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Research Article

Distribution of the Ponto-Caspian polychaeta *Hypania invalida* (Grube, 1860) in inland waters of Serbia

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Abstract

The aim of this paper is to present the distribution of the non-native species *Hypania invalida* (Polychaeta) within Serbian waters. In 1971, this species was found for the first time in the Danube and the Sava Rivers. According to our results, *H. invalida* is now widespread within potamon-type rivers that are under the influence of hydromorphological alterations and exposed to intensive ship traffic. The distribution of this polychaete species, as well as some other alien aquatic invertebrate taxa *Branchiura sowerbyi*, Chinese pond mussel *Anodonta woodiana*, Spiny cheek crayfish *Orconectes limosus* and Asian clam *Corbicula fluminea*, further indicates that heavily modified waterways are suitable recipient areas for species introduction and adaptation.

Key words: *Hypania invalida*, Polychaeta, Ponto-Caspian taxa, aquatic macroinvertebrates, aquatic invasive species, the Danube River, the Sava River, the Tisza River, Southern Invasion Corridor

Introduction

Hypania invalida (Grube, 1860) (Annelida: Polychaeta) is a Ponto-Caspian species. It is considered as eurytopic, active filter feeding and deposit feeding species (Manoleli 1975), with a preference for fine substrate, ranging from silt to gravel (Manoleli 1975; Popescu-Marinescu 1980; Rusev and Marinov 1964; Šporka 1998). It is typical species for eupotamon environments (Sporka 1998). *H. invalida* can be found in high population densities, especially within stretches that are under the influence of hydro-morphological alteration. Thus, high densities were reported from Ybbs-Persenbeug, Jochenstein (Tittizer 1997) and Gabčikovo-Nagymaros (Krno et al. 1999) reservoirs. A population density exceeding 104 ind m^{-2} was documented for Austrian (Weber 1964) and Romanian sectors (Popescu-Marinescu 1992) of the Danube River.

The origin and distribution of *H. invalida* has been described by several authors. The original location of *H. invalida* was discovered in Romania during the 1930s (Popescu-Marinescu 1992). Expansion of the range has been observed in the area of the Volga basin, where the species was initially introduced in the 1950s and 1960s to enhance the nutrition base for fishes in fish tanks (Nechvalenko 1977; Dzyuban and Slobod-chikov 1980). *H. invalida* further extended its range westward, where it was found in the upper Danube in 1967 (Kothé 1968). After the opening of the Danube – Main canal in 1992, *H. invalida* invaded the Main, the Rhine and the Moselle basins (Tittizer et al. 2000; Tittizer 1997; Schmidt et al. 1998). It reached the Netherlands in 1995 (Klink and Bij de Vaate 1996). It now occurs in the whole Rhine basin (Bij de Vaate et al. 2002) and has been found far upstream in the Belgian part of the River Meuse in 2000 (Van den Bossche et al. 2001). In 1993 *H. invalida* was recorded in the Moskva River (Lvova et al. 1996).

In this paper we present records of *Hypania invalida* (Grube, 1860) in Serbian waters, as a contribution to general knowledge on the distribution of this species in Europe.

Material and methods

The data used to analyze the dispersal of *Hypania invalida* covers the period 1971-2006. The distribution is evaluated based on published information (Nedeljkovic 1979a, b; Simic et al. 1997; Djukic et al. 2000; Paunovic et al. 2005), as well as unpublished data covering the investigation of sampling sites in running and standing waters from Serbia (Cakic et al. 2007). Samples were collected by various techniques – benthic hand nets (semi-quantitative technique), dredging, hydraulic polyp sampler (qualitative techniques), Van Veen, Petersen and Ekman grabs (quantitative sampling).

The classification of mineral substrate by particle size (Appendix 1) was performed according to the scale proposed by Wentworth (1922) and Verdonschot (1999) as follows: grains not perceptible by eye (< 0.125 mm – silt-clay), grains perceptible by eye (0.125-0.5 mm – fine sand), coarse sand (0.5-2 mm), gravel (2-16 mm), pebble (16-34 mm), cobble (34-256 mm), and boulder (> 256 mm). Presence of detritus, aquatic vegetation and/or empty mollusk shells were also recorded in samples. Sites previously investigated (Nedeljkovic 1979a, b; Simic et al. 1997; Djukic et al. 2000) were additionally examined to evaluate the dominate substrate type.

The relative abundance of *Hypania invalida* was evaluated according to the scale presented in Table 1.

For data collected within the period 2004–2006, the coordinates (latitude and longitude) of the sampling sites were measured by "Garmin eTrex" GPS and charted using ArcView 9.1 software (map 1:300,000, system WGS_1984). For the previous records, the sampling sites coordinates were derived from the map (1:25,000) by using ArcView 9.1 software, based on the description in sampling protocols.

Table 1. Relative abundance description sheet for *Hypania invalida*.

Description	No. of individuals per sample* or per m^2**	Relative abundance scale
Single record	1-2	1
Low abundance	3-4	2
Medium abundance	5-20	3
Abundant	21-100	4
Very abundant	>100	5
Low		UN

* In the case of semi-quantitative sampling;
** In the case of quantitative sampling

Results

In autumn 1971, a single specimen of *Hypania invalida* was found in the Danube River, upstream from settlement Donji Milanovac (Site 26; Appendix 1). During the same year, eight individuals were collected at the location Makis – the Sava River (Appendix 1 – site 41). These were the first records of *H. invalida* (see inserted photograph in Figure 1) in Serbian waters.

During the follow-up period (1971–1977), *H. invalida* was recorded at 13 additional sites in the Danube River (Figure 1 and Appendix 1 – sites 15, 16, 18, 20, 22, 24, 26, 27, 28, 29, 30, 31 and 32). These sites are under the direct hydrological influence of the Đerdap (Iron Gate) dam. A dense population of *H. invalida* has been observed at several locations (Appendix 1), up to 85.29% of the total benthic community (Site 15).

Investigations in the period 1995-2000 indicated that *H. invalida* became more wide-spread and frequent in the Danube River. Thus, several new sites for the species were confirmed (Figure 1 and Appendix 1 – sites 5, 8, 10, 11, 13, 17, 25 and 33). Furthermore, *H. invalida* was recorded at two sites from the Sava River (Figure 1 and Appendix 1 - sites 38 and 39).

During the investigation of the Serbian sector of the Danube River (2001, river km 1429-926, JDS – ITR National Report 2002), *H. invalida* was recorded at 11 sites (Figure 1 and Appendix 1 – sites 1, 2, 3, 4, 6, 7, 12, 19, 21, 23 and 35). *H. invalida* has also been reported from two sites in the Tisza River (JDS – ITR National Tisza Report 2002) (Figure 1 and Appendix 1 – sites 43 and 44). During the period 2002 – 2006, *H. invalida* was found in the Danube (Figure 1 and Appendix 1 – sites 9, 14, 34 and 36) and in the Sava (Figure 1 and Appendix 1 – sites 37, 40 and 42). Up to 2010, *H. invalida* had been found at 44 sites. It is widely distributed along the entire Serbian stretch of the Danube, the Sava and the Tisza Rivers. The species was found to be adapted to habitats where the bottom substrate consisted mostly of silt, clay and fine sand (Appendix 1). Within those habitats, *H. invalida* was found to coexist with Oligochaeta species, mostly representatives of family Tubificidae.

According our data, following high abundances of *H. invalida* sampled in the period 1971–1977 a significant decline in both the relative abundance and proportion of this species in benthic community has been recorded in 1995–2006 – from 2,62 and 18,8% to 1,41 and 2,35%, respectively.

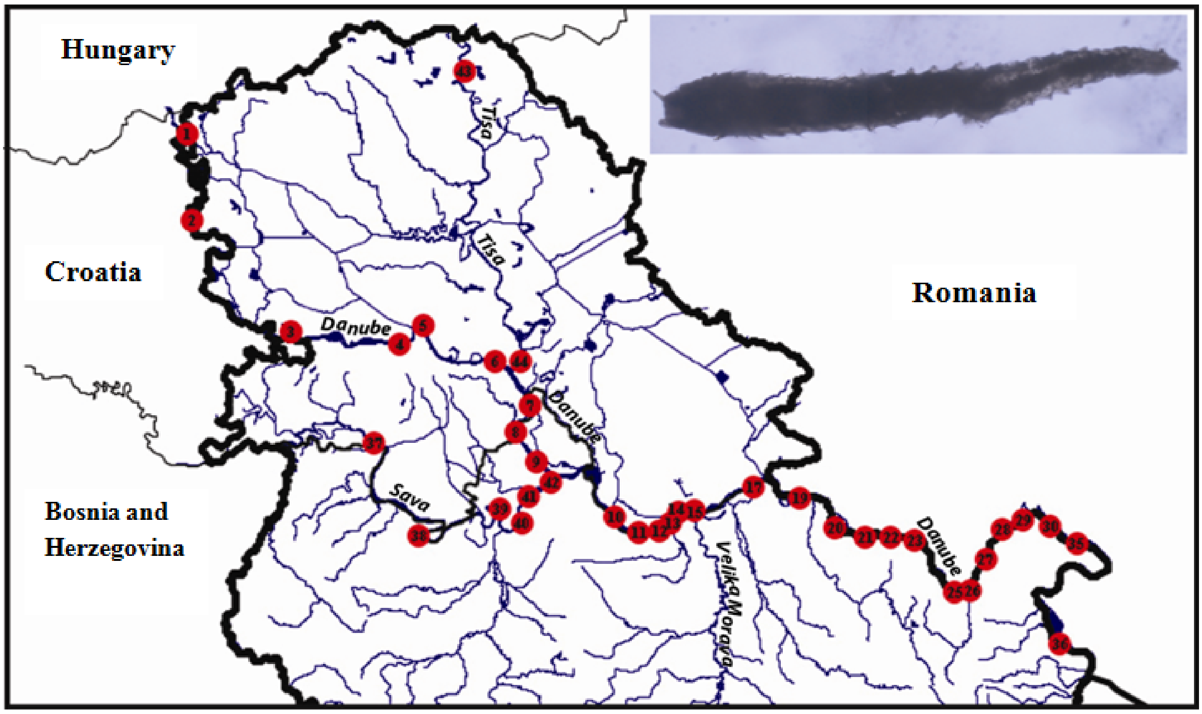

Figure 1. Distribution of *Hypania invalida* in Serbia (site numbers as in the Appendix 1, inserted photograph of *H. invalida* from Danube River by I. Bjelobaba).

Discussion

According to our results, *Hypania invalida* is limited to heavily modified water bodies, influenced by hydro-morphological changes, organic pollution and exposed to intensive ship traffic (SCG ICPDR National Report 2004).

The distribution pattern of this polychaete, as well as some other invertebrates (*Branchiura sowerbyi* (Beddard, 1892) – after Paunovic et al. 2005, *Anodonta woodiana* (Rea, 1834) – after Paunovic et al. 2006, *Orconectes limosus* (Rafinesque, 1817) – after Pavlović et al. 2006) indicates that heavily modified waterways are suitable recipient areas for the introduction and adaptation of invasive species. Several authors reported that invasive Ponto-Caspian species have been able to successfully spread along waterways into Europe using one of the three main shipping corridors (Northern, Central and Southern). After the opening of the Main – Danube Canal (September 1992) the Southern Invasion Corridor became one of the most important routes for the spread of the Ponto-Caspian fauna to the west (Bij de Vaate et al. 2002; Ketelaars 2004; Devin et al. 2005; Karatayev et al. 2008). As ship traffic has been underlined as one of the major vectors influencing the spreading of species beyond their natural range, waterways are under particular pressure (Galil et al. 2007). Arbačiauskas et al. (2008) confirmed that the Danube is under particular pressure of aquatic invasions, in the case of macroinvertebrate species. High pressure of invasions has been already recognized for the Danube (Cakic et al. 2004; Simonovic et al. 2001, 2006; Berneth et al. 2002; Paunovic et al. 2004, 2005, 2006, 2007; Pavlović et al. 2006), the Sava (Paunović 2004; Paunovic et al. 2008), and the Tisza (Csányi 2002) rivers.

After 1977, *H. invalida* was found at a lower population density (Appendix 1), with abundance up to 15.18% of the total macroinvertebrate community. The latest data show a decrease of the abundance of *H. invalida* in comparison with the period 1971-1977 (abundance up to 85.29% – Appendix 1). A general decline in population density following exponential growth is a typical pattern observed in population dynamics. Initially invaders inhabit "empty" habitats for example, newly created reservoirs, where the communities are usually impoverished following damming. With increasing density, limiting factors also increase, leading to decreasing density over time. After some time, a "climax" community is formed and population dynamics depends on constantly and variably limiting factors (Lampert and Sommer 2007; Brown and Sax 2004).

A similar population density pattern has been reported for some other invasive species, as well. For example, the scenario of the successful introduction of Chinese mitten crab *Eriocheir sinensis* (Crustacea: Brachyura: Grapsidae) in Europe, shows that the species at first was caught sporadically and a mass occurrence appeared after several years (Ingle and Andrews 1976; Gollasch 1997; Clark et al. 1998; Normant et al. 2002; Rabitch and Schiemer 2003).

The distribution of *Hypania invalida* along the Danube River has been reported by several authors (Bacesco 1948; Popescu and Prunescu-Arion 1961; Rusev and Marinov 1964; Kothé 1968; Popescu-Marinescu 1980, 1992, 1997; Šporka 1998; Titizer et al. 2000). Hydromorphological changes within the Danube River Basin have favored spread of *H. invalida*. Decreasing the flow rate caused by construction of the dams provides the flow conditions suitable for development of dense populations of *H. invalida*. Thus, high densities were reported from areas that are under the direct influence of the construction of dams (Iron Gate sector – Nedeljkovic 1979a, b; Popescu-Marinescu 1992; Austrian sector, Ybbs-Persenbeug and Jochenstein dams – Titizer 1997; Gabčikovo-Nagymaros Reservoir section, Slovakia and Hungary – Krno et al. 1999; Nagy 1999). According to this pattern, hydromorphological degradation of aquatic habitats provided adequate habitats also to other aquatic invertebrates – *Branchiura sowerbyi* (after Paunovic et al. 2005) and *Anodonta woodiana* (after Paunovic et al. 2006). It should be noted that the migration pattern of *H. invalida* was similar to that of the isopod *Jaera istri* (Valkanov 1936). The successful colonization and adaptation of this polychaete is aided by following biological characteristics: relatively short life span and generation time, euryhaline and nonspecific food preference (Van den Bossche et al. 2001; Bij de Vaate 2002).

Although widespread and well adapted in recipient areas, bearing in mind the decline in population density after 1977, it could be concluded that *H. invalida* has limited influence on the overall benthic community as it is restricted to soft bottom communities (silt, clay and fine sand, Appendix 1). Within those communities, *H. invalida* coexists with species of Oligochaeta (mostly representatives of family Tubificidae).

Further investigation on non-native species in recipient aquatic ecosystems, is essential in order to determine possible impacts to native biotopes.

The data presented confirmed that the Danube River is one of the most important invasive corridors in the Palearctic – Southern Invasion Corridor. Furthermore, the distribution pattern of *H. invalida* supports the concept of the invasive networks of Europe. The species first appeared in the Danube and then spread along the main tributaries, as well. This spread was previously confirmed for *Anodonta woodiana* (after Paunovic et al. 2006) and *Corbicula fluminea* (Müller, 1774) (after Paunovic et al. 2007). All these facts confirm that large tributaries of these main corridors, together with their connected east-west orientated passages of invasions, represent important parts of an invasion network. This invasion network concept can potentially be used for prediction of possible ways of dispersal of invasive organisms in the future.

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Supplementary material

The following supplementary material is available for this article.

Appendix 1. Records of *Hypania invalida* in Serbia (RA – relative abundance, see in Table 1). All records will be available at the Regional Euro-Asian Biological Invasions Centre information system (http://www.reabic.net).

This material is available as part of online article from:
http://www.aquaticinvasions.net/2011/AI_2011_6_1_Zoric_etal_Supplement.pdf