

Rapid Communication**First records of the alien amphipod *Dikerogammarus haemobaphes* (Eichwald, 1841) in the Neman River basin (Belarus)**

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The alien Ponto-Caspian amphipod *Dikerogammarus haemobaphes*, that is already well-established in the main rivers of the Belarusian part of the Black Sea basin, was recorded for the first time in the Belarusian part of the Neman River basin (Augustów canal in 2018 and Chornaya Hancha River in 2020). Most likely, this alien amphipod spread naturally and/or was introduced with boat hull fouling from the Polish part of the Narew River (Vistula River basin) via the Augustów canal. This species will invade the Neman River in the very near future.

Key words: demon shrimp, non-indigenous species, range extension, Central European invasion corridor

Introduction

The demon shrimp *Dikerogammarus haemobaphes* (Eichwald, 1841) is one of the Ponto-Caspian amphipods that have a high invasion potential. The species' spread within Europe was mainly enhanced by the opening of the canals connecting different basins. It has successfully established in different countries such as France (Labat et al. 2011), Germany (Schleuter et al. 1994; Bij de Vaate et al. 2002), Switzerland (Altermatt et al. 2019), Austria (Vornatscher 1965; Jażdżewska et al. 2020), Hungary (Muskó 1993), Croatia (Žganec et al. 2009), Slovakia (Lipták 2013), Serbia (Tubić et al. 2013), Poland (Konopacka 1998; Bij de Vaate et al. 2002; Jażdżewski 2003; Grabowski et al. 2007), Russia (Berezina 2007), and Great Britain (Aldridge 2013; Johns et al. 2018). Comprehensive information on the invasion history of *D. haemobaphes* in Europe was recently presented by Jażdżewska et al. (2020). It is known that this species used all invasion corridors that were proposed by Bij de Vaate et al. (2002) (Figure 1). In Belarus, *D. haemobaphes* was first found in 2006 in the Dnieper River (Mastitsky and Makarevich 2007). Since then, annual monitoring campaign has revealed the presence of this species in different riverine sites of the southern part of the country (Figure 2), making it one of the most widespread

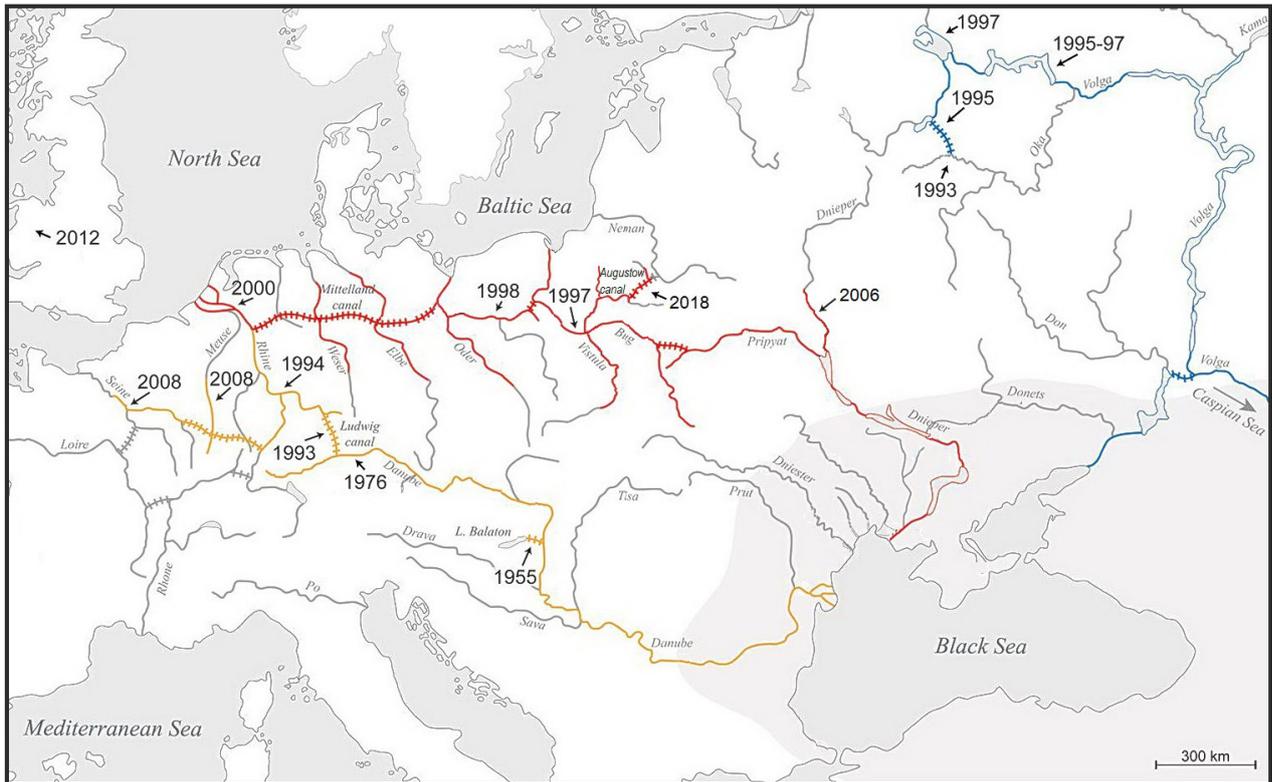


Figure 1. Map showing the history of invasion of *D. haemobaphes* in Europe (from Jażdżewska et al. 2020 with modification). European freshwater invasion corridors are color-coded following the classification of Bij de Vaate et al. 2002 (orange – Southern, red – Central, blue – Northern corridor). Years represent the first reports of *D. haemobaphes* at the sites indicated by arrows.

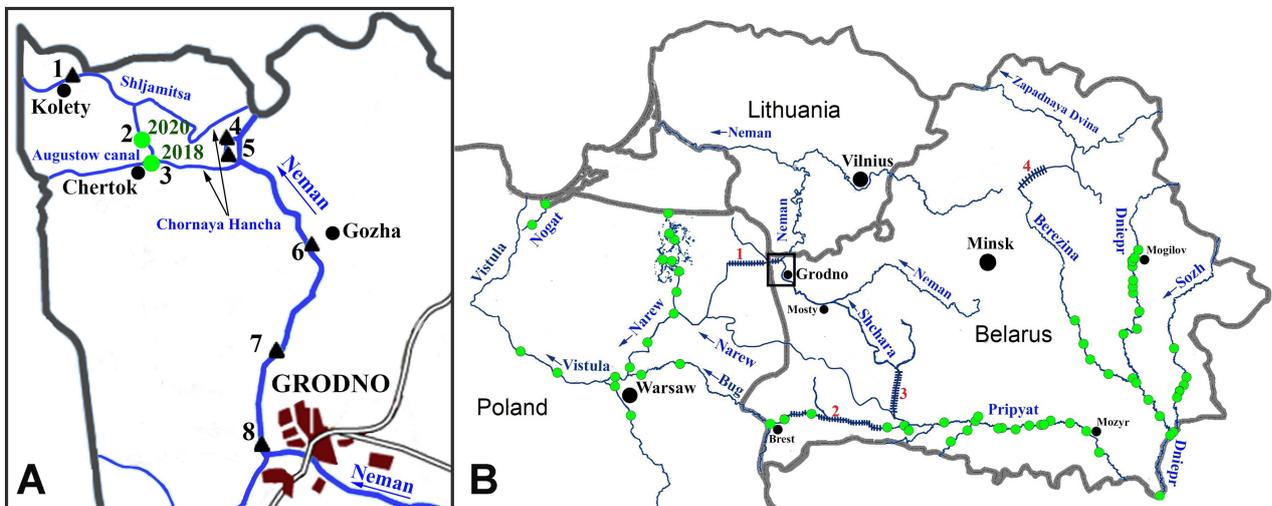


Figure 2. Sampling sites in the Neman basin in 2018–2020 (A) and maps of the previously known *D. haemobaphes* distribution in Belarus (from Makarenko and Vezhnovets 2014 with modification) and the Vistula River basin (B) (from Jażdżewski 2003). Green circles and black triangles – sampling sites with and without *D. haemobaphes* records, respectively. Canals marked by red numbers: 1 – Augustów canal, 2 – Dnieper-Bug canal, 3 – Oginski canal, 4 – Dnieper-Zapadnaya Dvina canal. See site number and description in Supplementary material Table S1.

alien gammarids in Belarus (Makarenko and Vezhnovets 2014). *Dikerogammarus haemobaphes* spread to the rivers of Belarus from the Kiev reservoir (Ukraine), which is a donor area for several amphipod species of Ponto-Caspian origin currently found in Belarus. They were intentionally introduced into the reservoir in the 1970s and spread

naturally or due to human activities (Lipinskaya et al. 2020), whereby they also extended their range into Belarus. *Dikerogammarus haemobaphes* first passed through the territory of Belarus via the Dnieper-Bug (Royal) canal and it was recorded in the Vistula River in Poland in 1997 (Konopacka 1998; Bij de Vaate et al. 2002). Later, this species was commonly found in the Bug (the main Vistula's tributary), Noteć, Warta, and Oder rivers, along the coasts of the Vistula Lagoon, as well as in the Narew River and the Masurian Lake District in Poland (Jażdżewski and Konopacka 2000; Jażdżewski 2003; Grabowski et al. 2007). So, it appears that *D. haemobaphes* used the Central European invasion corridor to colonize the aquatic ecosystems of Belarus and Poland as well as those of Western Europe and Great Britain. This possibility was confirmed by Jażdżewska et al. (2020) who did a molecular study of specimens from the native and invaded ranges.

The aim of this study is to present the first records of *D. haemobaphes* in the Belarusian part of the Neman River basin.

Materials and methods

Demon shrimp was sampled in October 2018 in Augustów canal (N53.870476; E23.670134) and in July 2020 in a tributary of the Neman River - Chornaya Hancha River (N53.870597; E23.671617). The samples of macroinvertebrates were taken in different parts of the Neman River basin (Belarus) for different projects. Samples were collected by hand net (ISO 7828, 25 × 25 cm frame; 500 µm mesh size) in the littoral zone (50–70 cm depth) (Supplementary material Table S1; Figure 2a). Sampling effort was proportionally distributed over all types of presented biotopes along about 150–200 m of the canal/river coastline. 15–20 square meters of bottom substrate were sampled. This included the substrate such as stones, sand or mud, floating, submerged, and emerged macrophytes, and all other natural or artificial substrates, floating or submerged in the water. Specimens were picked from the whole sample. The taxonomic keys of Mordukhaj-Boltovskoj (1969), Konopacka (2004), and Dobson (2013) were used for species identification. The main features for species diagnosis were the shape of the pereopod-5 basis, shape of elevations on urosome segments, and uropod-3 armature (Figure 3).

Results

Eight sampling sites in the Belarusian part of the Neman River basin were studied in 2018–2020 (Supplementary material Table S1). Three adults of *D. haemobaphes* were found in the Augustów canal in October 2018, and one male was found in the Chornaya Hancha River in July 2020. The substrate at these locations consists of slightly silty sand, gravel and stones covering 30–50% of the bottom.

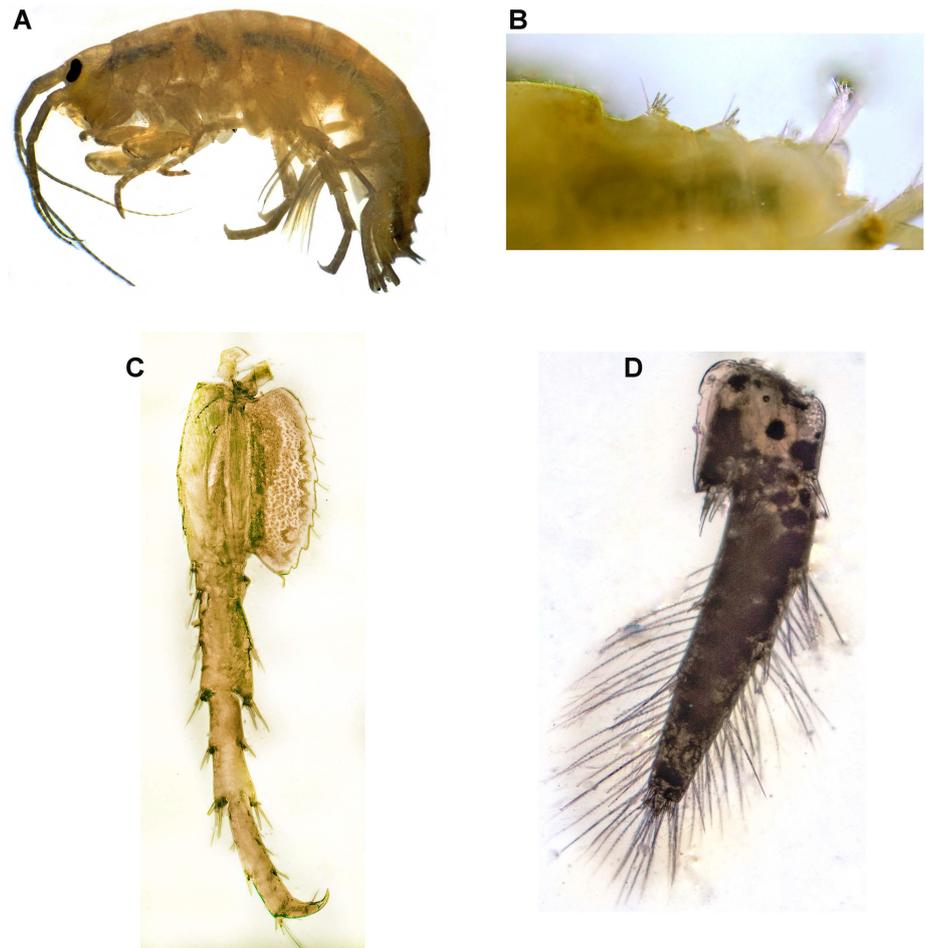


Figure 3. *Dikerogammarus haemobaphes* preserved in ethanol (A – general view; B – urosome; C – pereopod-5, D – uropod-3). Photographs by A. Makarenko.

Discussion

Dikerogammarus haemobaphes has invaded a new river basin in Belarus. It should be noted that this alien species was not introduced to the Neman river system (Kaunas reservoir, Lithuania) in 1961 with the batch of Ponto-Caspian crustaceans that were used to increase food availability for fish (Arbačiauskas 2002) and until now was not found in the Belarusian part of the Neman River (Semenchenko et al. 2009; Lipinskaya et al. 2020) indicating that this is a recent invasion.

There are two artificial waterways such as the Oginski and Augustów canals that connect the Neman River basin with the Dnieper and the Vistula River basins, respectively.

The Oginski canal was constructed in the 18th century and connects the Yaselda River (tributary of the Pripjat) and the Shchara River (tributary of the Neman River). The canal was used mostly for timber transportation from the Pripjat River basin to the Baltic coast until World War I. Navigation was restored during the interwar period but most of the hydraulic structures were destroyed during World War II. The land reclamation of Polesia finally drained this canal and the last water gates were blown up in the 1960s. Now the canal is neglected.

The Augustów canal was built for transporting wood and merchandise, and later became a tourist attraction (Romanova et al. 2018). It is a navigable watershed canal, linking the Vistula River through the Biebrza River (tributary of the Narew River) with the Neman River through its tributary – the Chornaya Hancha River. After both the First and Second World Wars, the canal's hydraulic structures were damaged. The Polish part of the canal was partially restored and used for tourism purposes, the Belarusian part remained neglected till the beginning the 21st century. Restoration of the Belarusian part of the Augustów canal was finished in 2006. The canal became very popular place for tourists on small boats after the border control simplification in 2016.

Dikerogammarus haemobaphes, which is a well-established species in the southern part of Belarus, might have used the Oginski canal to invade the Neman River basin. However, it was found neither on the two sites of monitoring for alien species on the Neman River (near Mosty town and Gozha village) nor in other parts of the Neman River and its tributaries which were sampled almost annually since 2006 (Figure 2b). The Polish part of the Narew River is the most likely source for unaided spread and/or introduction of *D. haemobaphes* with boat hull fouling *via* the Augustów canal to the Belarusian part of the Neman River basin. Small number of specimens found in the study indicates very early stages of invasion. So, *D. haemobaphes* that spread to Poland *via* the Dnieper-Bug canal, extended its range naturally and/or by human activities there, and invaded a new basin in Belarus *via* the Augustów canal from Poland, thus taking a roundabout route of spread within Belarus. The similar phenomenon for *Dikerogammarus villosus* (Sowinsky, 1894) in Poland was noticed by Rewicz et al. (2015). This species originally invaded Poland from East and reached the Vistula River, while to the Oder River it came from the West, after invading Western Europe.

Up to now, six alien aquatic invertebrate species such as mollusks *Haitia acuta* (Draparnaud, 1805), *Lithoglyphus naticoides* (C. Pfeiffer, 1828), *Dreissena polymorpha* (Pallas, 1771), amphipod *Chelicorophium curvispinum* (Sars, 1895), crayfish *Faxonius limosus* (Rafinesque, 1817), and mysid *Paramysis lacustris* (Czerniavsky, 1882) were found in the Belarusian part of the Neman River basin during the long-term macroinvertebrate monitoring program (Semenchenko et al. 2007, 2008, 2009; Alekhovich and Razlutskiy 2013; Lipinskaya et al. 2020). Records of *D. haemobaphes* in the Chornaya Hancha River and the Augustów canal expand the list of alien species in the Neman River basin to seven species.

Taking into account the high rate of spread of *D. haemobaphes* in Belarus (Semenchenko et al. *in press*), we can predict a further expansion of its range into the Neman River in the next few years. Also, we may expect introduction of several new alien macroinvertebrates from Polish (e.g. *Sinanodonta woodiana* (Lea, 1834)) and Lithuanian water bodies (e.g.

Pacifastacus leniusculus (Dana, 1852); *Hemimysis anomala* G.O. Sars, 1907; *Chaetogammarus warpachowskyi* Sars, 1897) into the Belarusian part of the Neman River and its tributaries. Record of *D. haemobaphes* in the Augustów canal showed that the number of monitoring sites for alien aquatic invertebrates in the Neman River basin needs to be expanded and the Augustów canal can be a good option.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Sampling sites in the Belarusian part of the Neman River basin in 2018–2020.

This material is available as part of online article from:

http://www.reabic.net/journals/bir/2021/Supplements/BIR_2021_Lipinskaya_etal_SupplementaryMaterial.xlsx