Acta Zoologica Lituanica, 2007, Volumen 17, Numerus 1
ISSN 1392-1657

DISTRIBUTION OF PONTO-CASPIAN AMPHIPOD *PONTOGAMMARUS ROBUSTOIDES* IN LATVIAN WATERS

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Abstract. Data of the monitoring of inland waters, conducted during 1999–2005, show that the alien Ponto-Caspian amphipod *Pontogammarus robustoides* is quite widespread in Latvia. The species was detected at 15 monitoring sites. This non-indigenous amphipod occurs in the lower reaches and mouths of rivers emptying into the Baltic Sea, water reservoirs located on the Daugava River, and nearshore lakes which are connected to the brackish waters of the sea. The spread of *P. robustoides* in the lower reaches of the Daugava River and its water reservoirs must have originated from the intentional introduction of this amphipod into the Keguma Water Reservoir in the 1960s. Meanwhile, the invasion of this amphipod into the lower reaches of other Latvian rivers and nearshore lakes, including the vicinities of the Baltic Sea ports Ventspils and Liepaja, proceeded from areas already invaded by *P. robustoides* by migrating through the Baltic Sea waters, probably in hull fouling of ships. The closest source populations, which might have contributed to the dispersal of this aquatic invader, inhabited the Curonian Lagoon and the mouth of the Daugava River.
Key words: amphipod, non-indigenous, Ponto-Caspian, inland waters

Introduction

The Ponto-Caspian amphipod *Pontogammarus robustoides* first appeared in the Baltic Sea basin as a result of its intentional introduction into the Kaunas Water Reservoir (WR), located on the Nemunas River, in 1960–1961. Three species of amphipods, including *P. robustoides*, and mysids of Ponto-Caspian origin were introduced so as to improve the fish-food base (Gasiūnas 1972). Recently, this alien amphipod has become widespread in the southern part of the Baltic Sea basin. It occurs in inland waters of Lithuania, Poland and Germany, and was also detected in the Gulf of Finland (Jazdzewski 1980; Jazdzewski & Konopacka 2000; Martens *et al*. 1999; Arbačiauskas 2002, 2005; Berezina & Panov 2003).

In the 1960s, during the bout of introductions of aquatic invertebrates in the former Soviet Union, non-native amphipods and mysids (after the establishment of their populations) were translocated from the Kaunas WR to the regions located to the north of Lithuania, in particular to Latvia, Estonia and the St. Petersburg region (Gasiūnas 1972). The intention of these introductions was to supplement the food base for commercially important fish. In Latvia, Ponto-Caspian mysids and amphipods were first introduced in 1964 into eutrophic Lake Lielais Baltezers (Fig. 1). After a few years the Ponto-Caspian mysid *Paramysis lacustris* was reported to be established in this lake (Kachalova & Lagzdin 1968). Meanwhile, alien amphipods were never recorded in Lake Lielais Baltezers. During 1965 and 1966, Ponto-Caspian species including the amphipods *P. robustoides* and *Chaetogammarus warpachowskyi*, and the mysids *P. lacustris* and *Limnomysis benedeni* were also introduced into the Keguma WR located on the Daugava River (Fig. 1). The study of 1967–1968 confirmed the acclimatisation of the mysid *P. lacustris*, which produced three generations per year and was consumed by the perch (Kachalova & Lagzdin 1968). The subsequent investigation of fish nutrition in the Keguma WR during 1971–1972 also indicated the establishment of the Ponto-Caspian amphipod *P. robustoides*. Its proportion in perch food contents during certain periods amounted to 36–48%, whereas the share of the mysid *P. lacustris* was substantially lower and made up about 1–5% of the consumed food (Bodniece 1976). Since then no information has been published on Ponto-Caspian peracaridan species in Latvian waters. The purpose of this work is to present information on the current distribution of the Ponto-Caspian amphipod *P. robustoides* in inland waters of Latvia.

Material and methods

Recently, extensive monitoring of water resources has been undertaken in Latvia to preserve the existing and possible future drinking water supplies and to protect aquatic ecosystems. This activity is linked to the EU Water Framework Directive (2000/60/EC). To obtain an indication of the overall water quality, both biological and chemical monitoring is carried out. Separate biological components of aquatic ecosystems are monitored with respect to optimal time for each of them. Specifically, benthic macroinvertebrates were sampled in spring and/or autumn (May and October), while macrophytes and phytoplankton – during summer (July and August).

This work reports the results of qualitative sampling of benthic macroinvertebrates, i.e. the presence/absence of *P. robustoides* in monitoring samples, obtained during 1999–2005. During this period, the surface water-monitoring program was undergoing a change. As a result, the number of monitoring sites varied in different years and the relocation of monitoring sites took place. The total number of the studied monitoring sites before 2002, in 2002, 2003, 2004 and 2005 was less than 46, 46, 89, 97 and 99, correspondingly. Therefore, the whole study period was divided into three arbitrary periods: 1999–2002, 2003–2004 and 2005. The location of monitoring sites in large Latvian rivers is given in Figure 1. Monitoring samples were collected with a benthic hand-net with a 25 × 25 cm mouth (0.5 mm mesh size). In littoral habitats of each monitoring site, 10 individual samples were taken at depths down to 1.5 m and pooled together for analysis. Animals in pooled samples were counted and identified, when possible, to species level. Characteristics of rivers, water reservoirs and lakes in which the alien amphipod *P. robustoides* was detected are presented in Tables 1 and 2 (Kļavinš & Cimdiņš 2004). Mean annual concentrations of oxygen and nutrients in rivers, and nutrients in lakes and water reservoirs (see Table 3) were based on 10 and 4 measurements each, respectively. Water quality of the rivers invaded by *P. robustoides* was estimated as good, whereas that of water reservoirs and lakes was assessed as moderate (LEGMA 2005).

Results and discussion

During 1999–2005, the Ponto-Caspian amphipod *P. robustoides* was found at 15 monitoring sites located in the lower reaches or mouths of Latvian rivers emptying into the Baltic Sea, three water reservoirs located on the Daugava River and two nearshore lakes which are connected with the seawaters. Meanwhile, other rivers or upstream sections of the rivers already invaded by the alien amphipod were devoid of it (Fig. 1). Some chemical characteristics, dominating vegetation

Table 1. Characteristics of Latvian rivers in the lower reaches of which *Pontogammarus robustoides* was detected.

Rivers	Length, km		Watershed, 10^3 km²	
	Total	in Latvia	Total	in Latvia
Daugava	1,005	352	87.9	24.7
Gauja	452	452	8.9	7.8
Lielupe	119	119	17.6	8.8
Saka	6	6	1.1	1.1
Salaca	95	95	3.6	3.3
Venta	346	178	11.8	7.9

Table 2. Characteristics of Latvian lakes and water reservoirs (WR) inhabited by *Pontogammarus robustoides*. Trophic status: mesotrophic with eutrophic traits (m-e), eutrophic (e).

Water body	Area, km²	Mean depth, m	Maximum depth, m	Trophic status
Keguma WR	24.9	9.5	16.5	m-e
Lake Kisezers	17.3	2.4	4.2	e
Lake Liepajas	37.2	2.0	2.8	e
Plavinu WR	34.9	14.6	42.0	m-e
Rigas WR	42.4	7.5	18.0	m-e

and the occurrence of *P. robustoides* during the study period at monitoring sites where *P. robustoides* was detected are given in Table 3. Our results suggest that currently *P. robustoides* is quite widespread in inland waters of Latvia. However, it occurs mainly in the lower reaches of rivers flowing into the sea and probably does not disperse far upstream. The detection of *P. robustoides* at a few monitoring sites only in 2005 also suggests that dispersal of this species in Latvian waters is probably ongoing (monitoring sites 2, 5, 6 and 14 in the Saka, Lielupe and Gauja Rivers; Table 3, Fig. 1).

P. robustoides has definitely the widest distribution among non-native amphipods in inland waters of Latvia as it was the only alien amphipod species detected in our samples. Other Ponto-Caspian amphipods, i.e. *Obesogammarus crassus* and *C. warpachowskyi*, which have established permanent populations in inland waters of Lithuania after their intentional introduction, also can live in Latvian waters. *P. robustoides* is the most ecologically successful alien amphipod species in inland waters of Lithuania, also (Arbačiauskas 2002). This success probably may be related to a higher tolerance of this species to oxygen deficiency (that can emerge during winter or mid-summer, especially in eutrophic waters) than that of other Ponto-Caspian amphipods which have invaded the Baltic Sea basin (Dedyu 1980; Arbačiauskas 2005).

Although monitoring samples of benthic macroinvertebrates were qualitative, our results suggest that the most numerous populations of *P. robustoides* inhabited Lake Liepajas, Lake Kisezers, and the mouths of the Daugava and Venta Rivers. There, the newcomer comprised 16.5, 27.0, 21.6 and 16.5% of the total number of animals in a sample, correspondingly. The impact of *P. robustoides* on native communities in the places that favour the development of its populations is of interest and warrants investigation. Generally, it is considered that invading amphipods can alter native invertebrate communities drastically (Kelly *et al*. 2003). In the stony littoral of the Neva Bay, the Gulf of Finland, *P. robustoides* together with another alien amphipod has reduced the density of native benthic detritivores (Berezina & Panov 2003). It is noteworthy, that during the study period *P. robustoides* never co-occurred in a sample with native amphipod species. In inland waters of Lithuania, the negative impact of this alien

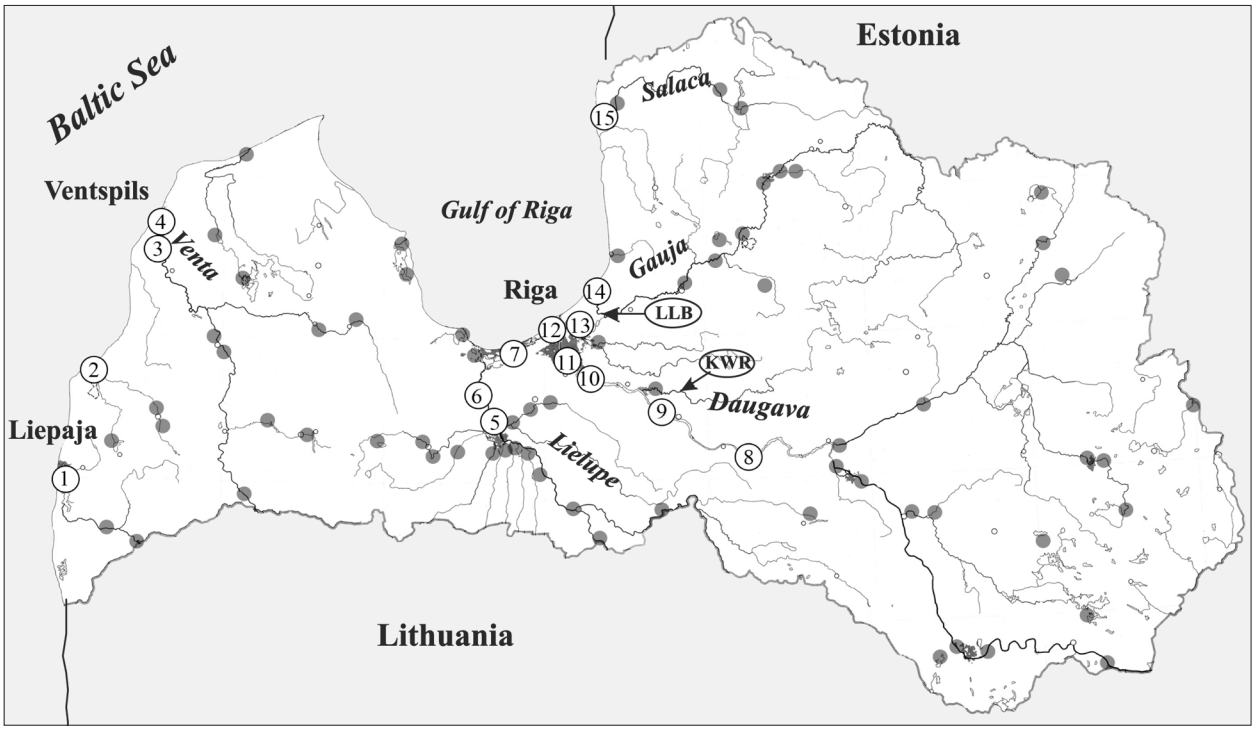

Figure 1. Monitoring sites in inland waters of Latvia. Open circles with numbers indicate sites where *Pontogammarus robustoides* was detected during 1999–2005. Numbers in circles correspond to numbers of monitoring sites in Table 3. Closed circles indicate monitoring sites in large rivers devoid of alien amphipod. Lake Lielais Baltezers (LLB) and the Keguma Water Reservoir (KWR) into which Ponto-Caspian species were intentionally introduced during 1964–1966 are indicated by arrows.

Table 3. Monitoring sites at which the non-native amphipod *Pontogammarus robustoides* was detected during 1999–2005. Mean annual characteristics of 2005 in mg L^{-1}: dissolved oxygen (O); total nitrogen (N); total phosphorus (P). Dominating vegetation: *Acorus calamus* (AC), *Ceratophyllum demersum* (CD), *Cladophora* sp. (Cs), *Elodea canadens* (EC), *Glyceria maxima* (GM), *Myriophyllum spicatum* (MS), *Nuphar lutea* (NL), *Phragmites australis* (PA), *Potamogeton* sp. (Ps), *P. pectinatus* (PPc), *P. perfoliatus* (PPr), *Sagittaria sagittofolia* (SS), *Schoenoplectus lacustris* (SL), *Spirodela polyrhiza* (SP). Monitoring periods: 1999–2002 (1), 2003–2004 (2), 2005 (3). Occurrence: present (+), absent (0), site was not monitored during the indicated period (-), total number of samplings (n) (in 2003–2004 and 2005, each monitoring site were sampled 3 times and 1 time, correspondingly).

No	Monitoring site	O	N	P	Vegetation	Monitoring periods			n
						1	2	3	
1	Lake Liepajas		1.00	0.051	PA, SL, Ps, EC, Cs	+	+	+	11
2	Saka River, 4.5 km upstr. mouth	8.8	1.17	0.078	PA, SP, NL, GM, SS	-	0	+	4
3	Venta River, Vendzava	9.2	1.40	0.061	MS, EC, PPc	+	+	+	14
4	Venta River, mouth and 0.5 km upstr. Ventspils	9.4	1.75	0.063	PA, NL, PPr	+	+	+	14
5	Lielupe River, 2.5 km downstr. Jelgava	10.4	2.64	0.070	PA, CD, SS, NL, SL	0	0	+	12
6	Lielupe River, 0.5 km downstr. Kalnciems	9.0	3.00	0.106	PA, CD, NL, SL	-	0	+	4
7	Lielupe River, mouth	10.4	2.54	0.093	PA, NL, CD	+	0	+	13
8	Plavinu Water Reservoir		1.46	0.070	MS	-	+	0	4
9	Keguma Water Reservoir		1.47	0.070	PA, SL, NL	-	+	+	4
10	Rigas Water Reservoir		1.44	0.070	MS	-	+	+	4
11	Daugava River, 0.1 km downstr. island Dole Sala				Cs, SL, PPc, PPr, SS, SL, NL	+	+	-	14
12	Daugava River, mouth	10.0	1.36	0.076	PA, Cs, SL, Ps	+	0	+	12
13	Lake Kisezers		1.47	0.060	PA, Cs, SL, PPc, PPr, SS	+	+	+	14
14	Gauja River, mouth	10.9	1.32	0.073	PA, Cs	0	0	+	14
15	Salaca River, mouth	11.4	1.61	0.052	AC, Cs, SL, PPr, PPc	+	+	+	12

amphipod on native amphipods is currently well-documented (Arbačiauskas 2002, 2005).

The spread of *P. robustoides* in the lower reaches of the Daugava River and its water reservoirs, where this species is also present, resulted from the intentional introduction of this amphipod into the Keguma WR and the subsequent natural dispersal. On the other hand, its invasion into the lower reaches of other Latvian rivers and nearshore lakes, including the vicinities of the Baltic Sea ports Ventspils and Liepaja, must have proceeded by migrating through the Baltic Sea waters, probably in hull fouling of ships. Although *P. robustoides* usually establishes sustainable populations only in salinities not exceeding 3–4 PSU (Grabowski *et al*. 2006), the salinity of Baltic coastal waters (7 PSU) permits a high survival rate and even reproduction of this amphipod species (Berezina & Panov 2003). The closest source population, which might have contributed to the dispersal of *P. robustoides* across Latvian waters, resided in the Curonian Lagoon. Later, after the invasion of *P. robustoides* into the mouth of the Daugava River due to its downstream migration from the Keguma WR, its spread over the Baltic Sea waters from this point is also to be considered.

Acknowledgements

The study was performed under the Latvian Surface Water Monitoring Program.

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Ponto-Kaspijos šoniplaukos *Pontogammarus robustoides* paplitimas Latvijos vidaus vandenyse

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Santrauka

1999–2005 m. vidaus vandenų monitoringo duomenys parodė, kad svetimkraštė Ponto-Kaspijos šoniplauka *Pontogammarus robustoides* yra gana plačiai paplitusi Latvijoje. Rūšis rasta 15 monitoringo vietų. Ši nevietinė šoniplauka sutinkama upių, įtekančių į Baltijos jūrą žemupiuose ir žiotyse, Dauguvos upės vandens talpyklose ir sujungtuose su druskėtais jūros vandenimis priekrantės ežeruose. Po Dauguvos žemupį ir jos vandens talpyklas *P. robustoides* plitimas turėjo vykti iš Kegumos vandens talpyklos, į kurią šešiasdešimtaisiais ši šoniplauka buvo tikslingai introdukuota. Tuo tarpu invazija į kitų Latvijos upių žemupius ir priekrantės ežerus, tame tarpe ir vandenis, besijungiančius su Ventspilio ir Liepojos jūrų uostais, tikriausiai vyko migruojant per Baltijos jūros vandenis laivų korpusų apaugimuose iš tų vietų, kur ši Ponto-Kaspijos šoniplauka jau buvo įsitvirtinusi, pirmiausiai iš Kuršių marių ir Dauguvos žiočių.

Received: 28 February 2007
Accepted: 15 March 2007