

Invasive algae, plant, bivalve and crustacean species along the Hungarian Danube section: arrival time, colonisation characteristics, relative importance

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Introduction

Invasions are one of the most important – and greatly human-facilitated – aspects of modern ecology. They includes many aquatic and water-bound taxa and a high number of these biological processes also have other, e.g. economic relevance such as in the case of the spread of muskrats from the initial locus of introduction to many European countries (Lochwood et al. 2007). As biological invasions are often human-mediated processes several aspects are especially important to study such as transport vectors and pathways, trends in numbers of invaders and their relationship with human activities, biotic interactions between native and non-native species and their different biological ways (e.g. competition, predation, mutualism). For practical reasons other aspects are also relevant to deal with such as invasion prediction, risk assessment and management.

The River Danube is a main aquatic corridor in Europe. Its importance increased even further with the opening of the Main-Danube canal providing connection also to the River Rhine. The Hungarian Danube Research Station of the Institute of Ecology and Botany of the Hungarian Academy of Sciences monitors biodiversity changes by more than half a century. This paper introduces invasive algae, plants, bivalves and crustaceans along the 417 km Hungarian stretch of the River Danube.

Site and methods

Sampling sites included the complete Hungarian Danube stretch, in some cases additional waters, such as the River Ipoly were also investigated. The presence or abundance of invasive species were detected and determined by standard methods appropriate for the given group.

Results

Results are discussed according to the taxonomical categorisation of the species.

Algae

Didymosphenia geminata is a large, easily-recognisable algae found at several sites in the Hungarian Danube section. It is spreading in Europe and considered to be invasive in meso-eutrophic lowland waters (Érces 2002, Kawecka & Sanecki 2003), where it can reach an abundance that makes the use of running waters impossible for drinking or industrial purpose. On the other hand, however, it is declining in its original, oligotrophic mountain habitats that emphasize its Red List status in that environment (Krammer & Lange-Bertalot 1986). This difference might indicate genetical changes, the development of a new ecotype adapted to increasing pollution and higher nutrient availability or the lack of knowledge finding the common key characteristics of the habitats it exists. *Diadetsmia (Navicula) confervacea* is considered to be an invasive tropical species indicating the warming up of European running waters (Coste & Ector 2000). Earlier it had mainly been present in glasshouses in Europe but recently it has been detected in several streams and power plant cooling water canals in

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France, Germany, Great Britain and Slovakia (Ector et al. 2001). In Hungary it is known from the Laskó and Rákos streams, where it can reach high relative abundance. A new record of the species is from the River Ipoly, a tributary of the River Danube, in 2007 both at Ipolytarnóc and Letkés with a 0.25% and 2% relative abundance, respectively. In earlier investigations, e.g. in the 2005 ECOSURV survey (van Dam et al. 2005), it was missing from both sites.

Macrophytes

Several invasive alien macrophyte species exist along the Hungarian Danube stretch. *Elodea canadensis* (Canadian waterweed) is known from 1870 (Hungary), mostly from the western, Transdanubian parts of the country. However, recently it has also been found in other areas east to the River Danube even as far east to the River Tisza. Along the Danube it is present in the Szigetköz Region in the westernmost part of the investigated stretch but it also became predominant in the Szeremlei-Danube, a side arm in the Gemenc region approximately 350 km downstream in 2003 (Steták 2003). Another *Elodea* species, *E. nuttallii* was discovered in the Forrásos-ág at Cikolasziget, in the Szigetköz Region (Ráth 1992), where it gradually spread into several branches. According to our present knowledge both species have the ability to outcompete indigenous species by developing dense stands. A similar distribution pattern is characteristic for *Azolla* spp. *Azolla filiculoides* was first detected in Central-Europe in the 1880s, but it was only found along the studied reach of the Danube at Kis-Rezéti (Fás-)Duna in the Gemenc Region in 1998 (Fehér & Schmidt 1998). By today, records on its presence are available from several sites south to Paks including the Kis-Rezéti(-Fás)-Duna, Cserta-Duna, Szeremlei-Duna (Baja) and Bezerédy-Duna (Dunafalva). Lately, *Azolla mexicana* was also found in the backwater of the Solti-Danube in the Gemenc floodplain (Steták 2006). A further alien species, native for the southeast USA is *Cabomba caroliniana*. Besides invading thermal waters at Hévíz, Eger and Miskolctapolca, it is also present in the Danube-Tisza canal since 1995 (Steták 2004) and it can also be found in the Gemenc floodplain (Janauer & Steták 2003), where it was first discovered at Vajas-torok but it is known to exist in other canals and in the Danube floodplain as well (2000).

Bivalvia

In the Hungarian Danube section 4 invasive mussel species can be found: *Corbicula fluminea*, *Corbicula fluminalis*, *Dreissena polymorpha* and *Sinanodonta woodiana*, which represents 15% of the mussel fauna. These non-indigenous species compete with native mussel species and are thought to reduce their abundance, population densities and may be responsible for the extinction of some species. *Corbicula* species (Bivalvia, Corbiculidae) are inhabitants of freshwater and estuarine habitats in South Asia, the Indian subcontinent, Australia and Pacific Islands, where they form an important component of benthic communities in both lentic and lotic environment (Morton 1977). In the late 1970s both *C. fluminea* and *C. fluminalis* were introduced to Europe, and *C. fluminea* spread across France, Portugal, Spain, Germany, Belgium and Netherlands (McMahon 1999). The genus *Corbicula* was first detected in Hungary in the Vén-Duna at Baja in June, 1999 (Csányi 1998-99). Until now *C. fluminalis* was not detected upstream the confluence of the warm water outlet of the Paks Nuclear Power Plant in Hungary. On the other hand, *C. fluminea* spread throughout the River Danube and it has already appeared in the active alluvial floodplains of the Szigetköz Region as well. Due to its rapid expansion, it is one of the most abundant mussel species in the Hungarian Danube section, its density can reach 736 ind. m⁻² in the Danube Bend above Budapest (Bódis 2007). *Dreissena polymorpha*, native to the Baltic and Black Seas, is one of the most successful invaders present in Hungary since 1867 (Tittizer 2006). Today, it is a common and often dominant element of the native benthic fauna, which can affect all components of the freshwater ecosystem and cause unprecedented bio-fouling problems in freshwater-based industrial facilities such as the nuclear power plant at Paks. *Sinanodonta woodiana* is a

representative of the Unionidae family, with populations distributed both in East and South-East Asia. It was accidentally introduced to Europe, and was first recorded in Hungary in 1984 from material collected in 1980 (Popa et al. 2007).

Crustacea

Amphipods (Crustacea, Amphipoda) are a group of primary significance among invasive species in Europe. Six non-indigenous amphipod species have established in Hungary so far, all of them originated from the Ponto-Caspian region. Four species, *Dikerogammarus haemobaphes*, *D. villosus*, *Echinogammarus ischnus* and *Chelicorophium curvispinum* are early immigrants, their first records date back to the first thorough faunistic surveys of the Hungarian Danube stretch (Dudich 1927, Unger, 1918), so their arrival date is rather uncertain. The status of the third *Dikerogammarus* species, *D. bispinosus* is even more problematic because it had long been regarded as a subspecies of *D. villosus*. The sixth species, *Obesogammarus obesus* Sars, 1894 was first reported in Hungary in the early 1990s (Nesemann et al. 1995). Isopods (Crustacea, Isopoda) are represented by one non-indigenous aquatic species, *Jaera istri*. Except for the recently arrived *O. obesus*, all these crustacean species are widely distributed in the main rivers of Hungary. The number of mysid (Crustacea, Mysida) species occurring along the Hungarian Danube stretch has risen to three in this decade owing to the invasion of *Katamysis warpachowskyi* and *Hemimysis anomala* joining the earlier invader *Limnomysis benedeni*, which was first recorded as early as in 1946 in the Lágymányosi-öböl, a bay in the southern part of Budapest (Woynárovich 1954). Since then, it has spread all over the main rivers and connected waters (e.g. oxbows) in Hungary. The invasion of *Katamysis warpachowskyi* was largely unexpected because no range expansions were documented in this area before and, unlike some other species, it has not been involved in deliberate introductions, either (Wittmann, 2002). Until now it has been found only in the River Danube and adjacent riparian oxbows, where it reached high densities especially in the Szigetköz Region (Borza, 2007). The latest invader, *Hemimysis anomala* G. O. Sars, 1907 was first described for Hungary in 2005 (Wittmann, 2007) but later it was also found in samples in the faunistic collection of the Hungarian Danube Research Station from 2004 (Borza, 2008). Decapods (Crustacea, Decapoda) are an important invasive crustacean group also due to their size and potential to basically influence the communities they live in. Two species are present in the River Danube, *Orconectes limosus* and *Eriocheir sinensis* (Puky et al. 2005). *O. limosus* is a North American crayfish species native to the eastern part of the continent. In natural waters the first individuals were recorded in 1985 in a large secondary branch of the River Danube at Budapest in Hungary (Thuránszky & Forró 1987). Colonising new areas downstream with a 13-16 km yr⁻¹, by 2001 it was also recorded from the Danube at the southern border of the country (Puky & Schád 2006a, 2006b) and in 2007 and 2008 it was also repeatedly found from the River Tisza and its effluents (Sallai & Puky 2008). This species is a main potential vector of *Aphanomyces astaci*, which was also proved by recent (1998-99 and 2004) outbreaks of crayfish plague in smaller brooks and rivers in the Czech Republic (Kozubiková et al. 2005). In large rivers, however, where the habitat diversity, discharge and current velocity is high and crayfish density is low, native species can still coexist with *O. limosus* (Pöckl & Pekny 2002), what is also proved by occasional records of *Astacus astacus* in the Danube at Paks in the 2000s. *E. sinensis*, native to Eastern Asia, has been recorded from the Hungarian stretch of the River Danube three times in the last decade (2006a). As it is a catadromous species, rapid increase in its numbers is not expected in recent years in spite of its remarkable speed (Herborg et al. 2003).

Table 1. Characteristics of invasive or potentially invasive species from four aquatic groups along the Hungarian stretch of the River Danube

	Continent of origin	Arrival	Deliberate introduction	Area expansion in the last decade	Dominance in communities
Algae	Tropics	1894	No	Yes	No
Aquatic plants	America	1870 - 1995	(Yes)	Yes	Yes
Bivalves	Asia	1867 - 1999	No	Yes	Yes
Crustacea	Asia, America	1918 - 2004	(Yes)	Yes	Yes

Summary

The status of invasive and potentially invasive species of the Hungarian Danube stretch was evaluated in four groups, algae, macrophytes, bivalves and crustaceans. With algae, potential invasive species are present in the aquatic system of the River Danube but no mass invasion occurred so far. Several invasive macrophytes were also detected, in some areas they have already become predominant. Invasive species are getting more important with bivalves, where they represent 15% of the local fauna and can reach high densities in several areas. Similarly, to that group, some alien crustacea species are also present in Hungary since the XIXth century, but their colonisation accelerated at the end of the 1990s and 2000s. They can become predominant or might even be the only representatives of their group along the Hungarian Danube section. The invasion of the above described species and several others basically alters the structure, dynamics and functioning of Danubian ecosystems. Due to the international importance of this process intensive co-operation is necessary to describe and mitigate the negative impacts of alien species along the Danube.

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