Faunistic and taxonomic investigation of Ponto-Caspian higher crustaceans (Crustacea: Malacostraca: Mysida, Amphipoda, Isopoda) in the River Danube water system

Booklet of the theses

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Introduction

The Ponto-Caspian region (comprising the Black, Azov, and Caspian Sea basins) is the most prominent source of aquatic invasive species in the North-Atlantic range. The explanation of the invasion success of the species endemic to this area lies in the geologic past: the salinity of the basins fluctuated widely in the neozoic era, promoting the evolution of euryhaline species, tolerating the brackish water of the seas as well as the freshwater of the rivers flowing into them. These species occur in the lower courses of these rivers natively; however, the developed commercial shipping, the river regulation measures, and the interconnection of isolated catchments allowed some of them to expand their ranges to formerly unattainable areas. Several taxonomic groups are represented among the invasive Ponto-Caspian species from cnidarians to fish, but peracarid crustaceans are eminent in terms of both species number and ecological impact.

Information on the Ponto-Caspian crustacean fauna in Hungary is not sufficient. In the first half of the 20th century several significant events of faunistic concern took place; however, the scientific attention devoted to this group cannot be regarded as sufficient, for the publications were based on a rather sporadic and incidental sampling. In the following decades only the results a few surveys have been published, then from the 1980s the debates revolving around the Gabcikovo dam brought biodiversity in the spotlight. The monitoring programmes commenced in this period provided large amounts of faunistic data, although requiring revision in certain cases.

Recently resolved and still undecided taxonomic questions also give currency to the investigation of Ponto-Caspian peracarids, of which here I highlight two issues. (1) Recently, a new isopod species has been described from the Slovak section of the River Danube, *Jaera danubica* Brtek, 2003. The species does not differ from the well-known *J. sarsi* Valkanov, 1936 regarding the most important identification feature of the genus, the male praeoperculum. The main attribute distinguishing it from *J. sarsi* is the shape of its body; in contrast to the oval contour of *J. sarsi*, the body of *J. danubica* is asymmetric, the posterior half being broader than the anterior one. The majority of isopod crustaceans have a special, biphasic moulting mechanism, during which the cuticle of posterior half of the body is shed first, followed by the anterior part after a while. Since this mechanism can be assumed to have implications on the body contour of the animals, I deemed a reassessment of the validity of *J. danubica* necessary. (2) The validity of *Chelicorophium sowinskyi* (Martynov, 1924)

(Amphipoda: Corophiidae) has been confirmed recently; however, due to its formerly controversial status it has very few reliable distributional data, making the revision of available recent and archive corophiid materials especially timely.

Aims

- Clarifying controversial taxonomic questions, if possible.
- Revealing the longitudinal distribution of the species in the River Danube based on the material of the „Joint Danube Survey 2”.
- Revealing the current distribution of the species in Hungary, documenting their range expansions, revising available archive materials.
- Investigating the possibility of spread by fish stocking (set as an additional goal based on the finding of mysids in fishing ponds)

Material and methods

To address the status of *J. danubica,* I studied the *Jaera* material of the Danube Research Institute of the Hungarian Academy of Sciences, and I also collected living specimens from the River Danube at Göd (river km 1668) on 19 October 2010. Among about 200–300 animals a single individual showing the characteristic body contour was found. It was photographed and placed into a Petri dish with Danube water and a piece of a decaying leaf as food source. It was photographed again after 21 hours.

The faunistic investigations were based on (1) my own sampling, (2) the material of the longitudinal Danube expedition (Joint Danube Survey 2, 2007) organized by the International Commission for the Protection of the Danube River (ICPDR), (3) the collection of the Danube Research Institute, (4) the Collection of Crustacea and Other Aquatic Invertebrates of the Hungarian Natural History Museum, (5) the surveys of certain Regional Inspectorates for Environment, Nature, and Water, and (6) the samples collected by Zsófia Horváth and Csaba Ferenc Vad in fishing ponds of the Northern Medium Mountains.

To assess whether water pumps (used by fishermen to fill fish transport tanks) can bring up mysid specimens from the littoral zone of rivers, tests were performed on 21 October 2010 in the Danube main arm at Göd with a Honda WA20 motor pump. To assess survival rates, *Limnomysis benedeni* Czerniavsky, 1882 and *Katamysis warpachowskyi* G. O. Sars, 1893 specimens collected by hand net in the winter harbour of Újpest on 5 November 2010 were transported to Göd, and let through the pump mentioned above. After the procedure the proportion of viable, actively swimming individuals was determined.

New scientific results

1. After 21 hours the difference in width between the anterior and posterior body regions of the living *Jaera* specimen vanished, proving that the specific body contour of *J. danubica* is merely a product of the biphasic moulting mechanism. In conclusion, *Jaera danubica* Brtek, 2003 should be treated as a junior synonym of *Jaera sarsi* Valkanov, 1936.
2. Based on the material of the Joint Danube Survey 2, I recorded *Chelicorophium sowinskyi* and *C. robustum* (G. O. Sars, 1895) for the first time in the German and Austrian Danube section. In the case of *C. sowinskyi* this represents the first record in the fauna of both countries, while *C. robustum* was new for the Austrian fauna. In contrast to the common occurrence of *C. curvispinum* (G. O. Sars, 1895), both species showed a disjunctive distribution; *C. sowinskyi* was missing between Vác and the Iron Gate II. dam, whereas *C. robustum* was not found between Vienna and Belgrade. Since the occurrence of *C. sowinskyi* in the Slovakian-Hungarian river section has been known for a long time, its absence in the downstream reach reflects that the environment is not tolerable for it for some reason. On the other hand, *C. robustum* reached the Upper Danube by recent jump dispersal, implying that it is spreading downstream in the river. Accordingly, the distributional gap reflects that it has not reached the Middle Danube.
3. Regarding the Hungarian distribution of mysids, it can be highlighted that my results dated back the first known Hungarian occurrence of *Hemimysis anomala* G. O. Sars, 1907 from 2005 to 1997. In the case of *K. warpachowskyi* I have not found specimens earlier than published (2001), confirming that the species reached the Austrian section by jump dispersal, and colonized the Middle Danube downstream. I recorded these two recently appeared mysid species for the first time outside the main channel of the River Danube, and in 2011 I also detected *H. anomala* in the River Tisza. *L. benedeni* has proved to be the most widespread mysid in the country. Its occurrence in fishing ponds merits special attention, having implications concerning the dispersal mechanisms of mysids.
4. With regard to corophiids, I demonstrated by examining the original materials that the first records of the group in Hungary (1917) were erroneously attributed to *C. curvispinum*; the first species expanding its range in the River Danube was in fact *C. sowinskyi*, while

the actual colonization of the Danube by *C. curvispinum* took place in the 1920-30s undetected. In a sample of 1943 in the River Tisza *C. maeoticum* (Sowinsky, 1898) was found, representing its first and so far the only record for Hungary. At present *C. curvispinum* is the most widespread corophiid in the country, while the once probably continuous range of *C. sowinskyi* in the Carpathian Basin has become fragmented; three isolated populations exist in the rivers Danube, Dráva, and Tisza. Although it was not present in the material of the Joint Danube Survey 2, I found *C. robustum* for the first time in Hungary in 2007, while in 2009 it already showed mass occurrences at several sites of the Danube. The species is still spreading downstream in the river; its most downstream Hungarian occurrence known is Paks.

5. Based on the material of the Joint Danube Survey 2 and my own sampling, I recorded *Echinogammarus trichiatus* (Martynov, 1932) for the first time in the Middle Danube (in 2007 in Slovakia, in 2009 in Hungary). The species has been found in the Upper Danube already in 1996, indicating that this species is also spreading downstream. The process will probably go on in the following years.

6. The presence of *L. benedeni* in numerous isolated fishing ponds (reservoirs, gravel-pit lakes) indicates the functioning of an effective dispersal mechanism independent of navigation, most likely fish stocking. Whitefish are usually restocked from large rivers and lakes (Danube, Tisza, Balaton). The fish are transferred to the ponds on lorries in tanks, which are usually filled up from the source water by motor pumps. Our sampling by pump in the Danube demonstrated that mysids may be pumped into the tanks, and a considerable proportion of them may survive the procedure (50% of *L. benedeni*, 82% of *K. warpachowskyi* in our test). In summary, there are no circumstances that could be identified as drastic mortality factors; mysids can be assumed to have a realistic chance of surviving a fish stocking transport. After establishing in a reservoir, the subsequent drift in the discharging stream also may enable the species to colonize otherwise inaccessible parts of drainage basins. We can assume that this mechanism contributed to the range expansion of *L. benedeni*, and it may be available for the two recently appeared species, as well.

Conclusions

The results discussed above modified our knowledge on the range expansions of Ponto-Caspian peracarids in the River Danube basin substantially, making a comprehensive appraisal of the process topical. Although the occurrence data available are rather incidental, if considered with appropriate caveats, they can provide a useful insight into the coarse-scale spatiotemporal patterns of the immigration process. The temporal changes in the immigration rate can be tracked based on the first occurrence of the species in Hungary (Figure 1.) During the 1910-40s number of species raised relatively steeply; however, since the first focused investigations were carried out in this period, the process likely started earlier and lasted longer. In the 1950-60s no further immigrants arrived, but then in the 1970-80s two additional species were detected (*Dikerogammarus villosus* (Sowinsky, 1894) and *Obesogammarus obesus* (G. O. Sars, 1894)). From the second half of the 1990s four new species appeared, indicating further increase in the immigration rate. The increasing pace is parallel to a significant geographic change; while in the preceding period all of the species were detected in the Middle Danube, the last four species appeared in the upper section of the river (or in the Main, as in the case *C. robustum*).

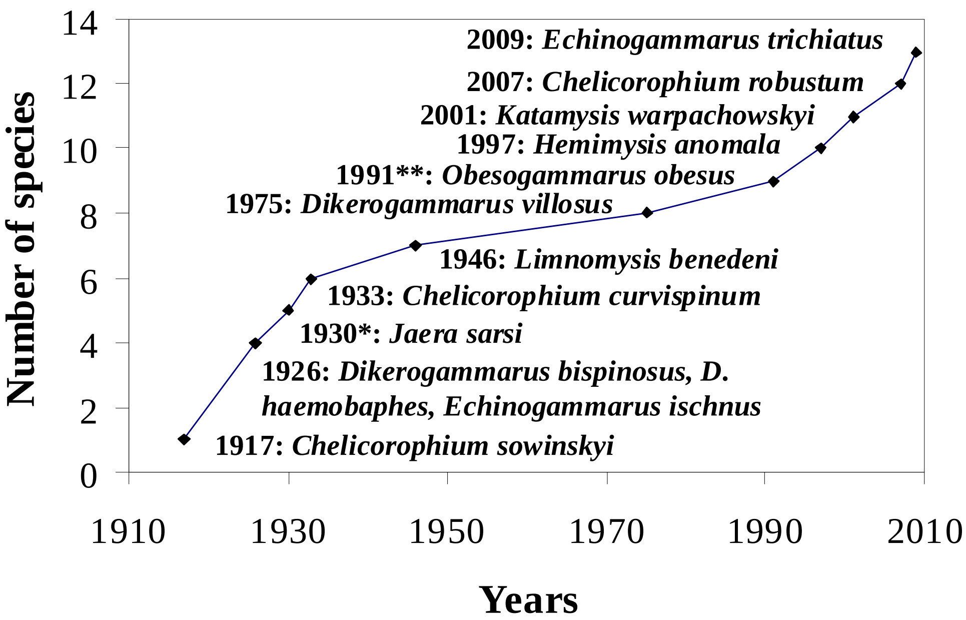

Figure 1. The first reported occurrence of Ponto-Caspian peracarids in Hungary. The linking of the points serves demonstrative aims. *: *J. sarsi* – unlike the other species – was first detected in the River Tisza. **: *O. obesus* was probably present already in the 1980s; therefore, I refer to it so in the text. Species not mentioned in the text: *Dikerogammarus bispinosus* Martynov, 1925; *Dikerogammarus haemobaphes* (Eichwald, 1841); *Echinogammarus ischnus* (Stebbing, 1899).

The most likely explanation for the changes in the rate and place of immigrations lies in the development in navigation. Regular, motorized, high-quantity ship traffic between the

Lower Danube and the upper reaches of the river was made possible by the regulation of the Iron Gate narrows finished in 1898. The first species began to spread probably after this, and then the pool of the species able to expand their ranges under the given circumstances ran out by the 1950s. The invasions of the 1970-80s may be linked to the construction of the Iron Gate I. dam (1972), further ameliorating the opportunities of navigation. The next impulse may have been brought about by the completion of Danube-Main canal in 1992. The subsequent upsurge in shipping and the relocation of the commercial hubs may be responsible for the increase in the immigration rate and the geographic rearrangements.

What can we expect in the future based on these considerations? It is hard to tell, since we do not know whether the process has reached a new saturation, or it is just on the rise. In Hungary, the further spread of the species already present can be anticipated first of all, since at present no Ponto-Caspian peracarid species can be found in the Upper Danube which does not occur in this country. *C. robustum* and *E. trichiatus* have not even reached every available part of the Danube, while *H. anomala* and *K. warpachowskyi* can be expected to expand their ranges outside the river. *H. anomala* and *C. robustum* can be regarded as the most probable future invaders of Lake Balaton.

With my results, I managed to make our knowledge on the occurrence and distribution of Ponto-Caspian peracarid species up-to-date, making up arrears of decades. This knowledge can serve as a solid basis for further, more thorough investigations, and can support the work of professionals of practice (e.g. in implementing the biological water quality assessment specified by the EU Water Framework Directive).

Publications in the subject of the dissertation

International journal publications

Borza, P. (2012): Remarks on the taxonomic status of *Jaera danubica* Brtek, 2003 (Crustacea: Isopoda: Janiridae). Zootaxa 3161: 67-68. [IF(2011): 0.927]

Borza, P., Czirok, A., Deák, Cs., Ficsór, M., Horvai, V., Horváth, Zs., Juhász, P., Kovács, K., Szabó, T., and Vad, Cs.F. (2011): Invasive mysids (Crustacea: Malacostraca: Mysida) in Hungary: distributions and dispersal mechanisms. North-Western Journal of Zoology 7(2): 222-228. [IF(2011): 0.747]

Borza, P. (2011): Revision of invasion history, distributional patterns, and new records of Corophiidae (Crustacea: Amphipoda) in Hungary. Acta Zoologica Academiae Scientiarum Hungaricae 57(1): 75-84. [IF(2011): 0.564]

Borza, P., Csányi, B. and Paunovic, M. (2010): Corophiids (Amphipoda: Corophioidea) of the River Danube - the Results of a Longitudinal Survey. Crustaceana: 83(7): 839-849. [IF(2010): 0.630]

Borza, P. (2009): First record of the Ponto-Caspian amphipod *Echinogammarus trichiatus* (Martynov, 1932) (=*Chaetogammarus trichiatus*) (Crustacea: Amphipoda) for the Middle-Danube (Slovakia and Hungary). Aquatic Invasions 4(4): 693-696.

Borza, P. (2008): Recent Establishment of the Invasive Ponto-Caspian Mysid *Hemimysis anomala* in the Hungarian Part of the Danube River. Aquatic Invasions 3(1): 99-101.

National journal publications

Borza, P., Puky, M. (2012): Current status of epigean aquatic Malacostraca (Crustacea) in Hungary: accelerating invasions, vulnerable and threatened native species. Acta Biologica Debrecina Supplementum Oecologica Hungarica 28: 33-46. [in Hungarian]

Horvai, V., Czirok, A., Lőkkös, A., **Borza, P.**, Bódis, E., és Deák, Cs. (2012): New faunistic data from the riparian zone of the Hungarian-Croatian reach of Drava River. Acta Biologica Debrecina Supplementum Oecologica Hungarica 28: 109-120. [in Hungarian]

Borza, P., Nosek, J. and Oertel, N. (2010): Contribution to the macroinvertebrate fauna of the Hungarian Danube. V. Amphipods (Crustacea: Malacostraca: Amphipoda). Folia Historico-naturalia Musei Matraensis 34: 17-27.

Borza, P. (2009): Spread of invasive mysids (Crustacea: Mysida) in the River Danube water system: Ráckeve–Soroksári Danube arm, canal network of the Kiskunság. Acta Biologica Debrecina Supplementum Oecologica Hungarica 20: 21-26.

Borza, P. (2009): Establishment of invasive mysids in Hungary. Halászat 102: 70-74. [in Hungarian]

Borza, P. (2007): Contribution to the Macroinvertebrate Fauna of the Hungarian Danube. III. Mysid Shrimps (Crustacea: Mysidacea). Folia Historico-naturalia Musei Matraensis 31: 125-129.

Borza, P. (2007): New Data to the Distribution of the Recently Appeared Representatives of the Order Mysida (Crustacea) in the Hungarian Fauna: *Katamysis warpachowskyi* G. O.

Sars 1893 and *Hemimysis anomala* G. O. Sars 1907. Acta Biologica Debrecina Supplementum Oecologica Hungarica 16: 39-45.

International conference publications

Borza, P. (2010): Recent discoveries on the distribution of Corophiidae (Crustacea: Malacostraca: Amphipoda) along the River Danube. 6th NEOBIOTA Conference, 14-17.09.2010, Copenhagen (Denmark). Poster

Borza, P., Oertel, N. (2010): Recent drastic changes in the amphipod and mysid fauna (Crustacea: Malacostraca: Amphipoda, Mysida) of the Hungarian Danube stretch. 38th Conference of the International Association for Danube Research (IAD), 22-25.06.2010, Dresden (Germany). Poster

Puky, M., Ács, É., Bódis, E., **Borza, P.**, Erős, T., Kiss, K.T. and Tóth, A. (2009): Aquatic invasions accelerated around the millenium in Hungary: Colonisation characteristics, taxonomical differences, relative importance. World Conference on Biological Invasions and Ecosystem Functioning, 27-30.10.2009, Porto (Portugal). Poster

Puky, M., Ács, É., Bódis, E., **Borza, P.**, Kiss, K. T., and Tóth, A. (2008): Invasive algae, plant, mollusc and crustacean species along the Hungarian Danube section: arrival time, colonisation characteristics, relative importance. Proceedings of the 37th IAD Conference, 29.10-01.11.2008, Chisinau, Moldova 76-81.

National conference publications

Borza, P., Puky, M. (2012): Current status of epigean aquatic Malacostraca (Crustacea) in Hungary: accelerating invasions, vulnerable and threatened native species. IX. „MaViGe" Aquatic Macroinvertebrate Research Conference, 12-14.04.2012, Gyula. Oral presentation [in Hungarian]

Horvai, V., Czirok, A., Lőkkös, A., **Borza, P.**, Bódis, E., és Deák, Cs. (2012): New faunistic data from the riparian zone of the Hungarian-Croatian reach of Drava River. IX. „MaViGe" Aquatic Macroinvertebrate Research Conference, 12-14.04.2012, Gyula. Poster [in Hungarian]

Bódis, E., **Borza, P.**, Potyó, I., Weiperth, A., Puky, M. és Guti, G. (2012): Invasive mollusc, macrocrustacea, fish and reptile species along the Hungarian Danube section and some connected waters. EuLakes National Conference, 09.03.2012, Veszprém. Oral presentation [in Hungarian]

Borza, P., Oertel, N. (2010): Changes of the last decades in the Mysida and Amphipoda (Crustacea: Malacostraca) fauna of the Hungarian Danube section. VII. „MaViGe" Aquatic Macroinvertebrate Research Conference, 15-17.04.2010, Sümeg. Oral presentation [in Hungarian]

Borza, P. (2009): Revision of the distribution of Corophiidae (Amphipoda) in Hungary. LI. Hidrobiologist Days, 30.09-02.10.2009, Tihany. Oral presentation [in Hungarian]

Puky, M., Ács, É., Bódis, E., **Borza, P.**, Kiss, K.T. és Tóth, A. (2009): Invasive species in the Hungarian section of the Danube River. 8. Hungarian Ecologist Congress, 26-28.08.2009, Szeged. Poster [in Hungarian]

Borza, P. (2009): Spread of invasive mysids (Crustacea: Mysida) in the River Danube water system: Ráckeve–Soroksári Danube arm, canal network of the Kiskunság. VI. „MaViGe" Aquatic Macroinvertebrate Research Conference, 16-18.04.2009, Villány. Poster [in Hungarian]

Borza, P. (2007): New Data to the Distribution of the Recently Appeared Representatives of the Order Mysida (Crustacea) in the Hungarian Fauna: *Katamysis warpachowskyi* G. O. Sars 1893 and *Hemimysis anomala* G. O. Sars 1907. IV. „MaViGe" Aquatic Macroinvertebrate Research Conference, 12-13.04.2007, Tihany. Poster [in Hungarian]