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Short communication

First record of the invasive species *Dikerogammarus villosus* (Crustacea: Amphipoda) in the Vltava River (Czech Republic)

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Abstract

Dikerogammarus villosus, an amphipod crustacean of the Ponto-Caspian origin, was introduced into the Labe (Elbe) River from the Danube River in 1998 after the opening several of man-made canals and by 2001 it had invaded the whole German course of the Elbe and the lower part of Czech course of the river. In September of 2008 *D. villosus* was found in the Vltava River, a tributary of the Labe (Elbe) River and the biggest river in the Czech Republic. The density and biomass of this species in the Vltava River in September of 2008 reached 214-247 ind. m^{-2} and 5-7 g wet weight m^{-2}. 40% of specimens in the study population were mature females and around 23% were juveniles (up to 6 mm), which indicates successful conditions for reproduction. *D. villosus* has become a major component of the macrobenthic fauna in large rivers of the Czech Republic, and further monitoring and assessment of its ecological significance in aquatic communities is warranted.

Key words: *Dikerogammarus villosus*, aquatic species introductions, Ponto-Caspian invader, range extension, Elbe/Labe River basin, Czech Republic

Introductions of exotic species have dramatically increased in the past few decades. The destruction of natural barriers between different basins of Europe in the 19th and 20th centuries is considered to be one of the most important factors, which have resulted in range extension of many species in different directions (Jażdżewski 1980; Ketelaars 2004). Rivers are considered among the most invadable systems, especially if they have been significantly changed by human activities. Construction of canals and alterations of rivers (dams, locks, etc.) has improved navigation but has also facilitated the accidental invasions of new species carried in ballast waters of ships (Josens et al. 2005).

In the case of the amphipod crustaceans it is assumed that the assemblages in the European rivers were rather stable until the mid 1960s (Pinkster et al. 1992). The opening of the Main–Danube Canal in 1992, which connected the Rhine and Danube rivers, resulted in the range extension of some Ponto-Caspian amphipods such as *Chelicorophium curvispinum* (Sars, 1895), *Obesogammarus obesus* (Sars, 1894), *Dikerogammarus villosus* (Sowinsky, 1894) and *D. haemobaphes* (Eichwald, 1941) from the Upper Danube River to the Rhine River (Van der Velde et al. 2000; Bij de Vaate et al. 2002) and further extension of their ranges in different directions. The ability of most amphipods to migrate long distances is a common behavioural trait in freshwater, as well as marine, ecosystems and has facilitated their range expansion via man-made waters ways (Berezina 2007).

Dikerogammarus villosus is a very recent amphipod invader in European waters. Similar to other Ponto–Caspian invaders, it occurs naturally in the lower courses of large rivers in the Black, Caspian and Azov Sea basins (Mordukhai-Boltovskoi 1960). It has spread to Western Europe through the southern and central migration corridors (Bij de Vaate et al. 2002; Grabowski et al. 2007). Outside its natural range, it was first found in the upper Danube in 1992 by Tittizer et al. (1994), and it soon penetrated into the Rhine River via the Main–Danube Canal (Bij de Vaate and Klink 1995). From the Rhine River,

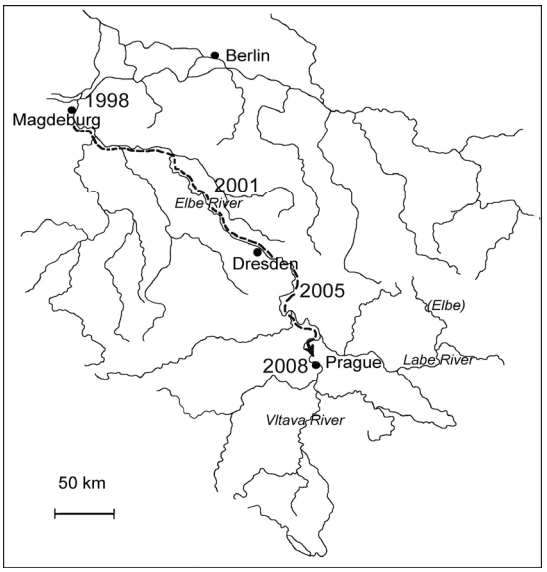

Figure 1. Map of the Elbe River and Vltava River with year of records of *Dikerogammarus villosus.*

D. villosus continued its range expansion eastward by using the Mittelland Canal joining the Rhine, Weser, Elbe (both German and Czech parts) and Oder rivers basins (Grabow et al. 1998; Grabowski et al. 2007).

In the Elbe River, *D. villosus* was probably introduced near Magdeburg in 1998 (Tittizer et al. 2000) and in one year the species occurred over a 500 km stretch downstream. By 2001, it had invaded the whole German course of the Elbe River (Krieg 2002; Nehring 2006). In 2003-2004, *D. villosus* was monitored as an abundant species in the River Elbe, with a continuing increase in abundance towards the river mouth (Koop et al. 2008). The high dispersal rate of this species has been noted in various rivers (Josens et al. 2005; Bacela et al. 2008). For example, in the Meuse River it spread upstream at a rate of 30-40 km per year (Josens et al. 2005). From the Elbe River, *D. villosus* most probably dispersed widely (Müller et al. 2001; Jażdżewski et al. 2002). This species has spread to the Bug River in Poland (Konopacka 2004) and almost along the entire stretch of the Oder (Grabowski et al. 2007) and was also found recently in the Vistula River (Bacela et al. 2008). Obviously, it colonized Elbe, Vltava and Oder rivers through the southern corridor, while Bug and Vistula from the central one.

At present, the Czech fauna of the amphipod crustaceans is comprised of eight species [*Crangonyx subterraneus* Bate, 1859; *Gammarus roeselii* Gervais, 1835; *G. fossarum* Koch, 1836; *Niphargellus arndti* (Schellenberg, 1933), *Synurella ambulans* (O. F. Müller, 1846), *Niphargus aquilex* Schiödte, 1955, *N. tatrensis* Wrześniowski, 1888], and *Dikerogammarus villosus* (Hrabě 1954; Straškraba 1958, 1962; Roušar 1981, 1982; Sukop and Sedlák 1999; Ďuriš and Horká 2005). The Balkan species *G. roeselii* and the Ponto-Caspian *D. villosus* are allochtonic elements in fauna of the Czech Republic.

D. villosus is currently being distributed through some watercourses of the Czech Republic (Ďuriš and Horká 2005; Petrusek and Beran 2006). It was first recorded in the Czech Republic in the lowest 40 km part of the Labe (Elbe) River in 2003 where reported near Hřensko, Loubí and Střekov (Starcová 2003; Špaček et al. 2003). By 2005 *D. villosus* had spread at least to Kly near Mělník in the Labe River – about 105 km upstream of the German border, and 5 km upstream of the confluence of the Vltava River into the Labe (J. Špaček – see: Petrusek 2006). Considering the cases of big European rivers, such as the Rhine (Dick and Platvoet 2000; van Riel et al. 2006), Meuse (Josens et al. 2005) and others, we may expect fast colonization of this invader up the Labe River and also penetration to its main tributary, the Vltava River.

The Vltava River (430 km, basin area 28 090 km²) is the largest river in Czech Republic, and winds northwards through Bohemia (Figure 1). Despite being longer than the Labe upstream of the confluence and having greater discharge and a larger drainage basin, due to historical reasons the Vltava River is regarded as tributary (the Vltava meets the Labe at almost a right angle, so it appears to be a tributary), and the river after the confluence is called the Labe (and then Elbe in Germany).

Sampling of amphipods was carried out on September, 25 and 26, 2008 in shallow areas (0-1 m) of the Vltava in Prague (50°05′N, 14°25′E, Figure 2) near the Charles and Mánes Bridges (Table 1: sites 1 and 2). The substrate at the locations studied consists of gravel and stones covering 80% of bottom area (Figure 3), with developed growth of filamentous algae on the substrate surface. All amphipods were collected from the lower surface of stones and preserved by 70% ethanol. Then, the largest surface area of the stones was measured using 200×300 mm^2

Figure 2. The Vltava River in Prague with the Charles Bridge (photo by N.A. Berezina).

Figure 3. Habitat of *Dikerogammarus villosus* in the Vltava River (photo by N.A. Berezina).

Table 1. Records of *Dikerogammarus villosus* in the Vltava River in Prague area, with abundance, biomass and sex ratio of the species.

Site	Location	Record date	Depth [m]	Abundance [ind./m²]	Biomass [g/m²]	Male/female ratio
1	Charles Bridge	25 Sep. 2008	0.2	247 ± 30	5.03	0.86
2	Mánes Bridge	26 Sep. 2008	0.4	214 ± 27	7.05	1

graph paper. The sex, size and biomass of specimens were evaluated in the laboratory. The density (biomass) of animals was calculated as ind. m^{-2} (g wet weight m^{-2}) of bottom surface (in the stony littoral zone) taking into account the largest stone surfaces and the coverage area.

The Ponto-Caspian invader *D. villosus* (Figure 4) was found at both sites in the River Vltava with respective average densities of 247 (± 30 SE) and 214 ind.m^{-2} (± 27 SE). Biomass reached 5 and 7g (wet weight) m^{-2}. A total of 35 *D. villosus* individuals were found, 37% of them males, 40% females, and the remainder juveniles (up to 6 mm). The body lengths of males and females were 9.1-14.3 and 6.5-12.5 mm, respectively (Figure 5). Similarly, in the Don River (August-September 1959) males and females reached 9.8-12.4 and 8-11 mm, respectively (Ioffe and Maximova 1968).

The life history of *D. villosus* in different regions has been previously studied by Ioffe and Maximova (1968), Kley and Maier (2003), Devin et al. (2004), Pöckl (2007), etc. and it is a species with high reproductive capacity. According to Pöckl (2007), in an Austrian stretch of the River Danube the mean population fecundity was 43 eggs per female in specimens with the body length ranging from 12 to 18 mm, with a maximum of 194 eggs (stage 4, after Pöckl 1993). In addition, the survival rate of eggs was high (74%). A similar fecundity rate was observed in females of a *D. villosus* population in native areas, varying between 11 and 211 eggs per female in specimens with the range of body length ranging from 7.1 to 19 mm (Ioffe and Maximova 1968).

Most specimens in the population studied were mature females, which along with the greater than 20% proportion of juveniles indicate successful reproduction in the recipient conditions. The rather high population density of this invasive amphipod has enabled it to become a major component of the macrobenthic assemblages in the Vltava River, evidently eliminating other invertebrate species as has happened in other ecosystems it has invaded. *D. villosus* appears to be an omnivorous feeder: it can act as a filter-feeder (Poyni 1961; Platvoet et al. 2006), or as a predator preying upon other macroinvertebrates and fish eggs or juveniles

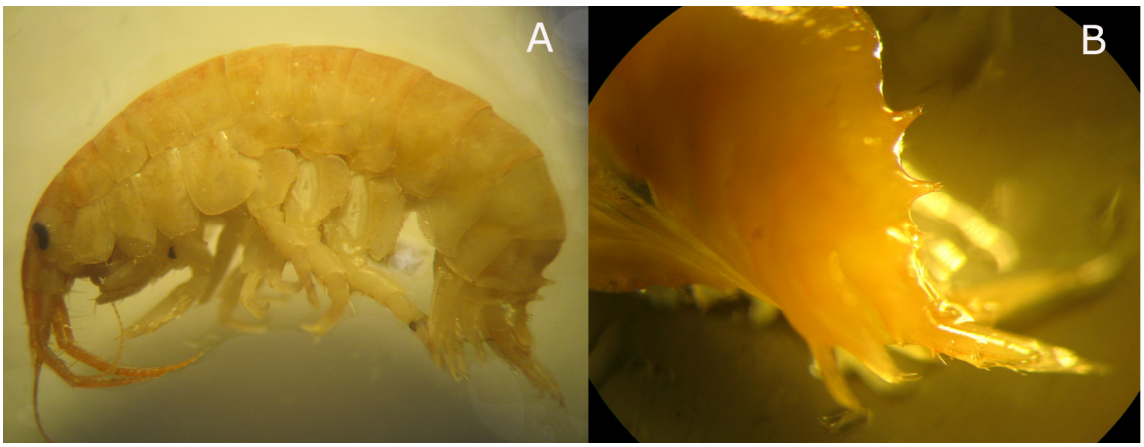

Figure 4. *Dikerogammarus villosus*, general view (A), urosome (B) (photographs by N.A. Berezina).

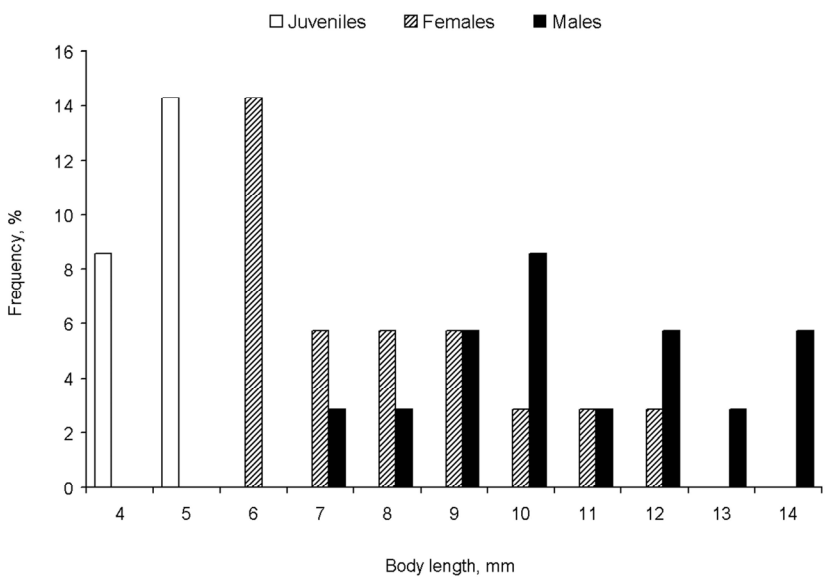

Figure 5. Size-sexual structure of population of *Dikerogammarus villosus* at the both study sites combined (the size classes 4, 5, 6, etc. mm start with the given length).

(Devin et al. 2003; Dick and Platvoet 2000; Dick et al. 2002; Van Riel et al. 2006). A substantial predatory impact of the invasive *D. villosus* on invertebrates has been found in several aquatic ecosystems of Europe (Tittizer et al. 2000; Dick et al. 2002; Krisp and Maier 2005, Van Riel et al. 2006), and isotope ($\delta^{15}N$) analysis has shown that large specimens of *D. villosus* have the same trophic status as benthivorous fish (Marguillier 1998).

The consequences of the spread of *D. villosus* to the River Vltava need further assessment; because it is clear that the impact of this invasive species on ecosystems can result in serious changes in aquatic communities.

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