

Rapid Communication

First record of *Dikerogammarus bispinosus* Martynov, 1925 in Kazakhstan: invasive or overlooked native in the Caspian Sea basin?

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Abstract

The Ponto-Caspian amphipod *Dikerogammarus bispinosus* is regarded as a native species throughout the lower stretches of rivers that drain into the Black Sea. Its occurrence in the Caspian Sea basin was uncertain due to conflicting reports. Here, we provide the first conclusive evidence for its presence in this basin. Individuals of both sexes, including ovigerous females, were collected in May 2000 from the Ural River in Kazakhstan, suggesting full establishment. If it was a recent invasion, the most probable dispersal pathway into the Caspian basin would have been via the Volga-Don canal as *D. bispinosus* was reported in the early 2000s from the lower Don River and the Saratov reservoir on the Volga River. However, given that until relatively recently *D. bispinosus* was considered a subspecies of *D. villosus*, we cannot rule out that it has been overlooked in earlier reports from the Caspian Sea basin by being mentioned as *D. villosus* or even *D. haemobaphes*. We also provide new data on the distribution of *Gammarus lacustris*, *Obesogammarus platycheir*, *Pontogammarus abbreviatus*, *P. robustoides*, *Turcogammarus aralensis* and *Wolgagammarus dzjubani* in western Kazakhstan and southwestern Russia.

Key words: Amphipoda, distribution, Ponto-Caspian, Ural River

Introduction

Gammaridean Ponto-Caspian amphipods represent a diverse evolutionary radiation with many euryhaline species, some of which have considerably extended their ranges in the last 60 years (Bij de Vaate et al. 2002; Cristescu et al. 2004). These range expansions occurred as a result of human activity in which species were either deliberately or unintentionally released, passively introduced via shipping, or have naturally spread through man-made canals which connected isolated basins (Grigorovich et al. 2002; Arbačiauskas et al. 2011). However, these range expansions seem asymmetrical because there are more documented cases throughout the Black Sea basin with further westward dispersal in comparison to the Caspian basin (Grigorovich et al. 2002, 2003).

The Caspian basin harbors approximately 70 Ponto-Caspian amphipod species (Gammaridae and

Corophiidae) most of which are native to the sea itself and the deltas and lower stretches of the major rivers, Volga and Ural (Mordukhai-Boltovskoi 1979; Pjatakova and Tarasov 1996). Seventeen of these species are known to have spread upstream through the Volga and Ural rivers and are considered non-native in these upper regions (Pjatakova and Tarasov 1996; Zinchenko and Kurina 2011; Takhteev et al. 2015). These are *Chaetogammarus warpachowskyi* (Sars, 1894), *Chelicorophium curvispinum* (Sars, 1895), *Dikerogammarus caspius* (Pallas, 1771), *D. haemobaphes* (Eichwald, 1841), *D. villosus* (Sowinsky, 1894), *Echinogammarus ischnus* (Stebbing, 1899), *Iphigenella acanthopoda* Sars, 1896, *Paraniphargoides motasi* (Carausu, 1943), *Pontogammarus abbreviatus* (Sars, 1894), *P. maeoticus* (Sowinsky, 1894), *P. robustoides* (Sars, 1894), *P. sarsi* (Sowinsky, 1898), *Obesogammarus obesus* (Sars, 1894), *Shablogammarus shablensis* Carausu, 1943, *Stenogammarus*

Table 1. Sampling localities (RU–Russia, KZ–Kazakhstan) from the current study and collected amphipod species.

Code	Locality	Water body	Latitude	Longitude	Date	Species	Status
1 (RU)	Zam'yany	Volga River	46.825	47.605	05.05.2000	<i>Obesogammarus platycheir</i> (1♂)	Native
						<i>Pontogammarus abbreviatus</i> (1♂, 3♀)	Native
						<i>Pontogammarus robustoides</i> (2♂, 2♀)	Native
						<i>Wolgagammarus dzjubani</i> (1♀)	Native
2 (KZ)	Zelenoe	Ural River	48.166	51.525	26.05.2000	<i>Dikerogammarus bispinosus</i> (1♂, 4♀)	Non-native
3 (KZ)	Kulsary	Zhem River	47.051	54.060	25.05.2000	<i>Turcogammarus aralensis</i> (4♂, 2♀, 1 juv)	Non-native
4 (KZ)	Shetpe	spring	44.100	52.210	11.05.2000	<i>Gammarus</i> sp. (2♂, 1♀)	Native
4 (KZ)	Shetpe	spring	44.100	52.210	14.05.2000	<i>Gammarus lacustris</i> (many specimens)	Native
5 (KZ)	Aktau	Caspian Sea	43.627	51.175	12.05.2000	<i>Dikerogammarus</i> sp. (fragmented material)	–

compressus (Sars, 1894), *S. macrurus* (Sars, 1894), and *Wolgagammarus dzjubani* Mordukhai-Boltovskoi and Ljakhov, 1972.

There are reports of an additional invasive species in the Caspian basin, *Dikerogammarus bispinosus* Martynov, 1925. It was first mentioned from the Saratov reservoir (Volga River, Russia) by Voronin and Yermokhin (2004) between 2002 and 2003. However, Filinova and Sonina (2012) mention that this species appeared in the Saratov reservoir only in 2006, whereas Zinchenko and Kurina (2011) do not even report it from this reservoir. Likewise, this species was never reported from the Ural River, and thus Kazakhstan (Mordukhai-Boltovskoi 1964; Tarasov 1995; Pjatakova and Tarasov 1996). This conflicting evidence means the presence of *D. bispinosus* in the Caspian Sea basin remains uncertain.

Here, we report *D. bispinosus* for the first time from Kazakhstan and thus confirm its presence in the Caspian basin. This is the second locality where this species is mentioned in this basin and the easternmost point of its entire distribution range.

Material and methods

Samples were collected during May 2000 with a hand net and/or by visual inspection of submerged substrates from five localities throughout the northern and northeastern Caspian basin: the Volga River close to Zam'yany (Russia), the Ural River at Zelenoe, the Zhem (Emba) River at Kulsary, springs in Shetpe, and the Caspian Sea at Aktau (the last four sampling points are located in Kazakhstan) (Table 1). Animals were fixed in 96% ethanol. Individuals were examined under a Nikon SMZ1000 stereomicroscope and identified using the keys in Cărauşu et al. (1955), Stock (1974), Karaman and Barnard (1979), Stock et al. (1998) and Özbek and Özkan (2011). Total length was measured with Digimizer software (<https://www.digimizer.com/>) following the landmarks in Fišer et

al. (2009). Occurrence data for *D. bispinosus* was collected from the literature in order to provide an up to date overview of its distribution (Martynov 1925; Yaroshenko 1957; Dudich 1947; Dedyu 1967; Jażdżewski and Konopacka 1988; Eggers and Martens 2001; Müller and Schramm 2001; Brtek 2001; Müller et al. 2002; Sayapin 2003; Voronin and Yermokhin 2004; Tischikov and Tischikov 2005; Kley and Maier 2005; Žganec et al. 2009; Son et al. 2010; Labat et al. 2011; Filinova and Sonina 2012; Lipták 2013; Borza et al. 2015, 2017; Gallardo and Aldridge 2015).

Results

A total of nine taxa were identified (Figure 1): Zam'yany – *Obesogammarus platycheir* (Sars, 1896), *Pontogammarus abbreviatus*, *P. robustoides* and *Wolgagammarus dzjubani*; Kulsary – *Turcogammarus aralensis* (Uljanin, 1875); Shetpe – *Gammarus lacustris* Sars, 1863 and *Gammarus* sp. (unknown species); Aktau – *Dikerogammarus* sp. (specimens were damaged and further identification was not possible). Details are provided in Table 1.

One male (14.3 mm) and four ovigerous female (10.7–13.7 mm, 46–114 eggs) *D. bispinosus* were collected from the Ural River in the vicinity of the settlement Zelenoe, Kazakhstan. The identified specimens exhibited the usual morphological characteristics of this species. Diagnostic features are presented in Figure 2.

The compilation of own and literature data indicated that *D. bispinosus* has a broad geographical distribution (> 3000 km), being encountered from the Rhine estuary, throughout the lower Rhine (North Sea basin), Danube, Dniester, lower Dnieper and lower Don rivers (Black Sea basin) and reaches the middle Volga and lower Ural rivers (Caspian Sea basin) (Figure 3, Table 2). The record from this study represents the easternmost point of the species range (Figure 3).

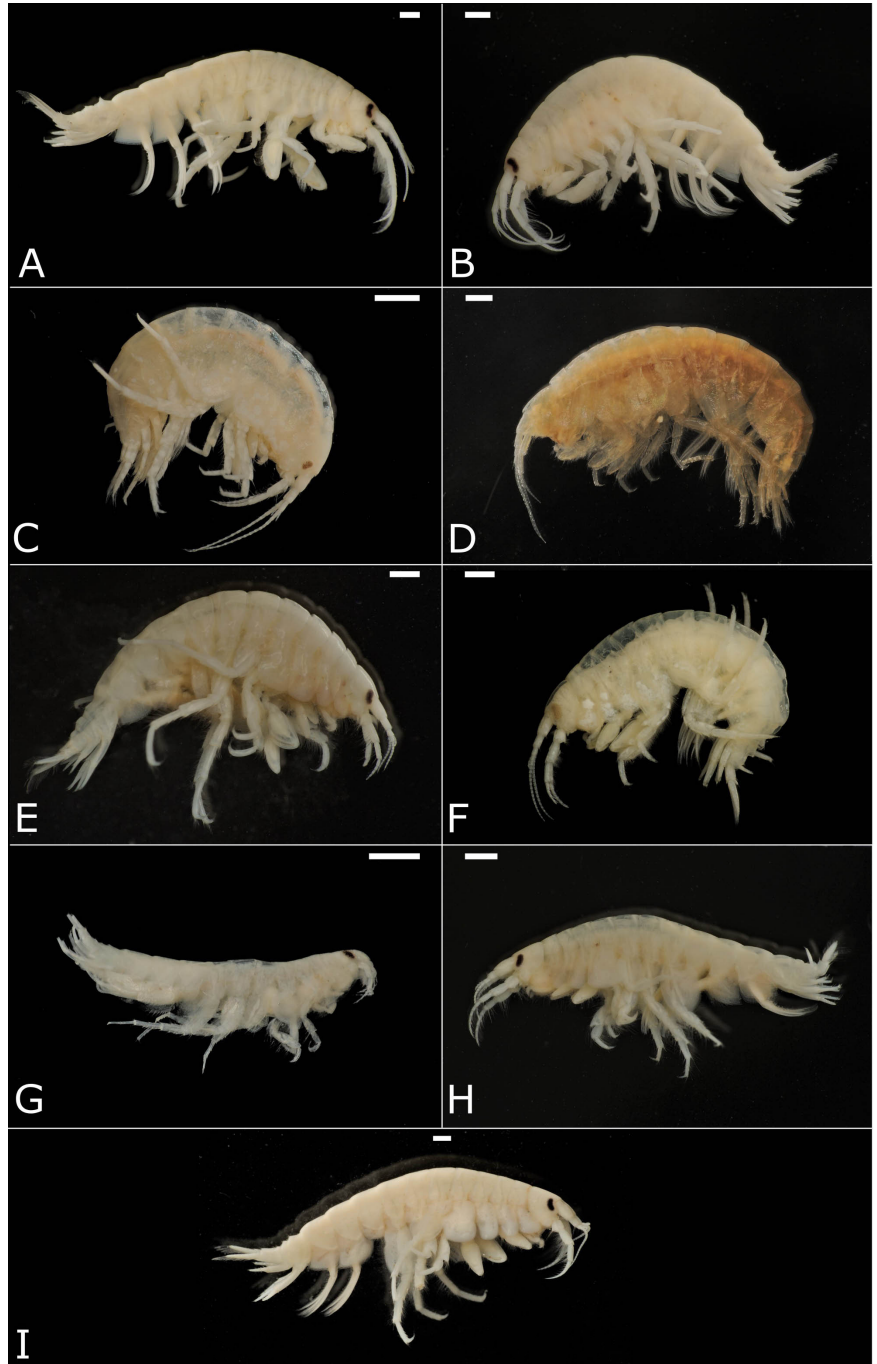


Figure 1. Habitus of amphipod species collected in the N and NE Caspian Sea basin in 2000.

A) *Dikerogammarus bispinosus*, male;
 B) *D. bispinosus*, female;
 C) *Gammarus* sp., male;
 D) *G. lacustris*, female;
 E) *Obesogammarus platycheir*, male;
 F) *Turcogammarus aralensis*, male;

G) *Wolgagammarus dzjubani*, female;
 H) *Pontogammarus abbreviatus*, male;
 I) *P. robustoides*, male.
 Scale bar = 1 mm.
 Photographs by Denis Copilaș-Ciocianu.

Discussion

Dikerogammarus bispinosus was described by Martynov (1925) from the lower Dnieper and appears to be native to the Black Sea basin (Cărăușu et al. 1955; Jążdżewski and Konopacka 1988). In Western

Europe it has spread throughout the southern invasion corridor reaching the Rhine estuary via the Rhine-Main-Danube canal (Bij de Vaate et al. 2002). This wide-ranging dispersal is contrasted by its considerable decline during recent decades in its native region in the lower Danube and also in Lake



Figure 2. Appendages of *Dikerogammarus bispinosus*, collected from the Ural River in the vicinity of settlement Zelenoe in 2000. A, B) antenna I; C, D) antenna II; E) epimeral plate II; F) telson; G, H) pereopod VII; I) uropod III; J, K) gnathopod II. Scale bar = 1 mm. Photomicrographs by Denis Copilaş-Ciocianu.



Figure 3. Geographic distribution of *Dikerogammarus bispinosus* and years of first reports. Localities from the current study are shown with triangles. Red triangle indicates the locality where *D. bispinosus* was collected. Question mark in SW Belarus is an unconfirmed/doubtful record and the black star indicates the position of the Volga-Don canal. See Table 2 for references.

Table 2. Regions where *Dikerogammarus bispinosus* has been recorded and years of first report. Localities marked with an asterisk need further confirmation.

Region	Country	Year	Basin	Latitude	Longitude	Reference
Lower Rhine	Netherlands	2008	North Sea	51.96	4.14	(Labat et al. 2011; Gallardo and Aldridge 2015)
Upper Rhine	France	2008	North Sea	47.68	7.51	(Labat et al. 2011)
Upper Danube	Germany	1998	Black Sea	48.80	12.97	(Eggers and Martens 2001)
	Austria	1998		48.31	14.32	(Müller and Schramm 2001; Borza et al. 2015)
Middle Danube	Hungary	1926	Black Sea	47.56	19.06	(Dudich 1947; Borza et al. 2015)
	Slovakia	1953		47.81	18.82	(Brtek 2001; Borza et al. 2015)
	Croatia	2009		45.72	18.90	(Žganec et al. 2009)
Lower Danube	Romania	1914	Black Sea	44.06	26.64	(Cărăușu et al. 1955; Popescu-Marinescu et al. 2001)
Lake Balaton	Hungary	1950	Black Sea	46.91	17.89	(Muskó 1994; Müller and Schramm 2001)
Upper Dniester	Ukraine	1928	Black Sea	48.51	26.50	(Jazdźewski and Konopacka 1988)
Lower and middle Dniester	Moldova/ Ukraine	1945–1950	Black Sea	46.71	29.96	(Yaroshenko 1957; Dedyu 1967)
Odessa Gulf	Ukraine	2009	Black Sea	46.55	30.81	(Son et al. 2010)
Bug*	Belarus	2005	Baltic Sea	52.07	23.65	(Tischikov and Tischikov 2005)
Lower Dnieper	Ukraine	1925	Black Sea	46.62	32.63	(Martynov 1925)
Lower Don	Russia	2003	Black Sea	47.57	40.84	(Sayapin 2003)
Middle Volga	Russia	2002	Caspian Sea	52.05	47.80	(Voronin and Yermokhin 2004)
Lower Ural	Kazakhstan	2000	Caspian Sea	48.166	51.525	This study

Balaton where it was introduced in 1950 (Borza et al. 2015, 2017). In European Russia it could have spread from the Black Sea to the Caspian basin through the northern corridor via the Volga-Don canal. This dispersal route is supported by the first reports from the Caspian basin in the Saratov reservoir (Volga River) between 2002 and 2006 (Voronin and Yermokhin 2004; Filinova and Sonina 2012) and throughout the lower Don (Black Sea basin) in 2003 (Sayapin 2003). In the present work, *D. bispinosus* was collected several years earlier and at a significant eastward distance from the Volga-Don canal (Ural River, > 800 km along the waterline), implying dispersal through the Caspian Sea. Furthermore, Tarasov (1995) does not mention this species in the Ural River several years earlier. The fact that all collected females from the Ural River were ovigerous suggests that the species was already established by the year 2000 in this area. Thus, overall the evidence indicates that invasion of the Caspian basin by *D. bispinosus* might have occurred sometime at the end of the 1990s. It seems that this species was never deliberately introduced into the Caspian basin. The only documented deliberate introduction of *Dikerogammarus* species took place between 1955 and 1959 from the Simferopol reservoir (Crimean Peninsula) to canals and reservoirs of Ukraine in the Black Sea basin (Grigorovich et al. 2002 and references therein). However, undocumented or unintentional introductions cannot be completely excluded either (Grigorovich et al. 2002). This further suggests that

the species could have dispersed naturally via the Volga-Don canal or was passively introduced through shipping activity.

On the other hand, it is also possible that *D. bispinosus* reached the Caspian basin earlier than the 1990s given that the Volga-Don canal was opened in 1952. Moreover, *D. bispinosus* was considered for a long time as a subspecies of *D. villosus* and only relatively recently was elevated to specific status based on mitochondrial and nuclear genetic markers (Müller and Schramm 2001; Müller et al. 2002). In addition, Pjatakova and Tarasov (1996) considered *D. villosus* (and consequently *D. bispinosus*) as a synonym of *D. haemobaphes*, so they may have overlooked *D. bispinosus* in the Caspian basin (Tarasov 1995). Similarly, it is likely that other authors did not distinguish *D. bispinosus* from *D. villosus* due to its subspecific status until 2002. Nevertheless, it appears that neither *D. villosus* is native to the Caspian basin (Mordukhai-Boltovskoi 1979), where it has been reported at least since 1964 (Mordukhai-Boltovskoi 1964), suggesting a similar dispersal route as for *D. bispinosus*. It is important to keep in mind that *Dikerogammarus* species are some of the most successful Ponto-Caspian invaders, being highly capable of dispersal in anthropogenic landscapes (Rewicz et al. 2014, 2015; Šidagytė et al. 2017). The only *Dikerogammarus* species that is most likely native to both basins is *D. haemobaphes* since it was described from the Black Sea but has been reported from the Caspian Sea since 1880 (Sars 1894), well

before the construction of the Volga-Don canal. In contrast, *D. caspius*, a native Caspian species, has spread into the Black Sea basin in recent times (Sayapin 2003). Thus, according to the available data, we tentatively conclude that even if *D. bispinosus* has been overlooked, it appears that it is not a native species in the Caspian basin and that it reached it between 1952 and late 1990s. Of course, at present, we also cannot completely rule out the possibility that it might be a native Caspian species. Phylogeography could prove invaluable in illuminating its origin and dispersal pathways. So far, *D. bispinosus*, *D. villosus* and *Shablogammarus shablensis* appear to be the only Black Sea native amphipod species that have spread into the Caspian basin (Grigorovich et al. 2002). Further upstream dispersal of *D. bispinosus* along the Volga and Ural rivers may be expected given its rheophilous affinity (Borza et al. 2017).

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