubia (Draparnaud 1805)
Macrogastra ventricosa (Draparnaud 1801)
5.2.1. Trasian
Oxychilus glaber (Rossmässler 1835)
Oxychilus inopinatus (Illicny 1887)
Pomatias rivulare (Eichwald 1829)
5.2.2. Illyro-Moesian
Balea biplicata (Montagu 1803)
Clausilia pumila (C. Pfeiffer 1828)
Daudebardia rufa (Draparnaud 1805)
Laciniaria plicata (Draparnaud 1801)
Malacolimax lenellus (O. F. Müller)
Perforatella incarnata (O. F. Müller 1774)
Tandonia budapestiensis (Hazay 1881)
Trichia hispida (L. 1758)
Vitrea diaphana (Studer 1820)
6. Adriato-Mediterranean
Chilostoma planospirum (Lamarck 1822)
Cochlodina laminata (Montagu 1803)
Discus rotundatus (O. F. Müller 1774)
Lehmania marginata (O. F. Müller 1774)
Limax cinereoniger (Wolf 1803)
Vitrea crystallina (O. F. Müller 1774)
7. Atlanto-Mediterranean
Arion ater (L. 1758)
Arion fasciatus (Nillson 1823)
Arion sylvaticus (Lohmander 1937)
Cepaea hortensis (O. F. Müller 1774)
Cepaea nemoralis (L. 1758)
8. Holo-Mediterranean
Cecilioides aciculata (O. F. Müller 1774)
Ena obscura (O. F. Müller 1774)
Lehmania nyctelia (Burguignat 1861)
Limax flavus (L. 1758)
Limax maximus (L. 1758)
Oxychilus draparnaudi (Beck 1837)
Oxychilus hydatinus (Rossmässler 1838)
Vertigo moulinsiana (Dupuy 1849)
Vertigo pusilla (O. F. Müller 1774)
Vitrea contracta (Westerlund 1871)
9.1. Carpathian
Perforatella dibothrion (M. V. Kimakowicz 1884)
9.2. Carpatho-Sudetian
Bielzia coerulans (M. Bielz 1851)
Perforatella vicina (Rossmässler 1842)
9.3. Carpatho-Baltian
Perforatella bidentata (Gmelin 1788)
9.4. Alpo-Carpathian
Isognomostoma isognomostoma (Schröter 1784)
Perforatella umbrosa (C. Pfeiffer 1828)
Trichia unidentata (Draparnaud 1805)
9.5. Daco-Podolian
Chilostoma banaticum (Rossmässler 1838)
Hygromia transsylvanica (Westerlund 1876)
Hygromia kovácsi (Varga et Pintér 1972)
10.1 Boreo-Alpine
Arianta arbustorum (L. 1758)

Thus, it can be stated that the number of species transported by running waters is positively correlated with the river density of the area and the water discharge of rivers. Similarly, there are differences

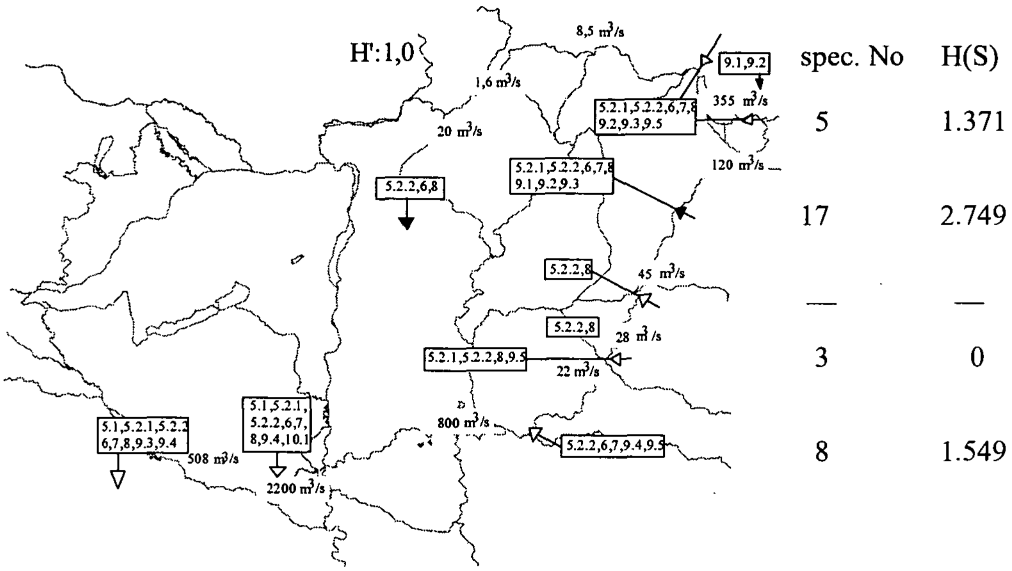

Fig. 1. Geographical distribution and localities of entrance to the Great Hungarian Plain for 48 stenoecic snail species. River discharge figures and diversity of water-carried snail assemblages are also shown.

between rivers in the diversity of water-carried species. Snails typical of hilly regions may invade certain forested parts of the Great Plain as well, e.g. the Gödöllő Hills, or the Bátorliget and Déda Forest sites on the Szatmár-Bereg Plain (Fig. 1). This zoogeographical phenomenon is termed between-forest dispersal, in which 24 % of the species is involved.

Historical factors may also influence the current distribution of organisms. The continuous occurrence of *Punctum pygmeum* since the Würm glaciation has been demonstrated by Krolopp and Sümegi (1991). Island-like gallery and swamp forests appearing along former Danube beds and wave areas preserved five species (e.g. *Vertigo pusilla* and *Perforatella incarnata*) typical of the Danube Valley. In the Tisza Valley, *Perforatella vicina* is such a relic species.

The flood plain of the Tisza and its tributaries might have extended from Kiskunfélegyháza to Debrecen, as reconstruction revealed. Following river retreat, large water surfaces remained behind, greatly enhancing the dispersal of riparian ubiquist species of wide geographical distribution. Most of these snails are common even today. Such ubiquists are e.g. the amber snails (*Succinea* spp.), and *Zonitoides* and *Bradybaena* species. Large areas of the Plain were covered by water permanently or temporarily several decades ago. These open water surfaces mostly disappeared by now as a consequence of drainage or melioration. With this, the list of causes behind fauna impoverishment have already started.

Causes of malacofauna impoverishment in the Tisza Valley

Drainage and regulation of riverways started in the 1840s in the Tisza Valley. As a consequence, the ground water table level — formerly being close to the surface — has dropped to 4-6 m deep at some places by the sixties. Recently, this unfavourable process has expanded to most parts of the Great Plain, thus changing the conditions for fauna dispersal markedly.

A peculiar feature of the Tisza Valley is the absence of an autochtonous malacofauna. Consequently, the region is inhabited by fauna elements arriving from other areas and establishing permanently or temporarily. Mostly forests providing sufficient moisture and food source are appropriate for the establishment of newcomers. This process might have operated until the previous century, as it can be inferred from the reconstructed vegetation map given by Zólyomi. Even in the 1920s, five species of montane character (including a *Clausilida* sp.) were recorded at Dorozsma Bath by Czógler (1914-36).

On the flood plain, the distribution of species with montane affinities among forest types was as follows: 67% in gallery forests, 47% in willow-poplar woods and 33% in hornbeam-oak woods. Most of these forests have been cut down by now. According to a recent survey by the WWF, gallery forests make up some 3% of the flood plain woods (Dobrosi et al. 1993). Most of these have survived at the Upper and Middle Tisza Reaches. Changes in the degree of forestedness and amount of precipitation in the catchment area of the Tisza water system determine the conditions of fauna colonization. River discharge is also influenced. The role of the four to five annual floods in fauna transport and selection might have been substantial before the source areas have been deforested. This intervention itself decreased considerably the abundance and diversity of the alluvial fauna.

Deforestation in inundation and reclaimed areas prevents the dispersal of river-carried fauna. This influence is especially serious if we consider that the continental climate of the Great Hungarian Plain hampers the spread of snails in the absence of forests and wet soil. Climatic districts A1-A5 (Kakas 1960) of the the Great Hungarian Plain are characterized by an arid, hot or moderately hot summer.

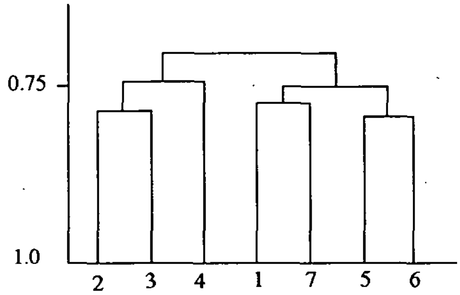

Fig. 2. Classification of Tisza Plain regions on the basis of fauna elements (study sites are listed in Table 2).

Snail dispersal is further limited in reclaimed areas by various human activities, like canalization, regular cutting of dikes for hay making, drilling drinking water wells, construction of the two barrage systems on the Tisza, establishment of recreation facilities, and agricultural production in flood areas. All these alter microclimatic conditions.

As the water chemistry deteriorates in the Tisza and its tributaries, the number of species with living river-carried individuals decreases gradually. This is the reason of the zero snail species diversity transported in the polluted Sebes Körös river.

Current distribution of the Tisza Plain malacofauna

The recent allocation of the Tisza Plain snail fauna is shown in Table 2. and Fig. 2. as the result of a cluster analysis on zoogeographical categories arranged according to geographical subregions. In this, the Nyírség (2), and the Upper and Middle Tisza Regions (3 and 4) form one cluster core. These areas are relatively rich in forests, especially in gallery forests. The other cluster core is made up by two pairs of regions: one is the level alluvial fan of the Northern Great Plain (1) and the Körös-Maros interfluve (7), while the other is the Lower Tisza Valley (5) and the Körös Region (6).

Table 2. Distribution of zoogeographical fauna groups among the Tisza Plain regions. The associated cluster diagram is also shown below.

Fauna groups	1	2	3	4	5	6	7
East Siberian	3	9	8	9	6	5	4
West Siberian	1	3	2	2	2	1	1
Euro-Siberian	0	2	2	3	1	1	2
Holarctic	4	8	8	7	7	5	5
Turkestanian	1	1	1	1	1	0	1
Kaspo-Sarmathian	2	3	2	2	2	2	2
Ponto-Pannonic	2	3	2	2	1	1	1
Daco-Podolian	1	1	2	1	0	1	2
Trasian	3	5	2	1	1	1	2
Illyro-Moesian	3	3	4	3	0	0	2
Adriato-Mediterranean	1	4	5	0	2	0	2
Atlanto-Mediterranean	1	2	2	0	0	2	0
Holo-Mediterranean	6	14	7	6	5	6	3
Carpathian	0	0	1	0	0	0	0
Carpatho-Sudethian	0	1	2	1	0	0	0
Carpatho-Baltian	0	2	1	0	0	0	0
Alpo-Carpathian	0	0	1	0	0	0	0
All species (fauna elements)	28	61	52	38	28	25	27

Study sites were: 1. Alluvial fan of the Northern Great Plain; 2. Nyírség (Samicum); 3. Upper Tisza Region; 4. Middle Tisza Region; 5. Lower Tisza Region; 6. Körös Region; 7. Körös-Maros Interfluve

This pattern mainly reflects local watercourse frequencies and climatic properties in the catchment area of the tributaries. In addition, regions in the second cluster core are homogenized by anthropogenic effects. In these areas (e.g. the Northern Great Plain, and the foothills of the Mátra and Bükk Mts.), forest cover is very low, the proportion of arable land is quite high and the climate is relatively arid. Low species number characterizes these latter four regions. Human impacts tend to homogenize the differences between them, although they can still be distinguished by several differential species surviving in refugia. Most species are holarctic ubiquists, although the proportion of Turkestanian Ponto-Pannonic and Daco-Podoloian steppe dweller elements is also high. European montane (Carpathian and Carpatho-Sudetian) and Atlanto-Mediterranean components are completely missing, just like the Illyro-Moesian species in the Lower Tisza and Körös Regions. A reciprocal behaviour of continental and subatlantic fauna groups characterizes areas 2, 3 and 4, composing the first cluster core. Also here, a lower ratio of montane Ponto-Mediterranean fauna group, and a higher preponderance of Siberian-Asian elements and steppe dwellers are typical. In the Lower Tisza Region, the proportion of Holo-Mediterranean steppe dweller components increases.

The environs of Tiszadob on the border of the Upper and Middle Tisza Regions deserve special attention, as four rivers (Takta, Sajó, Hernád and Tisza) join there. Extensive gallery forests occur along the Tisza, but not on the streamside of the three affluents. These forests are under forestry management in inundation areas. As a consequence, Central European montane elements (represented by the Carpatho-Baltic *Perforatella bidentata*) have become sporadic in their species composition. Alien synantropic slugs (*Arion hortensis, Limax maximus*) appear in gallery forests as a result of human influence.

The most serious threats for the survival of snail populations that have already established in inundation areas are clearcutting of forests, sylvicultural management and poplar plantation extensified in the past few years.

Impacts of forest management and poplar plantation

Bagiszeg in the Upper Tisza Region and Landor in the vicinity of Makó (both are protected areas) have identical malacofauna (Bába 1995). The former site has an oceanic-like climate with mild summers, while the latter is of a continental character with dry summers. Willow woods were cut down around Bagiszeg in 1969, where agricultural fields proceeded down to the forest margin. A major flood reached this area in 1970, that was followed by a *Lymantria* damage in 1973 and a stand thinning by forestry to increase timber production in 1984. At Landor, a moderate thinning took place in 1989. The influence of these events on snail assemblages was studied by following the fate of three species groups (Bába 1994). Results are shown in Fig. 3.

Despite major environmental changes, the relations of the reciprocal photophilous and sciophilous groups had not changed at Bagiszeg, where the climate is mild. The dominance of forest dwellers (F) within habitat types, and that of omnivores (O) among nutritional classes has been regenerated.

Sylvicultural management caused serious structural changes in snail assemblages at Landor, where the climate is more arid. Terrestrial eutrophication occurred as the following groups became dominant: riparian ubiquists typical of willow-poplar woods

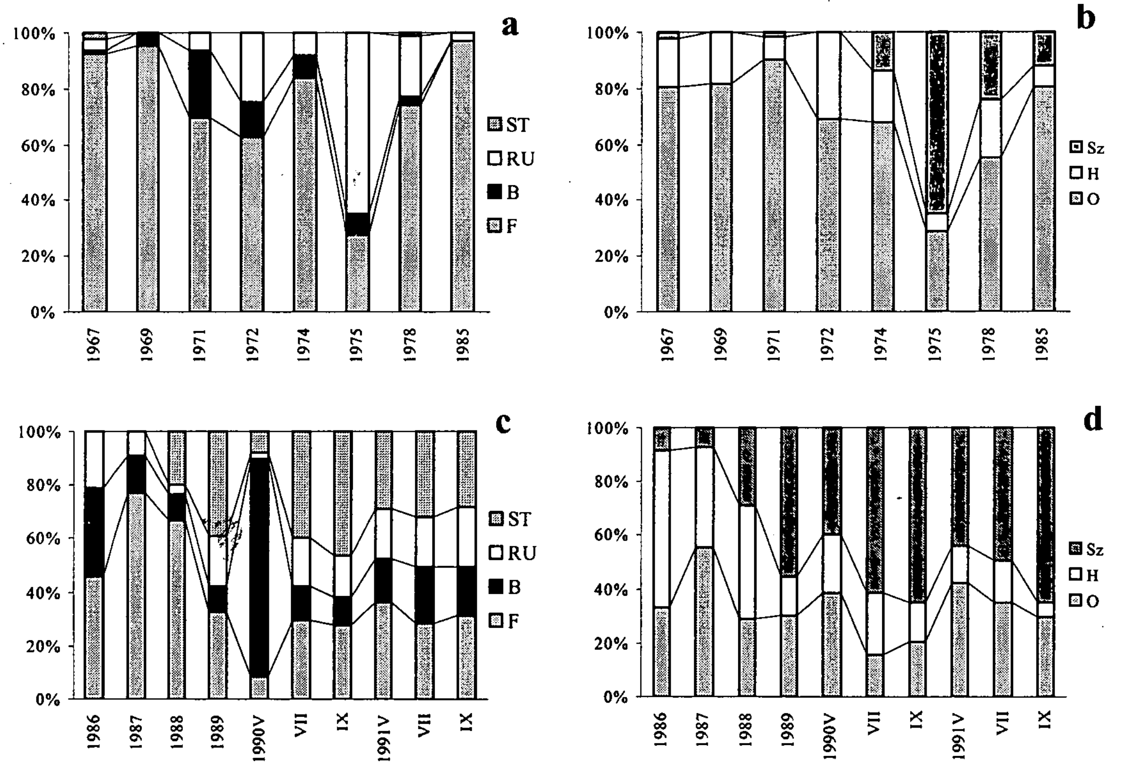

Fig. 3. Distribution of snail species among habitat types (a,c) and nutrition types (b,d) in Bagiszeg (a,b) and Landor (c,d). Habitat types. ST: steppe dweller; RU: riparian ubiquist; B: bush forest dweller; HP: hygrophilous swamp dweller. Nutritional types: SZ; saprophagous; H: herbivore; O: omnivore.

among ecological species groups, steppe dwellers (ST) among habitat types, and saprophagous species (SZ) among nutritional types.

The slow impoverishment of the fauna over the last 100 years has been crowned by the impacts of poplar plantation in wave areas that accelerated in the past few years.

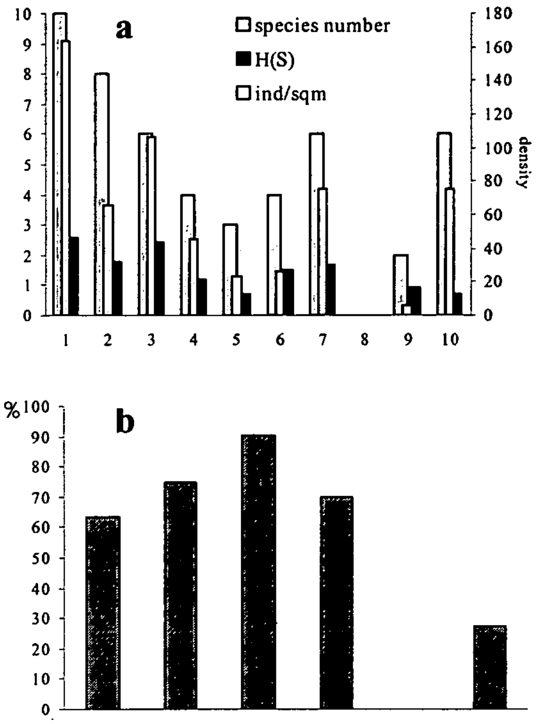

Fig. 4. Regional studies in the Middle Tisza Landscape Protection District; species number, diversity and abundance values are presented in par **a**; lower figure (**b**) shows the proportion of living individuals compared to all specimens. Number of stands: Upper Tisza 1: estuary of Szamos, 700 rkm of Tisza; 2: Tiszalök, 690 rkm; Middle Tisza 3: Kisköre, Borzanat, 403 rkm; Middle Tisza Landscape Protection District 4: *Saliceetum albae-fragilis* — Besenyszög; 5: *Saliceetum albae-fragilis* — Tiszasüly; 6: willow-locust-ash forest, Tiszasül;y; 7: *Saliceetum albae-fragilis* — Pėj; 8: oak plantation, Besenyszög; 9: old poplar plantation, oxbow lake at Kanyas; 10: Lower Tisza, Mártély.

The influence of new poplar forests was investigated within the Middle Tisza Landscape Protection District, along river reaches upstream of Szolnok, and at Algyő. In this protected landscape, the original willow-poplar woods have been turned into cultivated poplar plantations. The consequences of this intervention are reflected at the regional level in the decline of abundance, diversity and individual density, and in the higher proportion of dead specimens (Fig. 4). Collection sites 1-3 in the Upper Tisza Region, and site 10 in the Lower Tisza Valley are control plots studied in previous years.

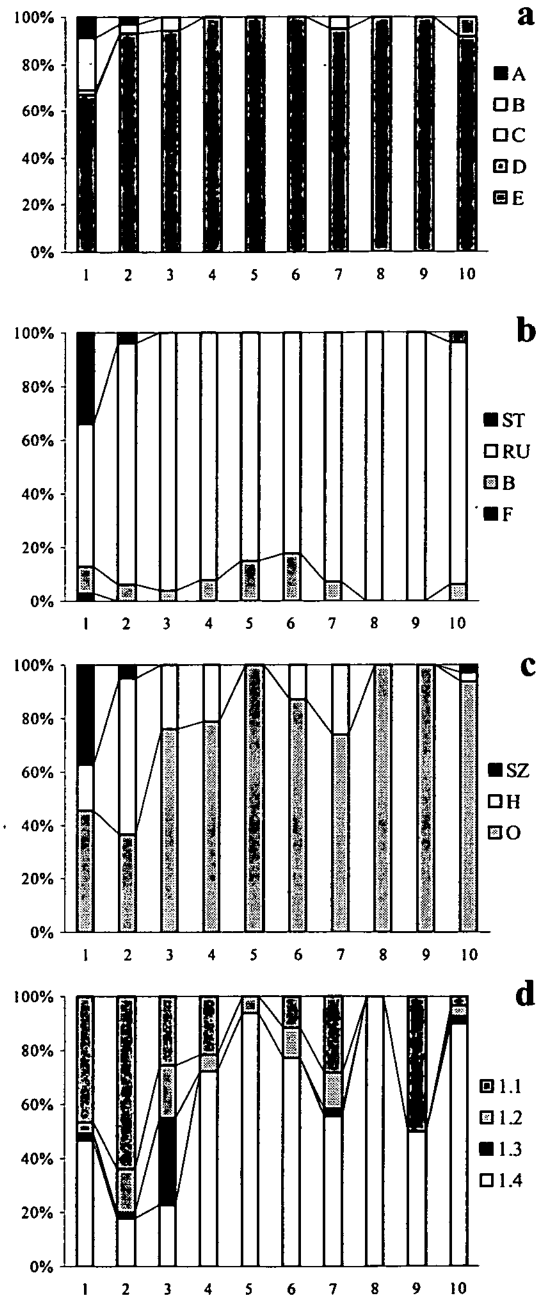

Fig. 5. Proportion of ecological groups (**a**), habitat types (**b**), nutritional types (**c**) and fauna elements (**d**). (For numbers of samplig sites see Fig. 4, and for legends of **b** and **c** see Fig.3). Ecological groups: A: sciophilous; B: swamp dweller; C: photophilous; D: species of open areas; E: riparian. Zoo-geographical classification: 1.1. East Siberian, 1.2. West Siberian, 1.3. Euro-Siberian, 1.4.

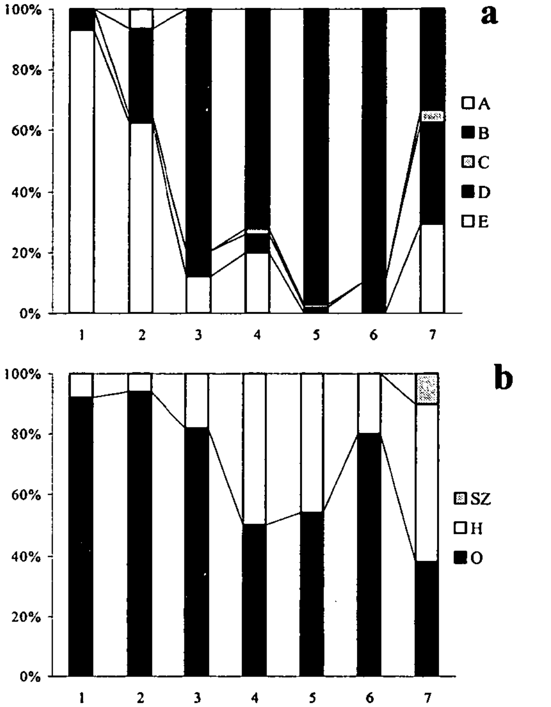

Fig. 6. Distributions of ecological species groups (**a**) and nutritional types (**b**) at Algyő in the area between riverbed and dike (for legends see Figs 3 and 5; codes of samplig sites are listed in Table 3).

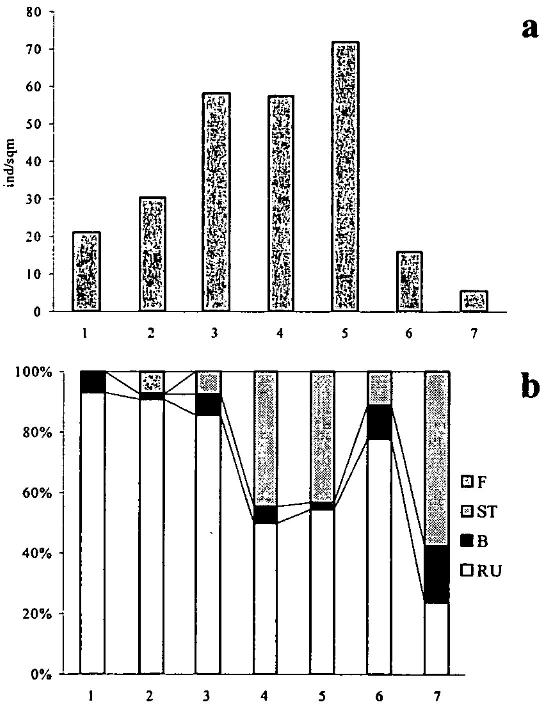

Fig. 7. Distributions of abundance (a) and habitat types (b) at Algyő in the area between riverbed and dike (for legends see Fig. 5; codes of samplig sites are listed in Table 3).

Changes in species group distributions were associated with the decrease of snail diversity (Fig. 5). Riparian ubiquist (E and RU) and omnivorous (O) snails became abundant, while in the zoogeographical composition holarctic ubiquist species (1.4) prevail.

A four-year study running from dike-foots to river margin at Algyő elucidated the role of middle-inundation area poplar plantations in the changes of the malacofauna (Table 3, Figs 6 and 7). In these figures, collection site 1 is located within a willow-polar forest at the dike, while plots 6 and 7 are from a willow thicket bordering the Tisza. Sites between these are situated within young or old poplar plantations, or in thickets common around digout pits or poplar cultivation. According to these, swamp dwellers (B) predominate among ecological species groups (Fig. 6), represented by the Holo-Mediterranean *Monacha carthusiana.* Concerning nutritional types, herbivores (H) gain a dominant role, as cultivated poplar stands and bordering thickets have a rich undergrowth.

Table 3. Proportion of species migrating from the direction of the Tisza and of the dikes at Algyő.

	1	2	3	4	5	6	7
Species migrating from the direction of the Tisza							
Perforatella rubiginosa		1				1	
Cochlicopa lubrica	1					1	
Succinella oblinga	1	7					
Succinea putris	1	1	15	9	1	28	2
Zonitoides nitidus		15	3				4
Σ	3	24	18	9	1	29	6
%	75	89	39	31	4	80	86
Species migrating from the direction of the dike							
Limax maximus	1	1					1
Monacha carthausiana		1	24	15	9	5	
Cepaea vindobonensis			4	3	18	1	
Vallonia costata		1					
Helix pomatia				2	1	1	
Σ	1	3	28	20	28	7	1
%	25	11	61	69	96	20	14

1. *Salicetum albae-fragilis*; **2.** aged poplar forest; **3.** young poplar forest; **4.** digout pit; **5.** *Amorpha* scrub; **6.** willow-poplar wood with *Urtica*; **7.** *Salicetum triandrae.*

The distribution of abundance (ind/m^2) values shows that few species occur with relatively high abundance in flood areas under human influence (Fig. 7). Among habitat types, steppe dweller species (ST) dominate in the altered vegetation. Their dispersal into inundation areas is enhanced by thickets along forest openings and alleys. Species migrating from direction of the Tisza and of the dike behave in a reciprocal way, as it appears in Table 3. Steppe dweller species can even reach the river.

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