Aquatic Invasions (2009) Volume 4, Issue 2: 327-335
DOI 10.3391/ai.2009.4.2.4

Research article

Ponto-Caspian amphipods in Croatian large rivers

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Received 12 March 2009; accepted in revised form 3 April 2009; published online 10 April 2009

Abstract

This study examines distribution of non-indigenous amphipods in Croatian large rivers and hypothesizes distributional changes of alien and native amphipods in these rivers on the basis of historical records. Samples were collected at 42 sites in the Sava, Drava, Kupa and Danube Rivers during the period from 2004 to 2008. Occurrence of five Ponto-Caspian amphipod species was recorded: *Chelicorophium curvispinum*, *Dikerogammarus bispinosus*, *D. haemobaphes*, *D. villosus* and *Obesogammarus obesus*. *C. curvispinum* was the most widespread species, recorded in all four examined rivers, at 20 sites in total. This species now inhabits the whole Croatian part of the Danube River and it has invaded Sava and Drava Rivers, about 500 and 210 km upstream from the mouth, respectively. *D. villosus* was the dominant gammarid species at all sites in the Danube. The species was also found in the section of the Drava River up to 175 km upstream from the river mouth, but it was not recorded in the Sava River. *D. haemobaphes* exhibited the same distribution in the Sava River as *C. curvispinum*, while in the Drava River it was found only at two sites (175 and 195 km from river mouth). *D. bispinosus* and *O. obesus* were recorded only in the Danube. Based on the comparison of historical records with present distribution of non-indigenous amphipods in the middle course of Danube, Sava and Drava Rivers, we conclude that *C. curvispinum* and *D. haemobaphes* were the first Ponto-Caspian invaders in these rivers, followed by *O. obesus* only in Danube and *D. villosus* in Danube and Drava. The latter species replaced *D. haemobaphes* in the middle part of Danube and in lower course of Drava, while it did not colonize the Sava River.

Key words: *Dikerogammarus bispinosus*, *D. haemobaphes*, *D. villosus*, *Obesogammarus obesus*, *Chelicorophium curvispinum*, Sava, Drava, Danube

Introduction

Amphipod crustaceans are among the most successful invertebrate invaders of freshwater ecosystems, whose invasion success is comparable to that of molluscs. During the last century European freshwaters have been heavily invaded by many amphipod species originating mostly from Ponto-Caspian basin and North America (Jazdzewski 1980; Van der Velde et al. 2000). The most important features of their ecology and behaviour that promoted this invasion success are relatively short generation time, rapid growth, early sexual maturity, high fecundity, protection of juveniles, non specific food preferences with predator appetite, euryoeciousness and eurihalinity (Van der Velde et al. 2000; Bij de Vaate et al. 2002; Grabowski et al. 2007). Amphipod range extension in Europe occurred mainly through unintentional introduction events, mainly by transport on ships or in ship ballast waters. Apart from unintentional introductions, amphipods were also intentionally introduced as fish food into lakes, and into newly formed impoundments and fishponds (Jażdżewski 1980). However, by far the most important human activity that facilitated the spread of alien species in European freshwaters, were interconnections of large European rivers through numerous canals.

This enabled species spread into formerly separate river basins (Jażdżewski 1980; Bij de Vaate et al. 2002). Successfully established alien amphipods, especially gammarids, usually have severe impact on benthic communities which they invade; in many places alien gammarids have outnumbered or even completely replaced native species (Pinkster at al. 1992; Dick and Platvoet 2000; Jazdzewski et al. 2004; Bernauer and Jansen 2006) and also had strong predatory impact on other macroinvertebrates (Krisp and Maier 2005). Newly established amphipod invaders can have an impact on other already established non-indigenous species (Dick and Platvoet 2000). For example, *Chelicorophium curvispinum*, can reduce the availability of stony substrate necessary for the attachment of Zebra mussel (*Dreissena polymorpha*), another mass invader of freshwaters (Van der Velde et al. 2000).

In the recent study of invertebrate communities in the Danube, Paunović et al. (2007) recorded four species of Ponto-Caspian amphipods, at four different sites on the section that forms the easternmost Croatian border. However, highly invasive Ponto-Caspian amphipods (*Chelicorophium curvispinum*, *Dikerogammarus haemobaphes* and *D. villosus*) were recorded in the upstream Hungarian parts of the Danube already in the first half of 20th century (Dudich 1927, 1947; Muskó 1994), while records of *C. curvispinum*, *Dikerogammarus bispinosus* and *D. haemobaphes*, from downstream parts of the Danube nearest to Croatian reach, were made in 1950's and 60's (Karaman 1953; Pljakić 1965).

Rivers Sava and Drava are the largest tributaries of the Danube River in Croatia. These rivers have been and still are potential corridors for the spread of Ponto-Caspian alien and invasive amphipod species into Croatian waterways. However, invertebrate fauna of these rivers was sparsely studied, and in the few conducted studies, amphipod fauna was not determined to species level. Only four records of alien amphipods in Croatian rivers were published. These records originate from the middle section of the Sava River and were determined as *Corophium* sp. and *Pontogammarus* sp. (Matoničkin et al. 1975). Recently, *D. haemobaphes* was recorded by Karaman (2007) in the lower (Serbian) course of the Sava. The scarcity of detailed amphipod studies of the Drava and Sava Rivers, combined with the lack of scientific experts for this group, contributed to the fact that there are no published records of Ponto-Caspian amphipods, determined to species level, for Croatian part of these rivers. Furthermore, the distribution of these species, already present in Croatian watercourses, is completely unknown.

Hence, the objectives of this study are: (i) to determine the distribution of Ponto-Caspian amphipod species in the Croatian part of the Sava, Drava and Danube Rivers, and (ii) to give an overview of historical records of amphipods in these rivers, both in Croatia and neighbouring countries, in order to investigate and understand distributional changes of alien and native amphipods in these rivers.

Material and Methods

Samples analysed in this study were collected during different field studies conducted in the Sava, Drava, Kupa and Danube Rivers, in the period from 2004 to 2008. Altogether, samples were obtained from twelve sites in the Sava, twenty two sites in the Drava, seven sites in the Danube and one site in the Kupa River. At majority of sites on the Drava and the Danube, qualitative samples on all available microhabitats were collected during 2007 and 2008 with benthos nets on the banks during low discharge. At some sites (Db2, D14, D16-21 in Figure 1) at these two rivers, only large specimens under stones were collected. Amphipod samples at sites S6-S12 in Sava and at four sites in Danube River (Db1,3,5,6) were collected by benthos nets during 2-4 months in 2004 and 2005. Samples from three sites in the Sava (S2-S4) and three sites in Danube (Db4,5,7) were collected in 2007 during regular water quality monitoring, while at sites S1, S11, D15 and K twenty quantitative samples were collected in 2006 using the standardized method developed in the AQEM project (Hering et al. 2004). Amphipods were identified using the keys of Cărăuşu et al. (1955), Karaman and Pinkster (1977a, b), and Eggers and Martens (2001).

Results

Five Ponto-Caspian amphipod species were recorded in Croatian large rivers: *Chelicorophium curvispinum* (G.O. Sars 1895), *Dikerogammarus bispinosus* (Martynov 1925), *Dikerogammarus haemobaphes* (Eichwald 1841), *Dikerogammarus villosus* (Sowinsky 1894) and

Obesogammarus obesus (G.O. Sars 1894). Alien amphipod species were recorded at 31 out of 42 examined sites. They were not found only at six upstream sites in the Sava (S1-6), and at five upstream sites in the Drava (D1-D3, D5, D7) (Figure 1, Annex 2). In the lower course of the Sava only two species, *D. haemobaphes* and *C. curvispinum*, were found, while in the Drava *D. villosus* and *C. curvispinum* occurred at most sites, and *D. haemobaphes* was found only at sites D12 and D13. In the Danube *D. haemobaphes* was not found, but two additional species, *D. bispinosus* and *O. obesus*, were recorded.

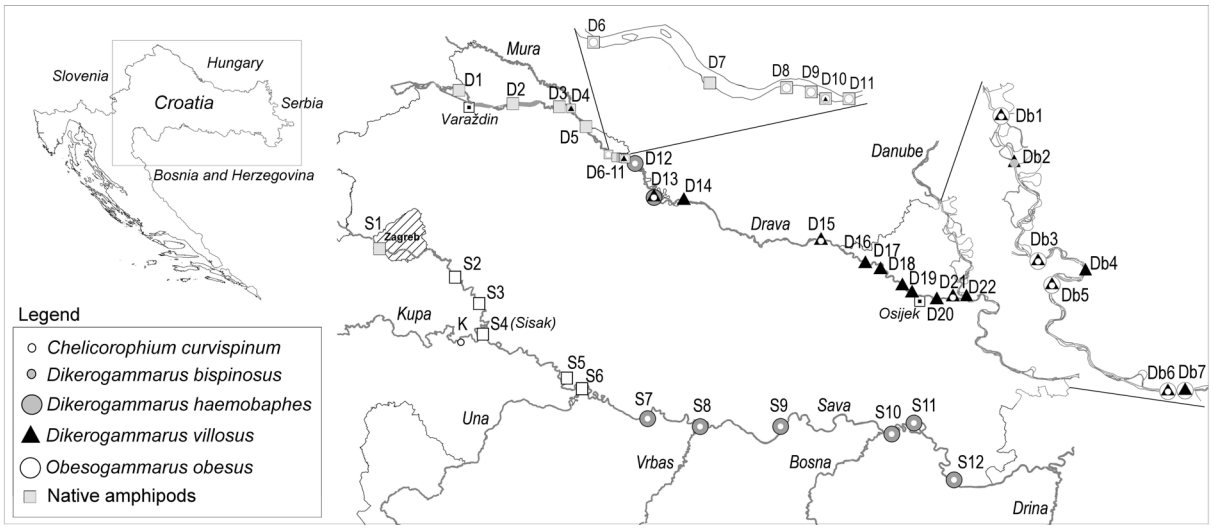

Figure 1. Distribution of five Ponto-Caspian amphipod species along the Sava (S1-12), Drava (D1-22), Danube (Db1-7) and Kupa (K) Rivers in Croatia. Small black triangles represent findings of *D. villosus* (one specimen at D4 and two at D10) in the Drava. Amphipods were not found at sites represented by empty squares (S2-S6)

Chelicorophium curvispinum is the most widespread species, present in all three rivers; it was recorded at 20 out of 42 sites examined. In the Sava it was recorded at five sites (S7-S12), with site S7 located 474 km from the mouth. The species was found at one site (Figure 1-K) in the lower course of the Kupa (23 km from the mouth), although it was not recorded at the site S4, which is near to the confluence of the Kupa and Sava. In the Drava, *C. curvispinum* was found at nine sites, where more intensive sampling with benthos net was performed (Annex 2). Its upstream end of distribution in the Drava was site D6, located 210 km from the mouth. The species was not recorded at eight sites downstream from D6. At the site D6, it had a much lower abundance than, for example, at sites D8, D11 and D12 where it was extremely abundant. In the Danube, it was found at four out of seven sites (Figure 1, Annex 2).

Three females of *Dikerogammarus bispinosus* were found only at the site Db2 in the Danube, where sampling was conducted only by collection of large specimens under stones. However, the species was not found at other sites in the Danube even though sampling was much more intense there.

Dikerogammarus haemobaphes was recorded at six sites along the Sava and two sites in the Drava. It coexists with the *C. curvispinum* at six sites (S7-11) in the Sava. Interestingly, it was found at sites D12 (195 km from the mouth) and D13, which represent upstream end of a continuous distribution of alien gammarids in the Drava. At D12 it was found in coexistence with *Gammarus fossarum* Koch 1835 and at D13 with *Gammarus roeseli* Gervais 1835 and *D. villosus*. At both sites *C. curvispinum* was the most abundant species in the invertebrate community. *D. haemobaphes* was the dominant gammarid at

D12, while *G. fossarum* had much lower abundance there. However, at D13, on the stony substrate used for the stabilization of banks, *D. villosus* was much more abundant than *D. haemobaphes*, while *D. haemobaphes* was more numerous in *Myriophillum*, where also *G. roeseli* was found in low abundance.

Dikerogammarus villosus was found at all seven sites in the Danube, while in the Drava it is continuously distributed and a dominant gammarid from the mouth to site D13, located 175 km from the mouth. It was the only recorded gammarid species at eight sites in the Drava (D14-22). At four of these sites (sites D12, 15, 16, 22), where more intensive sampling was performed, it is very likely that *D. villosus* was the only gammarid species. In 2007 one large male of *D. villosus* was found at D10, about 28 km upstream from D13 (present known upstream limit of *D. villosus* continuous distribution). Furthermore, two specimens of the same species were found in 2008 at D4, 64 km upstream from D13 (Figure 1, Annex 2).

Obesogammarus obesus was found at five sites in the Danube (Figure 1), in coexistence with *D. villosus* and *C. curvispinum* (Annex 2). This species was recorded in lower abundance than *D. villosus*, except at the site Db1 in the sample from August 2004 where it was more numerous than *D. villosus*.

In the reach of the Sava River, downstream from Zagreb (site S2-6), amphipods were not recorded. However, at site S1, located upstream from the main outflow of Zagreb's sewerage, *G. fossarum* was abundant and *G. roeseli* was the rare species of invertebrate community. Native gammarids in Drava were found in the upstream reach, from D1 to D13, with *G. fossarum* as the most widespread species, followed by *G. roeseli* and *Synurella ambulans* Müller 1846.

Discussion

Ponto-Caspian amphipods, some of which are highly invasive, can completely replace native species (Pinkster et al. 1992; Dick and Platvoet 2000; MacNeil and Platvoet 2005) and/or negatively impact the whole invertebrate community (Krisp and Maier 2005; Bernauer and Jansen 2006). Therefore, knowledge on alien amphipod distribution is *condicio sine qua non* for the preservation of biodiversity and assessment of biocontamination of benthic communities in freshwaters (Arbačiauskas et al. 2008). In this study, we established the distribution of five Ponto-Caspian amphipod species for the part of the Danube River, which forms the eastern most border of Croatia and its tributaries the Drava and the Sava Rivers. Paunović et al. (2007) recently studied invertebrate communities of the Danube (river km 925-1429 km from the mouth), and reported the distribution of all five amphipods that were recorded in our study. Records of Ponto-Caspian amphipods were already reported for the lower course of the Sava River (*Corophium* sp. and *Pontogammarus* sp.), but amphipods were not determined to species level (Matoničkin et al. 1975). Furthermore, some authors mentioned findings of Ponto-Caspian amphipods in lower parts of Drava and Sava Rivers (Jażdżewski 1980; Nesemann et al. 1995), but we could not find any record for these rivers in the original papers of Dudich (1927, 1947) and Karaman (1953). Our study is, therefore, the first to report distribution of Ponto-Caspian amphipods in Croatian part of the Drava and Sava Rivers.

The highest number of Ponto-Caspian species (4) was found in the Danube River, where only *Dikerogammarus haemobaphes* was not recorded. Records of Ponto-Caspian amphipods for the section of Danube from Kazan-pass (Romania) to Vienna (Austria) were summarized by Dudich (1947). Also, records from the downstream parts of Danube, that are nearest to our sites, were made by Karaman (1953) and Pljakić (1965). Interestingly, those authors found *D. haemobaphes* and *D. bispinosus* (previously subspecies of *D. villosus*), and did not find *D. villosus*, which we established to be the dominant gammarid at all seven examined sites in the Danube. Paunović et al. (2007) also recorded *D. villosus* at all eleven examined sites in the Serbian section of Danube from the Iron gates to the border with Hungary, while *D. haemobaphes* was recorded at only one site (identical to our site Db1). Furthermore, *D. villosus* was reported from upstream Hungarian section of Danube already in the first half of 20th century, together with *D. bispinosus* (Dudich 1927, 1947; Muskó 1994), but as there were no records of *D. villosus* for downstream Croatian and Serbian reaches of Danube, probably only *D. haemobaphes* and *D. bispinosus* occurred there (Dudich 1947; Karaman 1953; Pljakić 1965). Therefore, it is possible that *D. villosus* had dispersed by ship traffic and established its populations in upstream parts of Danube earlier than in downstream parts.

According to the above-mentioned historical data and recent research we assume that *D. haemobaphes* was the first gammarid colonizer of the middle Danube, but was almost completely replaced by *D. villosus* during 20th century. *D. bispinosus* was found only at one site in low numbers, and Paunović et al. (2007) recorded it at only two out of eleven examined sites. Therefore, this species is still a rare member of Danube invertebrate communities, which is in accordance with previous literature records.

Species *Obesogammarus obesus* was found only in the Danube, where it was originally distributed in the lower courses of the river (Dudich 1947; Pljakić 1965). It was not previously recorded in Hungarian section of Danube (Dudich 1927, 1947; Muskó 1994) and in the last few decades it has extended its distribution to upstream sections of the Danube from Hungary to Germany (Nesemann et al. 1995; Weinzierl et al. 1996). Recently, it entered Rhine River via the Main-Danube canal (Nehring 2006). As the former name of the species was *Pontogammarus obesus*, and since Matoničkin et al. (1975) reported records of a *Pontogammarus* sp. at some of the sites, it is quite possible that this species inhabited the lower course of the Sava River. However, *O. obesus* was not recorded in the Sava throughout this study. Nehring (2006) suggested that increased ship traffic was a major cause of its fast upstream range extension in the Danube and Rhine.

The species *Chelicorophium curvispinum* is today the most widespread Ponto-Caspian amphipod in Europe (Jażdżewski 1980; Van der Velde et al. 2000). First record of this species in middle Danube dates back to the beginning of 20th century when it was found in the Danube at Nagymaros (upstream Budapest, rkm 1752) (Ungar 1918); later it was found at many sites along the Danube (Dudich 1927, 1947; Muskó 1994). In this study, we established that *C. curvispinum* is the most widespread Ponto-Caspian amphipod in Croatia. It was found in all four rivers at 20 of 42 examined sites, even in the lower course of Kupa, tributary of the Sava River (Figure 1). This species was not found at some sites along the Drava River (downstream of D6) and at three sites in the Danube River. This is probably due to inadequate sampling (only large specimens under stones were collected) or because sampling occurred during high water level. Paunović et al. (2007) recorded *C. curvispinum* at eleven sites (four of which were in bordering area with Croatia) along 504 km stretch of the Danube River. Therefore, this species inhabits the whole course of the Danube that forms easternmost border of Croatia and it is probably continuously distributed in the Drava River up to the site D6. In the Sava it was recorded up to rkm 471 (site S7). Matoničkin et al. (1975) established that *Corophium* sp. was distributed from the mouth of the Sava to the most upstream site at Stara Gradiška. This site corresponds to the site S7 in our study. Thus, this species has been present in the lower half of the Sava River for at least 35 years. Similarly to other Ponto-Caspian species, its range extension is facilitated mainly by ship traffic (Nesemann et al. 1995; Rinhold and Tittizer 1999). Sava is navigable up to the city of Sisak, 600 km from river mouth. However, the species was not found at upstream sites (S1-S6) and the most upstream site where it was found (S7) is located 125 km downstream from Sisak. As other amphipods were also absent at sites S2-S6 (downstream Zagreb and Sisak), we conclude that pollution at these sites is still severe and restricts further upstream spread of the alien species, as well as downstream spread of native species. Previous studies showed that water quality below Zagreb and Sisak was heavily to very heavily polluted, while downstream of Jasenovac (S6) it improved to moderately polluted (Meštrov et al. 1978; Meštrov et al. 1989). Records of *C. curvispinum* in the Kupa River suggest that this species has probably extended its distribution to other tributaries of the Sava.

D. haemobaphes has the same distribution in the Sava as *C. curvispinum*. The spread of this species is probably also restricted by severe pollution downstream of Zagreb and Sisak. Pollution presumably caused decline or complete elimination of native species in lower course of Sava and opened the niche for colonization of alien Ponto-Caspian species from the Danube. Similarly, after the improvement of water quality in the Rhine River, recolonization of native species and appearance of exotic species was observed (Den Hartog et al. 1992). It is, however, interesting that only *C. curvispinum* and *D. haemobaphes* colonized Sava River, while *D. villosus* did not, although it invaded the Drava. In contrast to the Sava, lower course of the Drava has plenty of stony substrate suitable for *D. villosus*. Therefore, it is possible that the establishment of *D. villosus* in the lower course of Sava was disabled by unsuitable substrate, composed of mud and sand, and by the presence of a former invader *D. haemobaphes*, which was

competitively a stronger species in such conditions.

The Drava River is colonized by invasive amphipods about 230 km from the mouth, while in the Sava they are distributed about 500 km upstream from the mouth. This difference is probably due to the fact that the Sava is navigable on a much longer river length than the Drava (Sava up to Sisak, and Drava up to Osijek) (Figure 1). Hence, upstream spread of alien amphipods in the Drava was slower and probably occurred by unintentional transport of species by small fisherman's boats or active upstream and downstream movements of amphipods from the site of introduction.

Complex distribution pattern of alien and native gammarids was observed in the Drava (Figure 1, Annex 2). *D. villosus* is continuously distributed up to the site D13 (rkm 574) where it coexists with *D. haemobaphes* and *G. roeseli*. At this site *D. villosus* is more abundant than *D. haemobaphes* on stony substrate, while inverse is observed in *Myriophillum*. This indicates that species coexist by occupying different microhabitats. Furthermore, native *G. roeseli* at this site was found only in *Myriophillum*, together with *D. haemobaphes*. Kley and Maier (2005) established that co-existance of *D. villosus* with other gammarids had been possible by differential microhabitat selection of stony substrate by *D. villosus* and of macrophytes by other gammarids. *D. villosus* was the only gammarid recorded at all sites downstream (D14-D22) in the Drava. At four of those sites samples were collected with benthos net at all available microhabitats, which means that there is a high certainty that no other gammarids were present at these sites. Therefore, we assume that this species is the only gammarid present in the reach of the Drava from the mouth up to site D15 (82 km from the mouth). Further upstream, at site D13 *D. villosus* was the dominant gammarid found in coexistence with *D. haemobaphes* and *G. roeseli*, while at D12 (20 km upstream) only *D. haemobaphes* and *G. fossarum* were found. However, *D. villosus* was found at D10 (one male), about 28 km upstream from D13 (present upstream distribution limit of the species), while two specimens of this species were also found at D4, 64 km upstream from D13. These findings indicate that *D. villosus* has already started to invade upstream part of the river, by unintentional introductions, possibly by fisherman's boats. Many experimental studies showed that *D. villosus* has strong predatory impact on other native or alien species of amphipods (Dick and Platvoet 2000; MacNeil and Platvoet 2005). Although it is not clear how it impacts *D. haemobaphes*, distribution patterns of these two species in Drava indicate that later invasion of *D. villosus*, already inferred for Danube from the historical data (see above), caused reduction and disappearance of the earlier invader, *D. haemobaphes*.

Although there are many uncertainties in our conclusions about the causes of current distribution of Ponto-Caspian amphipods in the Sava and Drava Rivers, future studies of amphipods in these rivers should be carried out in the reaches for which we identified present upstream distribution limits of alien amphipods. In this way, important questions regarding the spread of most invasive species, *D. villosus* and *C. curvispinum*, and their impacts on invertebrate communities in reach of the Drava, which is already heavily influenced by hydrological changes from an upstream dam, can be addressed. Another interesting research topic to address is whether and how far did alien amphipods enter into Sava's tributaries, and how future pollution reduction in the Sava, after the water purification plant in Zagreb was put into operation in 2008, will influence further upstream spread of alien and invasive amphipods.

Acknowledgements

We would like to thank Jasna Lajtner, Andreja Lucić and Nina Jeran for their help during fieldwork. We are, also, grateful to Marko Ćaleta, Perica Mustafić, Zlatko Mihaljević and Siniša Vajdić from ichthyological study group and to Ivan Vučković, Ivana Mareković and Croatian Waters for providing part of the samples analyzed in this study. Spatial thanks to Saša Božić for her help with laboratory processing of samples. Samples from some sites were collected during the study entitled "Ecological research of freshwater in Croatia regarding criteria of the Water Framework Directive of EU". We thank to all that contributed in field work during this study. Finaly, our gratitude goes to Nika Galić and Bojana Horvat for linguistic improvements, and to reviewers for their critical comments on an earlier draft of this manuscript.

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Annex 1

Location of sampling sites along the Drava, Sava, Kupa and Danube Rivers in Croatia

Site	Closest settlement/Location	Geographic coordinates		River km	Distance to mouth, km
		Latitude,N	Longitude,E		
Drava					
D1	Svibovec	46°22′11″	16°17′23″	453	296
D2	Prelog	46°19′10″	16°34′23″	481	268
D3	Donja Dubrava	46°18′29″	16°49′07″	504	245
D4	Legrad	46°17′52″	16°52′56″	510	239
D5	Drnje	46°13′49″	16°57′23″	522	227
D6	Molve	46°07′27″	17°04′26″	539	210
D7	N. Virje_canal Bistra_1	46°06′48″	17°06′54″	542,9	206,1
D8	Novo Virje_2	46°06′42″	17°08′33″	545,1	203,9
D9	Novo Virje_3	46°06′38″	17°09′06″	545,9	203,1
D10	Novo Virje_4	46°06′32″	17°09′20″	546,3	202,7
D11	Novo Virje_5	46°06′28″	17°09′53″	547,0	202,0
D12	Karaska Luka	46°05′19″	17°12′49″	554	195
D13	Kriznica	45°57′46″	17°18′29″	574	175
D14	Terezino Polje	45°56′41″	17°27′56″	594	155
D15	Donji Miholjac	45°46′48″	18°10′56″	667	82
D16	Belisce	45°41′15″	18°24′36″	693	56
D17	Nard	45°39′48″	18°29′20″	704	45
D18	Karasica	45°36′00″	18°35′59″	720	30
D19	Visnjevac	45°34′19″	18°38′55″	725	24
D20	Nemetin	45°32′34″	18°46′35″	736	13
D21	Sarvas	45°33′03″	18°51′44″	743	6
D22	Drava-moth	45°32′22″	18°56′06″	749	0
Sava					
S1	Jankomirski bridge-Zagreb	45°47′37″	15°51′09″	246	699
S2	Oborovo	45°41′13″	16°14′54″	293	652
S3	Martinska Ves	45°35′13″	16°22′18″	318	627
S4	Galdovo-Sisak	45°28′45″	16°23′03″	346	599
S5	Krapje	45°18′20″	16°49′25″	404	541
S6	Jasenovac	45°15′50″	16°53′57″	421	524
S7	Stara Gradiska	45°08′53″	17°14′30″	471	474
S8	Davor	45°06′48″	17°30′52″	511	434
S9	Slavonski Brod	45°06′14″	17°55′59″	559	386
S10	Slavonski Samac	45°03′33″	18°30′36″	628	317
S11	Zupanja	45°05′47″	18°37′39″	657	288
S12	Gunja	44°52′50″	18°49′20″	715	230
Dunav					
Db1	Batina	45°51′08″	18°51′34″	1436	1421
Db2	Kazuk	45°44′42″	18°53′41″	1450	1407
Db3	Aljmas	45°31′53″	18°57′16″	1478	1379
Db4	Erdut	45°30′17″	19°06′37″	1494	1363
Db5	Dalj	45°28′58″	18°59′58″	1503	1354
Db6	Sarengrad	45°13′45″	19°20′25″	1565	1292
Db7	Ilok	45°13′47″	19°21′45″	1567	1290
Kupa					
K	Petrinja	45°26′45″	16°16′31″	273	23

Annex 2

Occurrence of Ponto-Caspian and native amphipods in Croatian large rivers

Site	Closest settlement/Location	*Gammarus fossarum*	*Gammarus roeseli*	*Synurella ambulans*	*Chelichorophium curvispinum*	*Dikerogammarus bispinosus*	*Dikerogammarus haemobaphes*	*Dikerogammarus villosus*	*Obesogammarus obesus*	Month/Year of sampling
Drava										
D1	Svibovec	●								07/2007
D2	Prelog	●	●							09/2008
D3	Donja Dubrava	●								09/2008
D4	Legrad	●	●	●				●		09/2008
D5	Drnje	●	●	●						07/2007
D6	Molve	●	●	●	●					07/2007
D7	N. Virje_canal Bistra_1	●								09/2008
D8	Novo Virje_2	●			●					09/2008
D9	Novo Virje_3	●	●	●	●					10/2007
D10	Novo Virje_4				●			●		09/2008
D11	Novo Virje_5	●			●					10/2007
D12	Karaska Luka	●			●		●			10/2007
D13	Kriznica		●		●		●	●		07/2007
D14	Terezino Polje							●		08/2007
D15	Donji Miholjac				●			●		07/2007
D16	Belisce							●		06/2007
D17	Nard							●		06/2007
D18	Karasica							●		06/2007
D19	Visnjevac							●		06/2007
D20	Nemetin							●		06/2007
D21	Sarvas				●			●		10/2008
D22	Drava-moth							●		09/2007
Sava										
S1	Jankomir bridge-Zagreb	●	●							06/2006
S2	Oborovo									5,8/2007
S3	Martinska Ves									5,8/2007
S4	Galdovo-Sisak									5,8/2007
S5	Krapje									07/2007
S6	Jasenovac									7,10/2004
S7	Stara Gradiska				●		●			7,8,9,10/2004
S8	Davor				●		●			6,7,9/2004
S9	Slavonski Brod				●		●			8,9,10/2004
S10	Slavonski Samac				●		●			7,8,9,10/2004
S11	Zupanja				●		●			07/2006
S12	Gunja				●		●			7,8,9,10/2004
Dunav										
Db1	Batina				●			●	●	8,9,10/2004
Db2	Kazuk					●		●		06/2007
Db3	Aljmas				●			●	●	8,9,10/2004
Db4	Erdut							●		09/2007
Db5	Dalj				●			●	●	8,9,10/2004
Db6	Sarengrad				●			●	●	8,9,10/2004
Db7	Ilok							●	●	09/2007
Kupa										
K	Petrinja	●			●					08/2006