# Spatial Distribution of Phytophilous Macroinvertebrates in a Side Arm of the Middle Danube River

*Nikolett Tarjányi, Árpád Berczik*

Danube Research Institute, Centre for Ecological Research, Hungarian Academy of Sciences
H-2163 Vácrátót/Hungary; E-mails: tarjanyi.nikolett@okologia.mta.hu, berczik.arpad@okologia.mta.hu

**Abstract:** The spatio-temporally diverse and variable hydro-ecological conditions of rivers and their floodplains determine the living conditions and thus the dynamic changes of the organism assemblages. The Gemenc and Béda-Karapancsa floodplains of the Danube River (rkm 1497-1433) part of the Duna-Dráva National Park (Hungary), represent an exceptional example of river-floodplain systems in Europe with meanders, oxbow lakes, marshlands and extended hardwood forests (25 000 ha). These floodplains are also a Natura 2000 area and Unesco Biosphere Reserve Park. After the river regulations in the 19th century this area has changed. The Mocskos-Danube side arm (MDU: 3.5 km long, 60 m wide, plesiopotamon), situated in the active floodplain, became an oxbow lake after the river regulations (1890). It has a surface lateral connection with the main channel above the medium water level of the Danube River (550 cm at the gauge Mohács, rkm 1447). The water level fluctuation of the Danube River is 9 meter. Another one is the Riha Oxbow (4.5 km long, 80 m wide, paleopotamon, on the protected side). It has no connection with the main channel.

There are two very dense macrophyte stands *(Trapa natans* and *Ceratophyllum demersum,* respectively) along the MDU and Riha Oxbow. The extension of these different-size macrophyte patches and the associated phytophilous macroinvertebrates (especially mayflies, caddisflies, dragonflies) were examined. The sampling work was carried out monthly between May and October 2012 and 2013 respectively. The investigations focused on differences in the phytophilous macroinvertebrate assemblages living in different bed of macrophyte species, with different morphology, as well as on the ecotone effects and the occurrence of the phytophilous macroinvertebrates in the centre and the edge of macrophyte patches. Certain phytophilous macroinvertebrate assemblages preferred different macrophyte densities. At the same time there were differences in the individual number of macroinvertebrates between the centre and edge of macrophyte patches.

**Keywords:** Large river, floodplain, macrophyte assemblages, phytophilous macroinvertebrates

## Introduction

Wetlands play an important role in the conservation of biodiversity, because of their high species richness (Bis, Palm 1990, Décamps 1996, Tockner, Bretschko 1996, Shiel *et al.* 1998, Ward 1998, Garcia, Laville 2001, Tockner, Stanford 2002) and habitat diversity (Ward *et al.* 1999). That is why backwaters are the major source of the potamal sections of rivers and the overall diversity. In addition, species richness correlated positively with the degree of connectivity between the main channel and the backwaters (Gepp *et al.* 1985, Tockner *et al.* 1998,1999).

Floodplains create a complex gradient between the river channel and the uplands. They form a variety of ecotones between land and water (littoral zone), surface water bodies and groundwater aquifers, and also between different stands of vegetation. All of these create a high level of environmen-

tal heterogeneity across the alluvial riverine land-scapes (Ward *et al.* 1999).

Generally, these backwaters are covered with highly diverse structures of macrophyte vegetation during the main growing season. Emerged, sub-merged and free-floating types provide suitable refuge for macroinvertebrates. Different types of macrophyte structure explain some of the variati-on in the abundance of epiphytic macroinvertebra-tes, with macrophytes with finely dissected leaves supporting more organisms than plants with broa-der, undissected leaves (Gerrish, Bristow 1979, Cattaneo *et al.* 1998, Cheruvelil *et al.* 2000, 2002, Feldman 2001, Bogut *et al.* 2007, Árva *et al.* 2009, Hansen *et al.* 2010).

Macroinvertebrates form an important com-ponent of shallow lakes and floodplain ecosys-tems. They are important as detritus decomposers (McQueen *et al.* 1986), as well as a food source for fish (Keast 1985) and birds (Batzer *et al.* 1993). Macroinvertebrates occur among submerged plants, and in the sediment. They are mostly epiphyton grazers (Cyr, Downing 1988, Vermaat 1994), but some of them are shredders, collectors and preda-tors. The species composition and structure, the biomass and the seasonal duration of the aquatic vegetation determine the composition of macroin-vertebrate assemblages (Lodge 1985, Rooke 1984, Kornij´ow 1989).

The essential aim of our study was to ana-lyse the effects of lateral connectivity on the yearly changes of macroinvertebrate communities. The results discussed below underline the importance of contrasting studies carried out in the Mocskos-Danube, which is situated on the active floodplain, with those of the Riha Oxbow, which lies in the protected area, without a direct influence from the Danube River.

# Material and Methods

The fieldwork was carried out from May 2012 to October 2013 (monthly regularity in the main grow-ing season) at two different oxbow lakes. One of them was situated on the active side, while the other – on the protected side of the floodplain**.**

## Studied sites

The Mocskos-Danube side arm is situated on the active side of the floodplain (Béda-Karapancsa,

Landscape Protection Area of the Duna-Dráva National Park, Hungary, at gauge of Mohács, rkm 1447). This oxbow is a about 3.5 km long and 60 m wide. The Mocskos-Danube is a plesiopotamon, it has a temporary connection with the Danube River (with the water flowing at 700 cm at the upper end and at 550 cm at the lower end of the Mocskos).

The other study site is the Riha Oxbow, about 4.5 km long and 80 m wide, which is located on the protected side. Riha Oxbow has no connection with the main channel, this is a paleopotamon.

In the main growing season, there are diversi-fied macrophytes in the oxbows. The average water depth is 1.5 m out of flow period in the Mocskos, and approximately 1-1.5 m in the Riha Oxbow. Both of them are strictly protected nature reserve areas.

## Sampling technique

We needed a suitable quantitative technique, so that the different macrophyte densities and structures could be compared.

Two different structures of macrophyte were investigated: a submersed structure: *Ceratophyllum demersum,* and an emerged structure: *Trapa natans* (European water chestnut). We used a hand net for sampling (D-frame, 500 μm). At all sampling sites, approx. 5 dm³ of the plant was pulled out by the net. We sampled the centre and the edges of every macrophyte patch three times. In the *T. natans* beds, three categories of density were distinguished: 1) water surface larger than vegetation surface per unit area; 2) vegetation surface larger than water surface per unit area; 3) complete macrophyte coverage. The *C. demersum* stands of this oxbow were studied in 2012 and 2013, similarly to those of the Mocskos-Danube.

We applied hand netting in the macrophyte patches and at the shoreline in order to explore the fauna thoroughly.

The collected macrophyte samples were washed in the laboratory, then the macroinvertebrates were sorted and identified to the lowest possible level. The wet and dry masses of the macrophytes (60°, 24h) were determined.

## Statistical evaluation

For the evaluation of the distribution of macroinver-tebrates in the three density categories of *T. natans* and in the centre and edges of the two different vege-tation stands (*T. natans* and *C. demersum*) a Principal
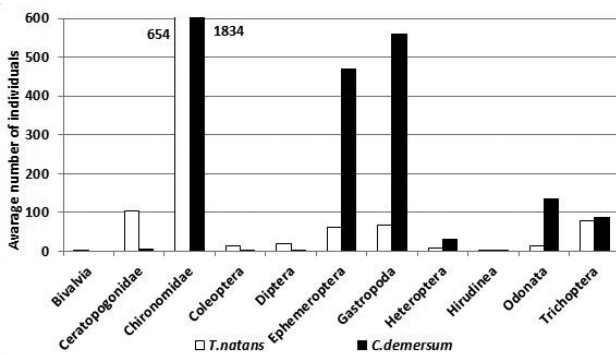
**Fig. 1.** Average number and distribution of macroinvertebrate individuals identified so far

Component Analysis (PCA) was carried out with the SYN-TAX 2000 software (PODANI 2001).

## Results and Discussion

We have studied two of the vegetation types which are abundant and typical of the Danube River backwaters (emerged, floating *T. natans* and submerged *C. demersum*). While in 2012 *T. natans* formed large stands in the Mocskos-Danube, in 2013 *Ceratophyllum* was the dominant species.

The 17 000 specimens sorted so far belonged to 2 families, 1 suborder, 5 orders, 1 subclass, and 2 classes (KRISKA 2008). The most abundant taxa were Gastropoda (snails), Ephemeroptera (mayflies) and Chironomidae (chironomids) (2488 ind./unit) (Fig. 1). Species-level identification of specimens is in progress.

The abundance of the studied macroinvertebrate taxa in the three density categories of *T. natans* stands varied significantly. The orders Ephemeroptera and Trichoptera were more abundant in the less dense stands (density category 1) of European water chestnut. In these stands, water flows easily and sunlight can penetrate the vegetation, thus creating a favourable environment for benthic grazers and collectors. According to CATTANEO *et al.* (1998), vegetation density is an important factor for the epiphytic fauna, since as the stand gets denser, light availability is limited and water flows slower, which is unfavourable for this community. Dragonfly larvae, owing to their hunting life form, tend to be more abundant in the dense, continuous *T. natans* patches (Fig. 2). For this group, the slower water flow of the dense, packed stands is more favourable. On the other hand, FELDMAN's study (2001) stated that better light availability improves predatory effectiveness (FELDMAN 2001).

Beside the effects of various densities, the edges and centres of single vegetation patches also create different life conditions. In the stands of *T. natans*, caddisflies and mayflies were more abundant at the edges, while dragonflies in the central parts of the patch. No such distinction in the abundance of the taxa Gastropoda and Chironomidae could be shown. The average abundance was not influenced by the edge effect. This is contradictory to the results of STRAYER *et al.* (2003), who found higher average abundance in the centre of a stand than at its edges, in the case of *Trapa* stands.

In the stands of *C. demersum*, which have a more complex structure (and run by the reeds surrounding the Riha Oxbow in a 5 to 10 m wide band), the average abundance between the centre and the edges of the patches tended to have a similar distribution: snails, chironomids and caddisflies are more abundant at the edges, while larger numbers of mayflies and dragonflies can be found at the centre. In the case of *Ceratophyllum* stands, the average total abundance of the 5 taxa also varied more between the edges and the centre of the stands: at the edges, three times more specimens could be found (Fig 3). Snails, as grazers, find less food in the middle of the very thick *C. demersum* patches, because of the higher shadiness.

Our results showed that the abundance of macroinvertebrates was smaller in *Trapa* stands. A possible reason for this is the lesser architectural complexity of this plant (CATTANEO *et al.* 1998, TESSIER *et al.* 2004), and the anoxic conditions that developed under continuous water chestnut cover (CARACO, COLE 2002). Various architectural complexities may account for the differences of abundance and species richness of macroinvertebrate communities living on the plants, as plants with dissected leaves support larger and richer communities than the ones with simple, undissected leaves (KRECKER 1939, GARRISH, BRISTOW 1979, CHERUVELIL *et al.* 2000, 2002, FELDMAN 2001, BOGUT *et al.* 2007, ÁRVA *et al.* 2009, HANSEN *et al.* 2010). Although CYR, DOWNING (1988b) did not show a clear relation between community species richness and architectural complexity, they found that epiphytic macroinvertebrate abundance per unit of plant biomass varied between different plant species; however, there was no direct connection with the complexity of the plant.
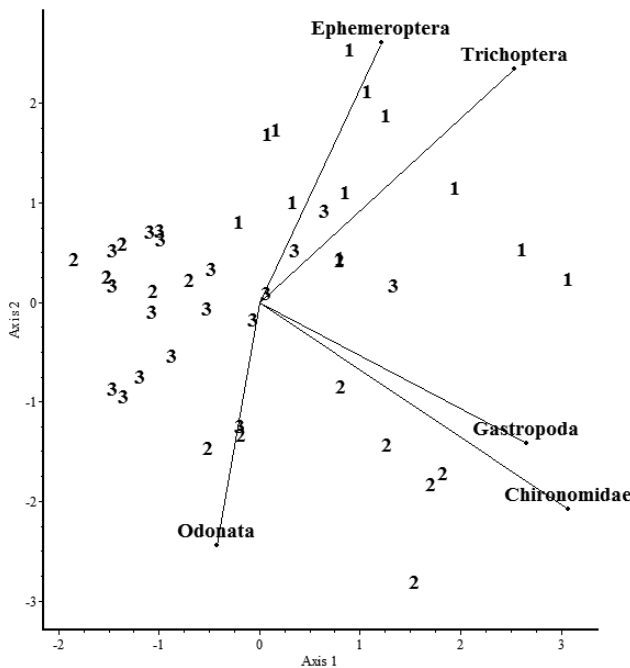
15

**Fig. 2.** Distribution of macroinvertebrate communities in different density categories of *T. natans*
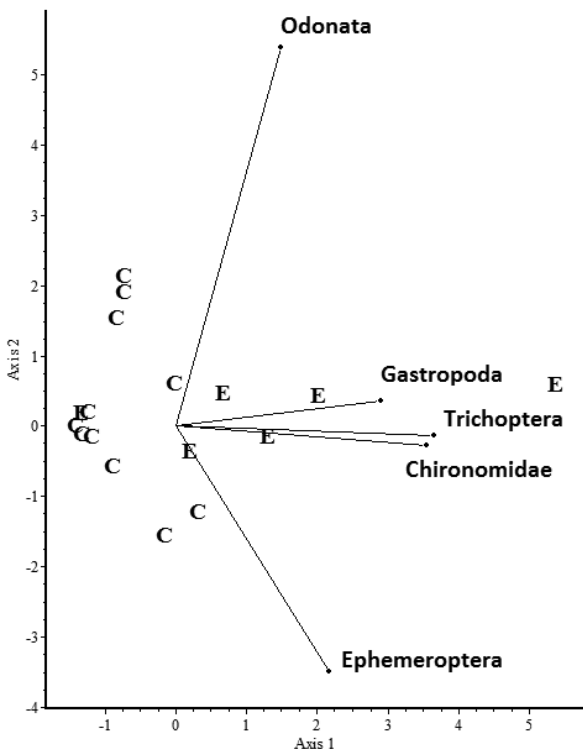


**Fig. 3.** Position of macroinvertebrate taxa in *C. demersum* stands (C: centre, E: edge)

Only in the group of undissected leaved plants they found significant differences, but not between two species of pondweed with different morphology (*C. demersum*, *Utricularia* sp. and *Potamogeton* sp., *Vallisneria americana*). CATTANEO *et al.* (1998) also examined the communities of the two pondweeds with varying morphology, and found a significant difference in abundance, but not in species richness or diversity. FELDMAN (2001) also showed that *V. americana* (wild celery, rooted, submerged) hosted more epiphytic macroinvertebrates than the floating *T. natans* (emergent, free-floating leaves). However, STRAYER *et al.* (2003) arrived at the opposing results in the case of *Vallisneria* and *Trapa*.

## Conclusions

The water of the Mocskos-Danube plesiopotamon only rarely flows (1-5 times per year), and this take place only for short periods at a time (gauge of Mohács 550 cm). Thus, during the long, undisturbed periods, the development of diverse macrovegetation is possible. The significant morphological differences of pondweeds fundamentally determined the composition of their macroinvertebrate communities. In large *T. natans* stands, the distribution of macroinvertebrate taxa typically differed among the various density patches, depending on the amount of epiphyton, which was in turn influenced by the penetration of sunlight and the velocity of the flowing water. Average abundance was always larger in the marginal band of the vegetation patch than in the middle, especially in stands of *C. demersum* (3:1). Habitat diversity was clearly greater in *C. demersum* stands, the structure of which was denser. The lower average species numbers detected in the connecting *T. natans* patches might be due to their anoxic environment, the lesser complexity of the plant and the inhibition of sunlight penetration.

## References

Árva D., M. Tóth and Gy. Dévai 2009. Növényzethez kötődő árvaszúnyog-együttesek (Diptera: Chironomidae) tér- és időbeli változásai a Boroszló-kerti-Holt-Tisza hínárállományaiban [Spatio-temporal changes of phytal-dwelling chironomid assemblages (Diptera: Chironomidae) in submerged vegetation of the backwater Boroszló-kerti-Holt-Tisza]. – *Acta Biologica Debrecina Suppl. Oecologica Hungarica,* **20**: 9-20. (In Hungarian).

Batzer D. P., M. McGee, V. H. Resh and R. R. Smith 1993. Characteristics of invertebrates consumed bymallards and prey response to wetland flooding schedules. – *Wetlands,* **13**: 41-49.

Bis R., K. Palm. 1990. Das Taubergiessengebiet-Besiedlung eines vielfältigen Gewässersystems. – *Limnologie aktuell,* **1**: 427-434.

Bogut I., J. Vidakovi´c, G. Palijan and D. Čerba 2007. Benthic macroinvertebrates associated with four species of macrophytes. – *Biologia Bratislava,* **62** (5): 600-606.

Caraco N. F., J. J. Cole 2002. Contrasting impacts of a native and alien macrophyte on dissolved oxygen in a large river. – *Ecological Applications*, **12**: 1496-1509.

Cattaneo A., G. Galanti, S. Gentinetta and S. Romo. 1998. Epiphytic algae and macroinvertebrates on submerged and floating-leaved macrophytes in an Italian lake. – *Freshwater Biol.*, **39**: 725-740.

Cheruvelil K. S., P. A. Soranno and R. D. Serbin 2000. Macroinvertebrates associated with submerged macrophytes: sample size and power to detect effects. – *Hydrobiologia*, **441**: 133-139.

Cheruvelil K. S., P. A. Sorrano 2002. Plant architecture and epiphytic macroinvertebrate communities: the role of an exotic dissected macrophyte. – *J. North Am. Benthol. Soc.,* **21**: 261-277.

Cyr H., J. A. Downing 1988. The abundance of phytophilous invertebrates on different species of submerged macrophytes. – *Freshwater Biology*, **20**: 365-374.

Décamps H. 1996. The renewal of floodplain forests along rivers: a landscape perspective. – *Verh. Int. Ver. Limnol.,* **26**: 35-59.

Feldman R. S. 2001. Taxonomic and size structures of phytophilous macroinvertebrate communities in *Vallisneria* and *Trapa* beds of the Hudson River, New York. – *Hydrobiologia*, **452**: 253-245.

Garcia X. F., H. Laville. 2001. Importance of floodplain waters for the conservation of chironomid (Diptera) biodiversity in a 6th order section of the Garonne river (France). – *Annal. de Limnol.,* **37**: 35-47.

Gepp J., N. Baumann, E. P. Kausch and W. Lazowski. 1985. Auengewässer als Ökozellen. Grüne Reihe des Bundesministeriums für Gesundheit und Umweltschutz, **4**: 337.

Gerrish N., J. M. Bristow. 1979. Macrionvertebrate associatons with aquatic macrophytes and artifical substrates. – *Internat. Assoc. Great Lakes Res.,* **5** (1): 69-72.

Hansen J. P., J. Sagerman and S. A. Wikstrom. 2010. Effects of plant morphology on small-scale distribution of invertebrates. – *Mar. Biol.,* **157**: 2143-2155.

Keast A. 1985. Planktivory in a littoral-dwelling lake fish association: prey selection and seasonality. – *Can. J. Zool.* **62**: 1289-1303.

Kornij´ow R. 1989. Seasonal changes in the macrofauna living on submerged plants in two lakes of different trophy. – *Arch. Hydrobiol.,* **117**: 49-60.

Krecker F. H. 1939. A comparative study of the animal population of certain submerged aquatic plants. – *Ecology,* **20** (4): 553-562.

Kriska Gy. 2008. Freshwate rinvertebrates – Identification key. [In Hung.: Édesvízi gerinctelen állatok – határozó] – Nemzeti Tankönyvkiadó, Budapest 268 pp.

Lodge D. M. 1985. Macrophyte gastropod associations: observations and experiments on macrophyte choice by gastropods. – *Freshwat. Biol.,* **15**: 695-708.

McQueen D., J. R. Post and E. L. Mills. 1986. Trophic relations in freshwater pelagic ecosystems. – *Can. J. Fish. Aquat. Sci.,* **43**: 1571-1581.

Podani J. 2001. SYN-TAX 2000. Computer Program for Data Analysis in Ecology and Systematics. ScientiaKiadó, Budapest, 53 pp.

Rooke B. 1984. The invertebrate fauna of four macrophytes in a lotic system. – *Freshwat. Biol.,* **14**: 507-513.

Shiel R. J., J. D. Green and D. L. Nielsen. 1998. Floodplain biodiversity: why are there so many species? – *Hydrobiologia,* **387/388**: 39-46.

Strayer D. L., C. Lutz, H. M. Malcolm, K. Munger and W. H Shaw 2003. Invertebrate communities associated with a native (*Vallisneria americana*) and an alien (*Trapa natans*) macrophyte in a large river. – *Freshwater Biology,* **48**: 1938-1949.

Tessier C., A. Cattaneo, B. Pinel-Alloul, G. Galanti and G. Morabito 2004. Biomass, composition and size structure of invertebrate communities associated to different types of aquatic vegetation during summer in Lago di Candia (Italy). – *J. Limnol.,* **63**: 190-198.

Tockner K., F. Schiemer and J.V. Ward. 1998. Conservation by restoration: the management concept for a river-floodplain system on the Danube River in Austria. – *Aquatic Conservation,* **8**: 71-86.

Tockner K., F. Schiemer, C. Baumgartner, G. Kum, Z. Weigand, I. Zweimüller and J. V. Ward. 1999. The Danube restoration project: species diversity patterns across connectivity gradients in the floodplain system. – *Regul. Rivers: Res. Mgmt.,* **15**: 245-258.

Tockner K., J. A. Stanford. 2002. Riverine floodplains: present state and future trends. – *Environmental Conservation,* **29** (3): 308-330.

Tockner K., G. Bretschko. 1996. Spatial distribution of particulate organic matter (POM) and benthic invertebrates in a river-floodplain transect (Danube, Austria): importance of hydrological connectivity. – *Arch. für Hydrobiol. Suppl.,* **115**: 11-27.

Vermaat J. 1994. Periphyton removal by freshwater micrograzers. In: Van Viersen W., M. Hootsmans and J. Vermaat (eds.), Lake Veluwe, a macrophyte-dominated system under eutrophication stress, Kluwer Academic Publishers, Dordrecht, 213-249.

Ward J. V., K. Tockner and F. Schiemer 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity. – *Regulated Rivers: Research and Management*, **15**: 125-139.

Ward J.V. 1998. Riverine landscapes: biodiversity patterns, disturbance regimes, and aquatic conservations. – *Biological Conservation,* **83** (3): 269-278.