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Alien invertebrates in Ukrainian inland waters in the context of basin approach to river management and monitoring

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Alien invertebrates in Ukrainian inland waters in the context of basin approach to river management and monitoring. — M. O. Son. — Principles and methods of water ecosystems monitoring and management in Ukraine are currently in the process of large-scale reset. In Ukraine, nine river basin districts are created (Dniester, Danube, Southern Bug, Don, Vistula, Crimean rivers, Black Sea rivers, Azov Sea rivers), which are the main units of management in the field of water use and protection and the reproduction of water resources. Ukrainian river basin districts significantly differ by the diversity of alien invertebrates. 22 exotic invertebrate species were recorded: *Craspedacusta sowerbii* Lankester, 1880, *Branchiura sowerbyi* Beddard, 1892, *Urnatella gracilis* Leidy, 1851, *Lophopodella carteri* (Hyatt, 1866), *Pectinatella magnifica* (Leidy, 1851, *Physa acuta* (Draparnaud, 1805), *Ferrissia californica* (Rowell, 1863), *Potamopyrgus antipodarum* (J. E. Gray, 1843), *Melanoides tuberculata* (Müller, 1774), *Tarebria granifera* (Lamarck, 1822), *Planorbella duryi* (Wetherby, 1879), *Sinanodonta woodiana* (Lea, 1834), *Corbicula fluminea* (Müller, 1774) *Corbicula* sp., *Eriocheir sinensis* H. Milne Edwards, 1853, *Rhithropanopeus harrisi* (Gould, 1841), *Procambarus virginalis* Lyko, 2017, *Macrobrachium nipponense* (De Haan, 1849), *Eocyzicus orientalis* Daday, 1915, *Eucyclops roseus* Ishida, 1997, *Mesocyclops pehpeiensis* (Hu, 1943), and *Mesocyclops isabellae* Dussart et Fernando, 1988. A lot of exotic species were discovered mostly in artificial waterbodies, especially, in warm-water reservoirs. The expansion of freshwater species native for the Black Sea region is difficult to assess, which needs a special retrospective historical evaluation for separate districts. Monitoring and management of species, which are historically present in the basin in context of biological invasions, should be different from exotic species monitoring and management, especially regarding risk assessment. The early detection and taxonomic identification of invaders must be centralized, as well as primary risk assessment and management of warm-water techno-ecosystems. Specific approaches to cross-border, non-controlled, and protected areas must be developed.

Key words: alien species, inland waters, river basin, Ukraine.

Introduction

Principles and methods of water ecosystems monitoring and management in Ukraine are currently in the process of large-scale reset. One of the directions of the integration of Ukrainian legislation to the environmental legislation of the European Union was the inclusion to the Water Code of Ukraine of a number of elements of the EU Water Framework Directive. The most fundamental changes in the management of water resources were the approval of the basin approach and a sharp increase in the role of biological indicators.

In Ukraine, nine river basin districts (RBD) are created, six of which are separate basins (Dniester, Danube, Southern Bug, Don, Vistula) and three are groups of small river basins (Crimean RBD, Black Sea RBD, Azov Sea RBD). RBD is the main unit of management in the field of water use and protection and the reproduction of water resources, consisting of river basin or group of adjacent river basins and related coastal and ground waters. Inland, transitional, coastal parts and ground waters must have separate monitoring methods and indicator complexes. Within the established RBD, the central executive body, which ensures the formation of state policy in the field of environmental protection, may allocate sub-basins. Separate river basin management plan must be developed in all RBD implemented with developed monitoring programs, cartographic products, priority environmental objectives, environmental assessments and prognoses, etc.

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At the same time, a number of elements of monitoring and management that require "biological" information (assessment of ecological status, assessment of environmental potential, allocation of valuable sites, etc.) are introduced, which essentially distinguishes new norms from traditional approaches for Ukraine and focus on the assessment of pollution.

Biological invasions are one of the principal anthropogenic factors of water ecosystem change and, theoretically, their monitoring and management should be part of river basin management plans, and their indicators are included in methods for evaluation of the ecological status and environmental potential of water bodies. However, concrete monitoring methods and environmental assessments are currently in need of development and are not yet approved by law.

In this article, we review the distribution of alien invertebrates in the freshwater parts of the created RBD and discuss the possibilities of its monitoring and management in the development of the basin approach.

Material and methods

We analysed the distribution of alien invertebrates in the nine river basin districts (RBD). We excluded areas that must be zoned as transitional or coastal and cryptogenic species.

The results of original studies carried out in the last years along with the published data on the study region served as a basis for the analysis. Original studies include work with the collections of the Zoological Museum of Ivan Franko Lviv National University (ZMLNU), National Museum of Natural History NAS of Ukraine (NMNH), and I. I. Schmalhausen Institute of Zoology NAS of Ukraine (SIZK).

Results and discussion

Distribution of alien invertebrates in river basin districts

The Dnieper RBD

The Dnieper River basin is an important part of the European network of inland waterways and the European inland water "central invasion corridor", linking basins of the Black and Baltic Seas. Five exotic invertebrates are established in the natural ecosystems of this area *Physa acuta* (Draparnaud, 1805), *Ferrissia californica* (Rowell, 1863), *Eriocheir sinensis* H. Milne Edwards, 1853, *Rhithropanopeus harrisi* (Gould, 1841), and *Craspedacusta sowerbii* Lankester, 1880 (Semenchenko et al., 2015, 2016; Protasov, 1978). The New Zealand mud snail *Potamopyrgus antipodarum* (J.E. Gray, 1843), which is widespread mostly along the Black Sea coast, was once reported from Sluch River (Afanasyev, 2005).

A lot of exotic species were recorded mostly in artificial waterbodies.

Only in warm-water techno-ecosystems were pointed *Melanoides tuberculata* (Müller, 1774), *Tarebria granifera* (Lamarck, 1822), *Planorbella* sp., *Branchiura sowerbyi* Beddard, 1892 (Silaeva et al., 2010; Protasov et al., 2013; Marenkov et al., 2018).

Several localities of *Urnatella gracilis* Leidy, 1851 were known in natural habitats (Tseeb, 1964), but the recent distribution of this species is also related to warm-water techno-ecosystems (Protasov, 1995; Protasov et al., 2013)

Two alien crustaceans were found in artificial waterbodies isolated from riverine channels: the ornamental cryfish *Procambarus virginalis* Lyko, 2017 in an old flooded quarry (Novitsky & Son, 2016) and the clam shrimp *Eocyzicus orientalis* Daday, 1915 in fishing ponds (Dobrynina, 2004).

More than 40 Ponto-Caspian species expand their range in the Dnieper Basin (Semenchenko et al., 2015, 2016).

The Dniester RBD

Ukrainian freshwater part of the Dniester Basin includes two isolated districts: Lower Dniester with freshwater zone of the Dniester Estuary and Kuchurgan Estuary and Middle-upper Dniester stretch in Western Ukraine.

In the lower part, four exotic invertebrates are established: *F. californica*, *Ph. acuta*, *Rh. harrissii*, and *P. antipodarum* (Son, 2007a, 2007c, 2008; Son et al., 2013). An established population of the tropical prawn *Macrobrachium nipponense* (De Haan, 1849) is present in Kuchurgan Estuary, which is a waterbody with warm-water influence from the Moldavian Hydro-power Station; this species also migrate to Dniester Delta in the warm season of the year (Son et al., 2013).

Among Ponto-Caspian species, only the invader *Dreissena bugensis* (Andrusov, 1897) is non-native for this region (Son, 2007b).

Only one exotic species *Ph. acuta* is present in the Western Ukrainian part of the Dniester Basin (Shevtsova et al., 1998). Significantly expand their ranges and penetrate to Western Ukraine such Ponto-Caspian species as *Obesogammarus crassus* (Sars G.O., 1894) (Shevtsova et al., 1998), *D. bugensis*, (Son, 2007b), *Dreissena polymorpha* Pallas, 1771, *Theodoxus donasteri* (Lindholm, 1908) (collections of ZMLNU and NMNH), and isopod *Jaera istri* Veuille, 1979 (new data).

The Danube RBD

The Danube basin is an important part of the European network of inland waterways and the European inland water "southern invasion corridor", linking basins of the Black and North Seas (Panov et al., 2009).

The basin consists of two isolated parts: Lower Danube with associated lakes and small rivers and sub-basins of the Prut and Tisa.

In the "lower" sub-basin, established are *Sinanodonta woodiana* (Lea, 1834), *Corbicula fluminea* (Müller, 1774) and *Ph. acuta*, *Rh. harrissii*, *B. sowerbyi*, *P. antipodarum*, *F. californica*, *Lophopodella carteri* (Hyatt, 1866), *Pectinatella magnifica* (Leidy, 1851) (Polischuk, 1974; Son, 2007 a; Aleksandrov et al., 2011; Sanzhak et al., 2011; Son et al., 2013, new data).

The state of two species that were noted for the Danube Delta are unclear. The cryptic line of *Corbicula* clam, which is called "Danubian *fluminalis*" (Son, 2007a) or "morph II" (Bódis et al., 2011), was massive in many locations in the early 2000s, but was notrecorded later. *U. gracilis* was a common species in the 1960s, but has not been recorded during recent years.

The Chinese mitten crab *E. sinensis* was repeatedly recorded in the estuarine part of the Lower Danube and surrounding marine waters (Son et al., 2013). *E. sinensis* was not reported from the main channel of the Danube, but this waterway must be a corridor of its migrations to upper courses. Also, on a local internet-resource (http://dumskaya.net) information was published about the record of this species in the Yalpuh-Kuhurluy lake system. This resource also indicates the appearance of American crayfish *Orconectes limosus* (Rafinesque, 1815) into the Lower Danube, which requires further confirmation.

Only one Ponto-Caspian species is alien for this region *D. bugensis* (Lyashenko et al., 2010).

Carpathian sub-basins are not directly connected with other Ukrainian waterways. In the Ukrainian part of the Prut River, no alien invertebrates were recorded. In the Tisa sub-basin *S. woodiana* is established (Pampura & Yanovich, 2011). The state of three species: *F. californica, Ph. acuta* (present in collections of ZMLNU and NMNH) and Ponto-Caspian *Hypania invalida* (Grube, 1860) (Afanasyev, 2015) is unclear.

In a lot of local news resources and online forums observations of freshwater medusa in Zakarpattia Region by amateur divers were discussed. Usually, such cases refer to *C. sowerbii*, but we have not found scientific publications confirming it.

The Southern Bug RBD

Only two exotic species, *Ph. acuta* and *P. antipodarum,* are relatively widespread in the basin (new data). Two species (*M. tuberculata* and *U. gracilis*) were reported from cooling ponds (Protasov, 1995; Grigorovitch et al., 2002).

Several relic species are probably expanded to the basin, but data about their original distribution might be incomplete: *Cryptorchestia cavimana* (Heller, 1865), *D. bugensis*, *J. istri* (new data).

Two exotic species of Atlantic origin (*Mytilopsis leucophaeata* (Conrad, 1831) and *Rh. harrissii*) occur in the Lower Southern Bug and Ingul (Son et. al., 2013; Zhulidov et al., 2018), but, probably, they are limited by transitional zone.

The Don RBD

Only one exotic species (*Ph. acuta*) is widespread in this basin (Zatravkin, 1980). Another species, the ornamental snail *Planorbella duryi* (Wetherby, 1879) was found only once[1].

A lot of Ponto-Caspian species penetrate this basin through systems of canals: *Pontogammarus robustoides* (Sars, 1894), *Obesogammarus obesus* (Sars, 1894), *Gmelina pusilla* G.O. Sars, 1896, *Chelicorophium curvispinum* (G.O. Sars, 1895), *Chelicorophium maeoticum* (Sowinsky, 1898), *Psammoryctides deserticola* (Grimm, 1877), *D. polymorpha, D. bugensis*, (Dedyu, 1980; Zatravkin, 1980; Grigorovitch et al., 2002; Sidorovsky, 2014).

The Vistula RBD

Only one alien species of Ponto-Caspian origin (*D. polymorpha*) was reported (Tsaryk et al., 2014).

The Crimean RBD

Only two exotic species, *Ph. acuta* and *F. californica*, are established in Crimean rivers (Son, 2007c; Son et al., 2010; Prokopov, 2011). Several freshwater plankton species, such as medusa *C. sowerbii* and cyclopids *Eucyclops roseus* Ishida, 1997, *Mesocyclops pehpeiensis* (Hu, 1943), and *Mesocyclops isabellae* Dussart et Fernando, 1988, are known only by a few records from isolated lakes and artificial ponds (Prokopov, 2011; Anufriieva & Shadrin, 2016).

In the lower course of the Chornaya River having very specific salinity conditions we also found an exotic polychaete *Merceriella enigmatica* Fauvel, 1923 (unpublishied data). Probably, this river section can be considered as transitional waters.

The expansion of freshwater species native for the Black Sea region is difficult to assess. A lot of Ponto-Caspian and common European species were introduced to artificial waterbodies or expanded through the systems of canals. However, the fact of their intentional introductions does not guarantee that these species were historically absent in the Crimea before, because the Crimean aquatic fauna was not well studied before their introduction, except for molluscs.

Most of such "nearby" aliens did not spread beyond the system of canals and water bodies filled with the Dnieper's water, and such case must by analysed as part of the Dnieper River Basin District. The fate of many species noted as introduced is little known (especially in connection with the modern change in the operating regime of the North Crimean canal).

Among "nearby" aliens reported from the Crimean Peninsula only a small part are really present and established in natural habitats of Crimean rivers: *D. polymorpha*, *D. bugensis*, *Theodoxus fluviatilis* (Linnaeus, 1758), *Esperiana esperi* (Férussac, 1823), *Dikerogammarus villosus* (Sowinsky, 1894) (Prokopov, 2011).

The Black Sea RBD

Only two exotic species, *P. antipodarum* and *Ph. acuta*, are widespread and established in this district (Son, 2007a, 2008). A separate situation is observed in the original estuarine Sasyk Lake, which turned into a freshwater reservoir connected to the Danube Delta. In the lake and Danube-Sasyk Canal, several species common for the Danube Delta are present, including *C. fluminea* (SIZK collections), *S. woodiana*, *Rh. harrissii* (Son, 2007a; Son et al., 2013), but absent in other small Black Sea river basins. In the Kogylnik River that flows into the Sasyk Lake *B. sowerbyi* was recorded too (unpublished data).

Unidentified freshwater prawns were sampled in waterbodies near Sarata, Odesa Region. According to the photographs on local internet sources (especially, bessarabiainform.com) they can be preidentified as *M. nipponense*.

[1] Timoshenko, E. G. N. N.Yaroshenko, 1991. Freshwater mollusks of Donetsk Oblast'. Donetsk: Donetsk State University, 9 pp. (In Russian). Manuscript deposited in UkrNIINTI. 11.07.1029-UK91.

The expansion of Ponto-Caspian species in this district is contradictory. Originally, all small rivers and estuaries of the Black Sea coast could be occupied by relic Ponto-Caspian fauna, but the degradation of such ecosystems in the last centuries led to a significant reduction in the range of relic species. Modern anthropogenic processes caused resettlement of Ponto-Caspian species in this region. Massive expansion of Ponto-Caspian species from the Lower Danube occurred as a result of changes in the hydrological regime of the Sasyk Lake (Khalaim et al., 2017). A similar process of a smaller scale is observed in the Baraboy River as a result of the transfer of water from the Dniester (Son, 2007a). In many other cases of finds of Ponto-Caspian species in small rivers, it is difficult to determine whether they have an anthropogenic source.

The Azov Sea RBD

Several species, including *Ph. acuta* (Degtyarenko & Anistratenko, 2011), *T. granifera* (Khaliman & Anistratenko, 2006), *Rh. harrissii* (Son et al., 2013), *Eu. roseus* and *M. pehpeiensis* (Anufriieva & Shadrin, 2016) are known by a few records. Only one Ponto-Caspian invader, *D. bugensis*, is established (Sidorovsky et al., 2013). In many other cases of finds of Ponto-Caspian species in small rivers, it is difficult to determine whether they have an anthropogenic source.

Problems of basic concepts and definitions

The issue of problems in understanding of basic concepts and definition is not a formal question because of errors or inaccuracies present in the approved terminology and definitions. In addition, stagnancy and slowness of the bureaucratic apparatus can pose problems that will be difficult to correct by real experts.

Even now, before the developed monitoring and management protocols, it is possible to foresee some possible errors even at the stage of hydrographic zonation. As an example, borders between the division of the basin into inland, transitional and coastal parts (which must have separate monitoring methods and complex of indicators), according to WFD approaches, should be based on a detailed analysis of a number of environmental parameters, some of which (especially sedimentation) have not been studied for many areas.

Additional field studies are not expected and it is obvious that the zonation of the lower boundary of the transition zone will be based on a simplified scientific approach that does not take into account the requirements of WFD. The upper boundary of the transition zone will probably be carried out without any scientific analysis, based on everyday understanding. However, even if the scientific approach has been implemented, there are cases when zonation is difficult, such as the small rivers of the Crimea and the Sea of Azov, which directly fall into the sea. Their transitional zone is small and unstable (can change locations in different years and seasons), but is an important habitat for biota and, especially, alien species (Son et al., 2010).

The main conceptual problem is the definition of species that are native for Ukraine, but expand into separate areas (mostly Ponto-Caspian relicts). Most of such species before man-made changes of river basins were absent in the upper (or even middle) courses of the river and in tributaries. However, information about Ponto-Caspian expansion, its potential and impact is greatly exaggerated. A very small part of them are known outside the artificial reservoirs and canals. In addition, even the middle and upper sections of large rivers have been historically inhabited by relic fauna and its distribution is largely a reintroduction.

This does not eliminate the need to study this process, but in most cases it should not be considered in the context of the impact of aliens on the native biota (Semenchenko et al., 2015). Therefore, monitoring and management of species that have been historically present in the basin in the context of biological invasions, should be different from monitoring and management of exotic species, especially regarding risk assessment.

Choice of basin or centralised decision-making level

All key elements of management and monitoring must be separated regarding whether they can be implemented within the management program of a separate RBD or only as more global programs.

In our opinion, these aspects must be centralised:

1. Early detection, taxonomic identification. Information about the first records of alien species from all sources must be centralised and open, because it is important for all RBD and many other users. Primary risk assessment and taxonomic identification need the involvement of highly qualified experts and sometimes also foreign experts. The development of such expert communities in each RBD is impractical.
2. Primary risk assessment. One the one hand, it needs highly qualified experts, and on the other hand, for each new exotic species it should be the same in all areas. Its main task must be the classification of the species in relation to management tasks. For example, there might be three lists of species: dangerous species from black list must be managed, safe species from white list can be only monitored, and little-known species from grey list must be scientifically investigated (Panov et al., 2009).
3. Management of warm-water techno-ecosystems. The general characterization of the distribution of alien invertebrates in river basins reveals the special importance of warm water techno-ecosystems. The structure of post-soviet energy development requires large-scale use of reservoirs as cooling ponds. Firstly, a lot of exotic species, which are sporadic or absent in natural habitats, can form established populations in the warm-water conditions. Secondly, alien species in techno-ecosystems can have high-risk impact on the work of strategically important constructions. Thus, it is critically important to develop a separate approach to assessing the risk of invasive alien species in warm water techno-ecosystems. Management of such situation must be centralised in connection with the special regime of work in the energy sector.

On the RBD level, monitoring of alien species (as part of holistic hydrobiological monitoring), ecological assessment of biological pollution, and programs of management for all species with high risk must be developed. It must be based on secondary risk assessment, which includes prognoses of specific high-risks impacts. It may be ecological impact (especially, in the protected area) or economic impact, which may concern, for example, energy development and shipping infrastructure.

Specific approaches to special territories

Cross-border areas. All RBD, besides Southern Bug and Crimean, includes cross-border areas. Basin approach requires international cooperation in such cases. The main task of international cooperation regarding alien species is a rapid exchange of information about first records of new species and new data on their ecological and economic impacts.

Non-controlled areas. Management and monitoring of non-controlled areas in the Crimean, Don, and Azov Sea RBD require a lot of specific activity, which differ from the conventional, and sometimes must be additionally coordinated with different ministries and departments.

Protected areas. They must have separate monitoring programs. Mainly in such territories, a detailed scientific study of the environmental impacts of invasive species is possible.

Summary

Ukrainian river basin districts significantly differ by the diversity of alien invertebrates. A lot of exotic species were recorded mostly in artificial waterbodies, especially, in warm-water reservoirs.

The expansion of freshwater species native for Black Sea region is difficult for assessment and needs special retrospective historical assessments for separate districts. Monitoring and management of species, which historically has been present in the basin, in context of biological invasions, should be different from exotic species monitoring and management, especially in risk assessment.

The early detection and taxonomic identification of invaders must be centralised, as well as primary risk assessment and management of warm-water techno-ecosystems. Specific approaches to cross-border, non-controlled, and protected areas must be developed.

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